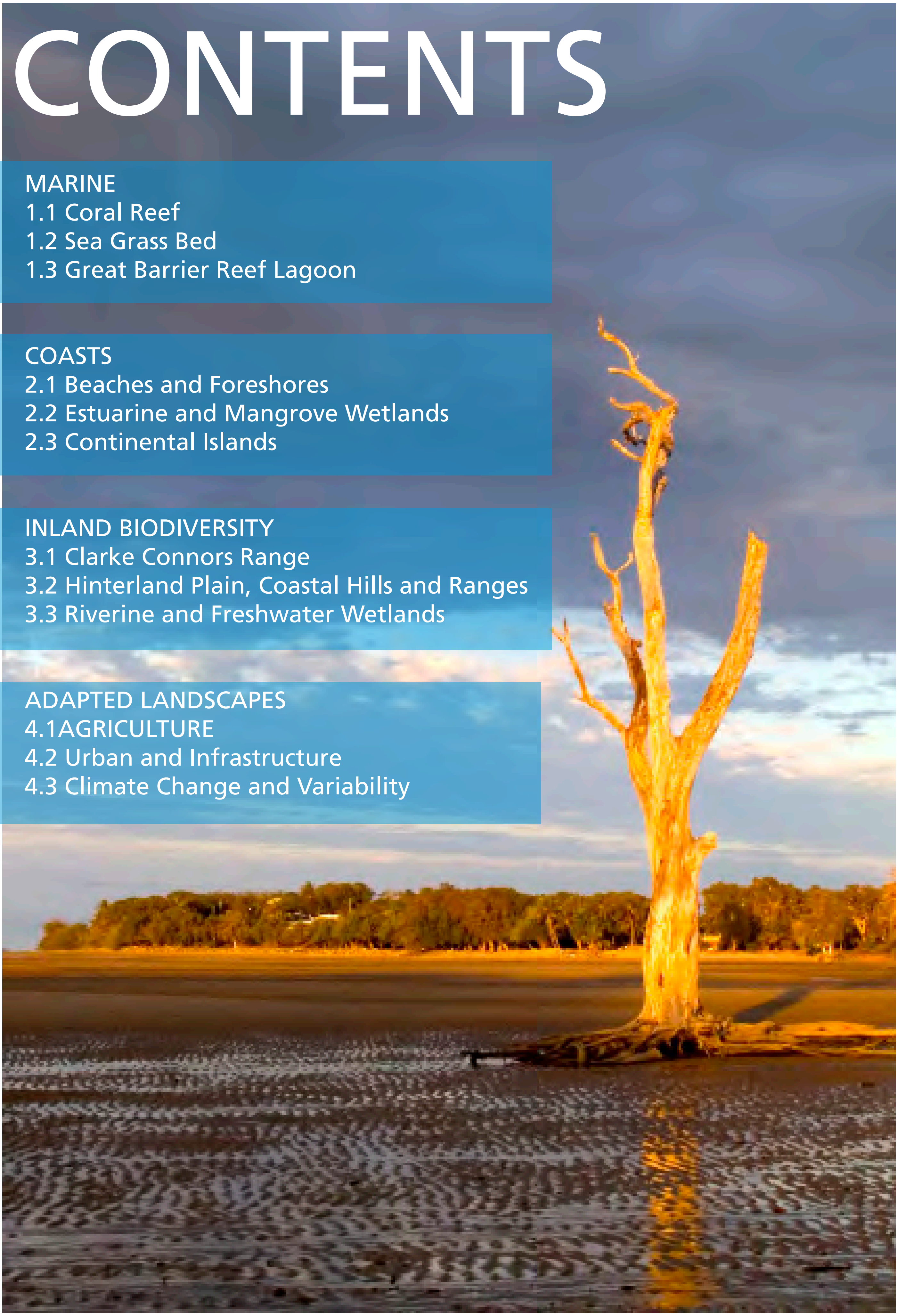
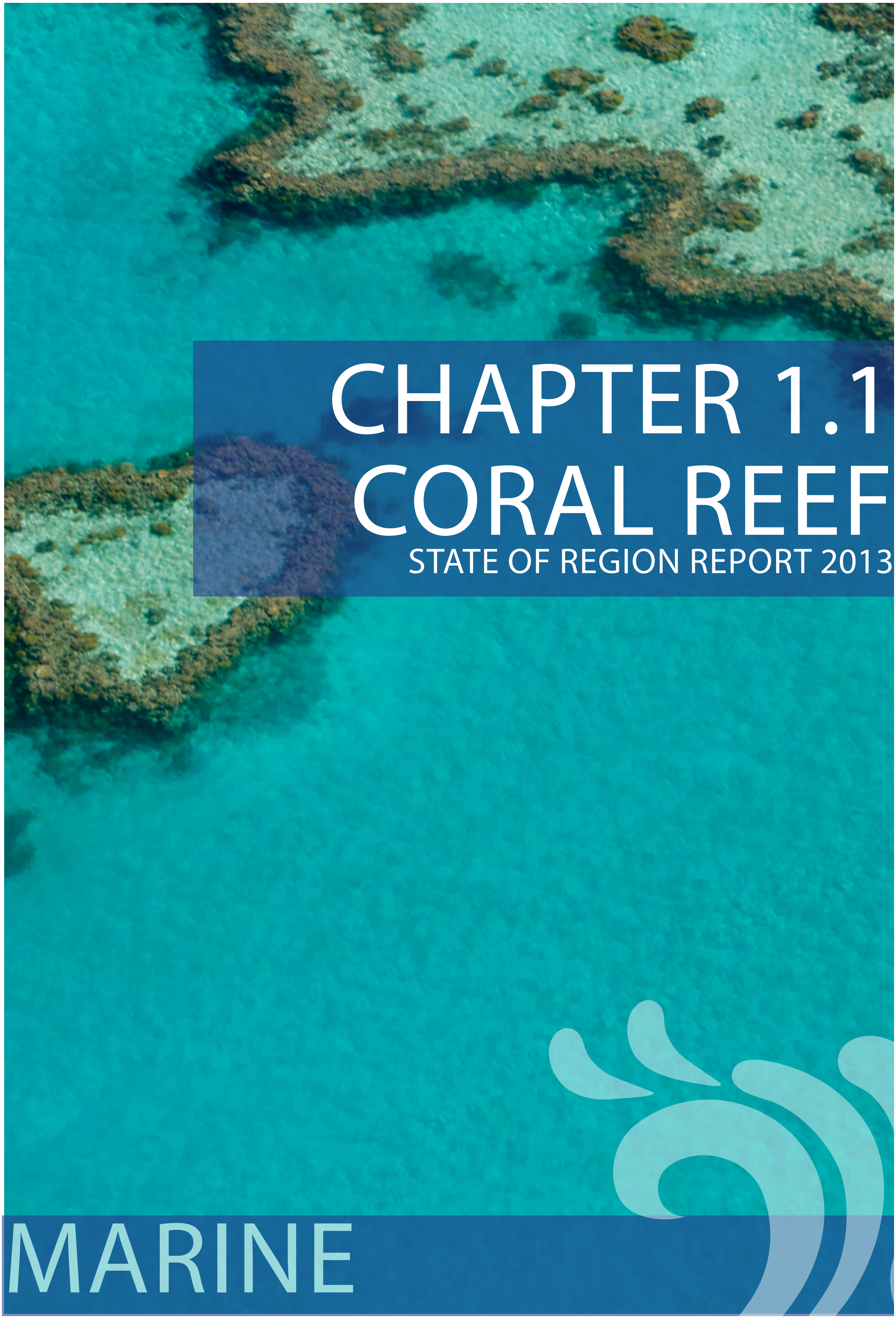
STATE OF REGION REPORT

MACKAY WHITSUNDAY ISAAC

REEF CATCHMENTS

CONTENTS





CHAPTER 1.1
CORAL REEF
STATE OF REGION REPORT 2013

MARINE

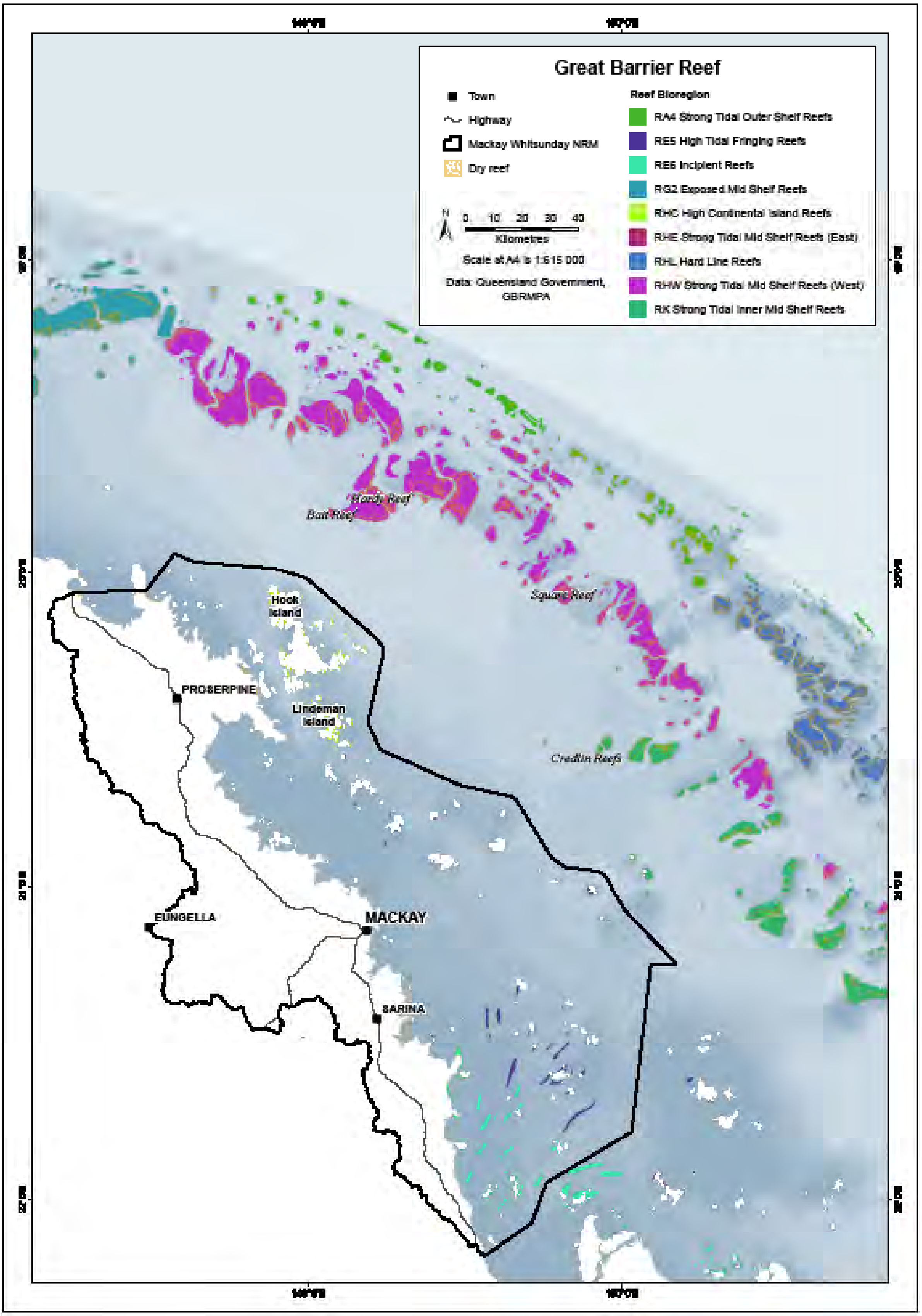


Figure 1: Coral reefs of the Mackay, Whitsunday and Isaac Region and immediate surrounds

SUMMARY

The Great Barrier Reef (GBR) stretches more than 2,300 km from the south-east Gulf of Papua to just north of Bundaberg. The GBR consists of over 2,500 individual reefs, over 900 islands and covers more than 348,000 square kilometres. The larger part of this area was gazetted as a World Heritage area in 1981. It is the only living organism that can be seen from space, is considered by some to provide the most spectacular marine scenery on the planet, is one of the riches and most complex natural ecosystems on earth and has globally significant marine faunal groups (DSEWPAC, 2012).

The regions fringing reefs vary considerably from species-poor muddy reefs close to the discharge of the Proserpine River, through to fragile hard and soft coral communities in inlets and embayments. Significant cross shelf and north to south gradient of reef type exists, so the reef changes gradually from a particular state inshore to mid-shelf and outer reefs, and in a similar manner from north to south.

In the Shoalwater Bay area incipient reefs are common. Here corals can grow but sediment is high and the water deep, meaning the conditions for forming reefs are poor. Conditions improve around southern Mackay islands with clear and shallower water. The northern Mackay and Whitsunday Islands provide the best conditions for coral growth in the north south gradient with shallow, warm water and high island density.

The cross shelf (or in the case of the GBR west to east) gradient is influenced by distance from the coast. Inshore and fringing reefs are exposed to higher levels of sedimentation and lower wave energy, which generally grades across the mid-shelf (lower sediment, higher energy) to the outer reef that has the least sedimentation and highest exposure. However, broad generalisations do not account for all factors, or combinations of factors that result in the differences in individual reefs.

Strong tidal mid-shelf reefs (e.g. Bait and Hardy Reefs) are typified by high-energy environments and contain distinct fish communities. Similarly, strong tidal outer shelf reefs (e.g. those associated with the outer area of Hydrographer's Passage) have high-energy environments, strong tidal influences and distinct biological communities. Hard line reefs (e.g. Cockatoo Reef) form an extensive outer barrier to this section of the GBR. Hard line reefs contain steep walled channels and sheltered leeward reef communities.

Strong tidal mid-shelf reefs (e.g. Credlin Reef) are high in diversity and are characterised by non coral dominated communities in leeward areas. Strong tidal inner mid-shelf reefs (e.g. those around Mackay islands such as Flat Top and Round Top Islands) form in moderate to high turbidity (very hazy) with varying exposure to wave action and other factors that influence their biological diversity and health. High tidal fringing reefs (e.g. Keswick and St Bees Islands) generally have high turbidity, which advantages non-hermatypic corals, octo-corals and gorgonian communities. Incipient Reefs are high in macro-algae coverage and poor in coral diversity.

REEF BIOREGION		EXAMPLE
RG2:	Exposed mid shelf reefs	Stanley Reef
RHC:	High continental islands (fringing reefs)	Whitsunday Islands fringing reefs
RHW:	Strong tidal mid shelf reefs (west)	Hardy and Bait reefs
RA4:	Strong tidal outer shelf reefs	Hydrographer's Passage reefs
RHL:	Hard line reefs	Cockatoo Reef
RE4:	Strong tidal inner mid shelf reefs	Flat Top and Round Top Islands
RK:	Strong tidal mid shelf reefs	Credlin Reef
RE5:	High tidal fringing reefs	Keswick and St Bees Islands fringing reefs
RE6:	Incipient reefs	Cape Palmerston fringing reef

Table 1 Regional Reef Bioregions

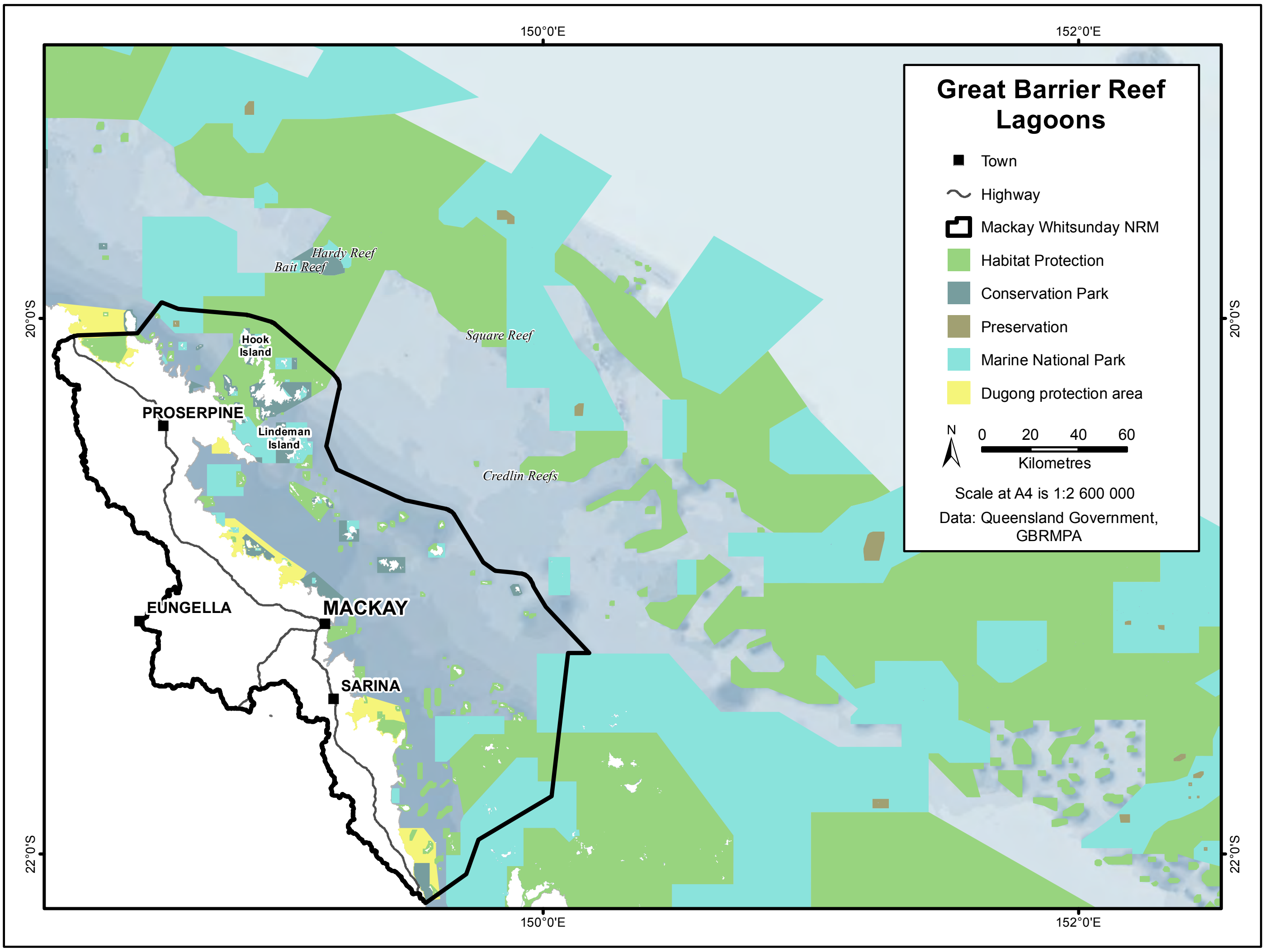


Figure 2 Protection areas within the GBR lagoon in the region

VALUES AND SERVICES

International Environmental Value

Inscribed on the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage List in 1981, the GBR was the first ever marine site listed for all four of the natural criteria and considered to have Outstanding Universal Value (OUV) as the largest assemblage of coral reefs in the world (McGrath, 2012). The OUV criteria were of sites that represent:

- Major stages of earth's evolutionary history
- Superlative natural phenomena or exceptional natural beauty
- Significant ongoing geological processes, biological evolution and man's interaction with his natural environment
- Habitats where populations of rare or endangered species still survive.

Ecological Value

Ecologically the GBR is unique amongst reef systems in the world. It provides habitat for a number of key species and assemblages that are international migrants. These include marine turtles, shorebirds and humpback whales. These natural assets are shared amongst international communities and Australia's duty of care for these whilst in Australian territories, is embedded within international treaties, such as the China-Australia Migratory Bird Agreement and Japan-Australia Migratory Bird Agreement.

The following provides a breakdown of the extent of the GBR's ecological values:

- The world's most extensive stretch of reef and an area of outstanding aesthetic value, providing what some consider the most spectacular marine scenery on earth.
- The Whitsunday Islands are an important calving area for humpback whales (GBRMPA, 2008), and an important feeding ground for turtles.
- Has globally significant marine fauna groups, providing habitat for:
    - 1,500 species of fish
    - 30 species of cetacean
    - 6 species of turtle (out of a total of seven world-wide)
    - 400 species of coral (including almost 1/3 of the worlds species of soft coral)
    - 800 species of echinoderms (e.g. sea stars) constituting 13% of the world's total species
    - 4,000 species of mollusc
    - 240 species of birds
    - An array of other species such as dugong, sponges, anemones marine worms and crustaceans. (DSEWPAC, 2012).

Economy, Trade and Shipping

A variety of commercial and recreational activities are supported by the GBR and many Australians rely on these regional economies for their livelihoods. In 2005 the GBR was considered to be worth over $5 billion per annum to the Australian economy (Access Economics, 2008) and accounted for some $17 billion of Australia's export trade.

At present 12 ports operate within the GBR World Heritage Area and two are within the Marine Park. One of the largest, Hay Point, is located within the catchment and Abbot Point is less than 30 km to the north. The port of Mackay and Dalrymple Bay are also found within the catchment.

These ports service a population of around 1 million in northern regional Queensland - nearly 27% of Queensland's population (Access Economics, 2008). The GBR is an internationally recognised safe shipping route, and as a marine nation the ports are valuable trade access points for Australian goods.

Visitor Services

According to the Great Barrier Reef Marne Park Authority (GBRMPA) (2011a) approximately 1.92 million visitor days are recorded on the Great Barrier Reef each year with 800,000 and 120,000 of those visiting the Townsville/ Whitsunday and Mackay/Capricorn areas respectively during 2011/2012.

Recreational use of coral reefs including fishing is very high within the region. The Queensland direct economic value of this activity is estimated at $300 million (Anon, 2005) of which at least 10% would be spent within the Mackay Whitsunday region.

Access Economics (2008) provide figures for tourism expenditure within the region in 2004/05 and 2005/06. $1,202 million was spent within the Mackay Whitsunday Region in 2005/06, a 30% increase from 2004/05 (Table 2). Across Reef Catchment areas, tourism industries are responsible for employing at least 30,000 people directly (Anon, 2005). Based on the assumption that employment level is proportional to expenditure it is estimated that approximately 6,600 people are directly employed by tourism industries in the region. It is important to note that neither expenditure nor employment figures take into consideration indirect benefits to the economy from tourism, and that these are substantial.

Tourism Region	*2004-05 day*	*2004-05 domestic overnight*	*2004-05 intnl*	*2004-05 total*	*2005-06 day*	*2005-06 domestic overnight*	*2005-06 intnl*	*2005-06 total*	*2005-06 overnight share (%)*	*2005-06 intnl share (%)*
Tropical North Qld	141	1,377	1,039	2,557	178	1,346	1,111	2,635	39%	82%
Northern	67	477	74	618	121	460	64	645	13%	5%
Whitsundays	19	440	110	569	32	676	121	829	20%	9%
Mackay	56	284	13	353	79	280	14	373	8%	1%
Fitzroy	179	435	30	644	182	502	32	716	14%	2%
Bundaberg	50	195	15	260	85	200	11	296	6%	1%
Total GBRCA	**512**	**3,208**	**1,281**	**5,001**	**677**	**3,464**	**1,353**	**5,494**	**100%**	**100%**
Australia	11,614	39,380	12,544	63,538	12,611	40,691	13,402	66,704		
GBRCA/Aust	4.4%	8.1%	10.2%	7.9%	5.4%	8.5%	10.1%	8.2%		

Table 2 Tourism expenditure in Great Barrier Reef Catchment Areas $ Million.

Other Values

Due to the relatively new nature of biotechnology industries, the potential contribution of coral reefs to development of resources such as novel pharmaceuticals is difficult to gauge. However, due to their inherent biodiversity the value of coral reefs is likely to be high to very high. At present, biotechnology industries in Queensland are generating in excess of $150 million per annum and employ over 1000 persons (Anon, 2005).

PRESSURES AND THREATS

"Almost all the biodiversity of the Great Barrier Reef will be affected by climate change, with coral reef habitats the most vulnerable. Coral bleaching resulting from increasing sea temperature and lower rates of calcification in skeleton-building organisms, such as corals, because of ocean acidification, are the effects of most concern and are already evident."

Great Barrier Reef Outlook Report (GBRMPA, 2009; i)

Climate Change

Coral reefs have always been impacted by tropical cyclones and are adapted to recover. However under climate change scenarios the intensity of cyclones is expected to increase (IPCC, 2007), therefore a threat exists in the cumulative impacts of cyclone damage particularly when combined with anthropogenic impacts. Cyclones are expected to track further southwards with some studies suggesting by as much as 130 km (Hardy et al., 2004 in Low, 2011), meaning the reefs within the catchment could experience more cyclone damage than in previous centuries (DERM, 2010). Reef damage from cyclonic activity includes damage to the physical structure of coral as well as the impacts of flood plumes including increased sedimentation, nutrient levels and an increase in turbidity.

The combined impacts of climate change, such as increased temperatures and reduced water quality, has potential to result in a reduced ability of a reef to recover from future cyclone impacts (GBRMPA, 2012). A rapid heath assessment survey was conducted following category five cyclone Yasi which crossed the coast in February 2011 and was one of the most powerful cyclones to affect the Queensland coast since records began. Surveys confirmed that more severe damage occurred to reefs in areas exposed to greater wind speeds, and reefs south of the cyclone were more damaged than those to the north. It is expected that signs of reef recovery will occur within 5 years in areas of low to moderate damage providing no further cyclones or other impacts such as Crown of Thorns Starfish (COTS) outbreaks occur. In more severely impacted areas this can be expected to increase to about 15 years, however damage will still be seen for decades on the reef proper.

Ocean Acidification and Coral Bleaching

Ocean acidification is the name given to the process of the world's oceans absorbing excess carbon dioxide from the atmosphere. A chemical reaction between water and the carbon dioxide results in a net increase in the acidity of the oceans. Further chemical reactions mean that there are a reduced number of carbonate ions available for reef builders such as corals to form their calcium carbonate (limestone) skeletons and make them more prone to dissolving. Calcium carbonate is also the main component of the shells of marine organisms.

This process, which is projected to increase in projected climate change scenarios, has obvious impacts on the ability of coral reefs to grow and repair following damage (e.g. after a cyclone) or bleaching event and make them more prone to breakage thus resulting in greater initial impact and possibly slower recovery time.

Water Quality

Coral ecosystems depend on the quality of water that surrounds them. Sediment, nutrients and contaminants such as pesticides all impact coral colonies. It has recently been shown that pollution and sedimentation combined dramatically increase coral death, and that this can occur rapidly when exposed to sediment containing even small amounts of organic matter (Weber et. al, 2012).

Coastal corals are naturally resilient to low levels of organic matter within the water, however when corals are coated with a thin layer of sediment such as occurs following flood plumes and through regular run off, just 1% organic matter within this sediment removes oxygen (through increased microbial activity) and raises acidity levels resulting in small areas of the coral dying (Weber et al., 2012). Continued microbial activity creates hydrogen sulfide that is highly toxic to coral and in the rest of the colony covered in sediment results in death in as little as 24 hours.

Earlier studies outline other problems with poor water quality for example Fabricius (2005) found that high sediment loads reduced the ability of coral polyps to settle and form new colonies and resulted in their death. Fabricius and De'ath (2004) found reduced recruitment, reduced diversity and subsequently a reduced species richness in highly turbid environments. Weber et al in 2012 found that marine snow (microscopic algae bound with sediment) has resulted in a major loss of coral cover and sea grass decline on the GBR by smothering young corals. They found that sediments enriched with organic nutrients reduced oxygen and increased acidity and caused coral death and were most common in areas of coastal development exposed to water enriched by flood plumes or during re-suspension events (e.g. dredging). Combine this information with the findings of Andutta et. al (2013), discussed below, and Brodie et. al (2012) that sediment, nutrients and other pollutants are thought to remain longer in the GBR lagoon than the freshwater they are suspended in, and a picture of the importance of water quality to coral colonies and their survival becomes evident, particularly close to areas of coastal development.

Coastal Development

> "It is clear that the scale of coastal development currently being proposed and consented presents a significant risk to the conservation of the OUV (outstanding universal value) and integrity of the property, and that the scale and pace of development proposals appear beyond the capacity for independent, quality and transparent decision making"
>
> (Douvere and Badman, 2012; 255)

Coal Port Expansion

The pressures placed on the GBR by the expansion of coal ports within and adjacent to the catchment (Hay and Abbot Points), is considered significant and compounded by current governance arrangements including regulatory, administrative and operational, which can inhibit effective management of port and shipping impacts (Grech et. al, in review).

The pressures placed on the GBR by the expansion of coal ports within and adjacent to the catchment (Hay and Abbot Points), is considered significant and compounded by current governance arrangements including regulatory, administrative and operational, which can inhibit effective management of port and shipping impacts (Grech et. al, in review).

A report commissioned by the Abbot Point Working Group with direction from BHP Billiton and North Queensland bulk ports states that as a direct consequence of the coal port expansion shipping traffic is expected to increase more than 9 times out of Abbot Point and nearly three times out of Hay Point in the next 20 years (Polglaze, 2012).

Increased coal shipping traffic increases the risk of oil and coal spills, groundings and vessel strikes impacting species such as migrating humpback whales. Other impacts include underwater acoustic (noise) pollution, coal dust, the impacts of dredging spoil on reef water quality, and the aesthetic values of the region. Increased shipping traffic also increases the risk of invasive species being introduced and contaminants such as toxic antifoul, sewage and galley scraps impacting marine ecosystems.

Dredging, Marinas and Marine Material Placement

The GBRMPA consider that the major impacts from dredging activity within the GBR come from the operation of coal ports (GBRMPA, 2011b). However, new and existing coastal developments such as marinas and other land reclamation activities have short-term (construction phase) and longer-term impacts on coral reefs that should also be considered when discussing the impact of dredging and marine material placement at the local scale.

New marinas such as the development at Port of Airlie (Muddy Bay) and the proposed marina development at Shute Harbour place increasing pressure on coral communities especially within inshore areas, as well as having detrimental impacts to other marine life such as seagrass communities. With a rapidly growing regional population, such pressures are forecast to increase.

Recent studies have shown that within the central GBR the time taken for fresh water from outside the reef to flush waters inside the reef under real wind conditions was 67 days. However, under calm weather conditions and with little external reef current inflow the flushing time could be as long as 9 months. In addition, up to half of the water leaving the GBR returns to the GBR through the movement of oceanic currents (Andutta at al, 2013). This means that marine material dredged from the ocean floor stays within the GBR for an extended period and may return once it has left.

Pests

Increased shipping and other vessel traffic increases the risk of species such as the Asian green mussel being transported to the catchment. The Asian green mussel can be carried on vessel hulls, in ballast water and in internal seawater systems (e.g. fire hoses) and may have serious economic, ecological and human health implications.

COTS (Acanthaster plancii) are a species of starfish native to the Indo-Pacific region that consume hard corals and in high numbers can dramatically reduce living coral cover. These outbreaks cause considerable public and industry concern particularly amongst marine tourism operators as they reduce the aesthetic value of the reef at the outbreak site. When combined with pressures such as declining water quality and climate change, COTS outbreaks reduce the reefs capacity to recover from such disturbances.

It is now well understood that COTS numbers increase as nutrient levels increase (Brodie et al. 2005). Phytoplankton are the primary food source of larval-stage COTS and increase in numbers due to elevated nutrient levels. COTS populations are thus able to increase dramatically as their primary food source also increases.

Outbreaks occur when the COTS summer breeding season coincides with a dramatic increase in nutrient levels in the water such as has occurred from the recent La Niña cycle. Increased nutrient levels allow many more of the larval COTS to survive, causing localised outbreaks on the GBR.

The GBRMPA is in the process (at April 2013) of formulating a control strategy for COTS to assist the tourism industry to protect coral at high value visitor sites. This short-term strategy is backed by longer term plans to improve water quality entering the GBR lagoon, such as the Reef Rescue Initiative and the Reef Water Quality Protection Plan (Reef Plan).

Coral Disease

Like COTS coral diseases are a natural occurrence in coral ecosystems and to date have not caused significant outbreaks on the GBR possibly due to its overall condition. Osbourne et. al (2011) state that only 6.5% of coral mortality between 1995 and 2009 was attributed to coral diseases and managing overall reef health will likely maintain this low incidence.

However world-wide infectious disease in corals has increased since the 1970's. Multiple factors are at play, however it has been established that increased ocean temperatures, increased carrier and host densities and the intensity of coral bleaching have a significant relationship with coral disease prevalence. Nearly all of the other negative anthropogenic coral reef impacts (e.g. ocean acidification, overfishing and marine pollution) have been suggested contributors in some way to coral disease (The Nature Conservancy, 2012).

Commerical Marine Tourism

According to Harriott (2002) the pressures of commercial marine tourism on the GBR can be summarised into 6 main types; coastal tourism development, island and marine based tourism infrastructure, boat-induced damage, water-based activities and wildlife interactions.

Commercial marine tourism is managed by GBRMPA and the Queensland Parks and Wildlife Service (QPWS) through a permit system. Anchor damage is managed through the installation of mooring and 'no-anchor zones' in heavily used areas. 85% of tourism on the GBR is centred around Cairns and the Whitsundays collectively meaning visitor numbers are high over an area covering only 7% of the GBR. This impacts coral reefs in particular through fin damage, collecting, in-water pollutants (such as sunscreens and oils) and impacts on the behavioural characteristics of marine creatures.

Fishing

Commercial and recreational fishing have a direct impact on the GBR through the removal of herbivorous fish, damage to the seabed and other habitats and removal of non-target species (by-catch). For example the removal or reduction in the number of herbivorous fish present within a coral colony can allow excessive growth of resilient and aggressive algae and seaweed. If fish stocks are consistently depleted algae and seaweed may dominate in the coral colony, and in some cases completely destroy it.

No take zones and other commercial fishing restrictions have a significant positive impact on the protection of the GBR and it's coral colonies (McCook et. al, 2010). Various other functional groups of herbivorous marine creatures (such as bioeroders or coral grazers) play important roles in the health of coral communities so maintaining the variety and abundance of the various functional groups and species will have the highest ecological impact.

CONDITIONS AND TRENDS

"While most of the stressors that are responsible for the decline of coral reefs worldwide are present on the GBR, damage to date has been localised rather than system wide"

Sweatman, 2011; 1

The condition of Australia's marine environment, when compared to the rest of the world is considered good (Australian Government, 2011). The eastern region including he GBR as defined by the SoE (2011) is also considered to be in good overall condition. However, herbicides in significant levels have been found within all sampling sites within the GBR and Kennedy, et. al (2010) consider these levels to have significant impacts on coral and other marine life. According to Reef Plan (2012), inshore reefs are in moderate condition and coral cover is poor but macroalgae results are very good (low cover). The number of juvenile corals is good but has declined in recent years.

The primary information sources on coral reef condition within the region are: Sweatman et al. (2011) - Long-term Reef Monitoring Project (LTRM) (Australian Institute of Marine Science (AIMS), 2012, which has occurred since 1985; and Sweatman et al, 2012) (AIMS); individual reports on local reefs available online; the first report card of the Reef Water Quality Protection Plan (Queensland Government, 2013); and the Great Barrier Reef Outlook Report 2009 (GBRMPA, 2009). It should be noted that The Outlook Report and Reef Plan report do not incorporate more recent information that includes recent storm and subsequent flooding events that will have impacted water quality.

"The major conclusion from the Long-Term Monitoring Program is that coral cover has undergone a wide range of changes, including dramatic increases and decreases on different reefs, and that there is no strong, consistent overall trend across the Great Barrier Reef…This is a reflection of the vast size of the ecosystem, the number and diversity of reef types, and the circumstances and events that affect them"
Outlook Report (2013; 14)

Although long-term data (i.e. greater than 20 years) are not available, there is some agreement from authors that there has been a general decline in coral cover (Bellwood et. al, 2004, Death et al, 2012) some by as much as 50%. However, other reports state that coral cover is stable (Osbourne et al, 2011), although a criticism of this study remarks that due to the depth at which the study was undertaken (6-9m) effects of flood plumes and coral bleaching may not be adequately considered as they tend to occur in shallower regions of the reef (Brodie, 2012). Indeed Brodie (2012) provide a comprehensive overview of the assessment of coral condition and the difficulty faced in coming to an absolute measure of coral health of the GBR.

In 1999, Van Woesik et al. found that inshore reefs close to river discharge had limited 'reef building' capacity and that this capacity had only recently been lost. They proposed that inshore reefs such as those at the mouth of the Proserpine River (e.g. Repulse Island fringing reefs) have 'switched off' as a result of increased nutrient and sediment load.

Cheal et al. (2001) also propose that patterns in reef development within the Northumberland Island are correlated with distance away from river discharge. Further, these authors recommend that reefs at South Percy, Pine and

Prudhoe Island are most suitable for monitoring studies because they are reef building, but lie on the limits of incipient reefs e.g. they may be more sensitive to disturbance.

The below tables represent a range of sites across the catchment and include inshore, mid shelf and outer shelf sites. These sites were selected to give an overview of the catchment trends (further information including data on all reefs from the AIMS LTMP can be found at http://www.data.aims.gov.au).

Fixed sites on NE flank	Current 10 year GBR		
	Year	Range	Mean
Hard Coral Cover in 2011	31%	28%	23%
Number of Fish Species	46	45	64

Table 3 Border Island Fringing Reef (surveyed for 16 years, last survey April 2013)

Fixed sites on NE flank	Current 10 year GBR		
	Year	Range	Mean
Hard Coral Cover in 2011	28%	33%	23%
Number of Fish Species	71	69	64

Table 4 Reef 19-138 mid-shelf lagoonal reef (surveyed for 23 years, last survey April 2013)

Fixed sites on NE flank	Current 10 year GBR		
	Year	Range	Mean
Hard Coral Cover in 2011	3%	15%	23%
Number of Fish Species	69	68	64

Table 5 Rebe Reef outer shelf planar reef (surveyed for 17 years, last survey April 2013)

There are active COTS outbreaks on 3 reefs adjacent to the catchment at present and an incipient outbreak on 1, while 19 have no outbreaks and 5 are recovering. On each of the reefs with current outbreaks hard coral cover is still in good condition and as they are mid-shelf reefs located well away from river mouths their ability to recover should be high.

Cyclone Hamish, a category 5 tropical cyclone that passed to the east of the region in March 2009, significantly damaged the outer shelf of the reef in the northern part of the catchment. According to Miller (2011) large areas of coral at Rebe Reef weighing tonnes were 'thrown onto the reef crest like so much gravel' demonstrating the damage caused by cyclonic activity.

Long term monitoring data describing reef fish communities is only available for some of the Whitsunday sector of the region. Generally populations of key indicator species have remained stable over 13 years of monitoring. On some reefs e.g. Border Island numbers of heavily targeted species such as coral trout (Plectropomus leopardus) and sweetlip/snapper (Lutjanidae) have decreased noticeably, although on some other reefs coral trout numbers have increased. A key tool in managing reef fish populations is through dedication of No Take Areas (NTA's). Within the region, the percentage of area of each reef bioregion within NTA's is relatively high but not always the 30% required for each bioregion (Bellwood, 2004). No take areas have been proven effective in recovering fish numbers (McCook et. al 2010).

REEF BIOREGION	% WITHIN NO TAKE AREAS (NTA'S)
RG2: Exposed mid shelf reefs	20.3
RHC: High continental islands (fringing reefs)	21.0
RHW: Strong tidal mid shelf reefs (west)	27.0
RA4: Strong tidal outer shelf reefs	31.8
RHL: Hard line reefs	21.4
RE4: Strong tidal inner mid shelf reefs	21.2
RK: Strong tidal mid shelf reefs	21.0
RE5: High tidal fringing reefs	30.2
RE6: Incipient reefs	40.0

Table 6 Percentage of No Take Areas (NTA's) over each reef bioregion.

Within the Whitsunday Islands sector of the region the level of damage from anchoring and swimmer/diver activity formed the impetus for a major investment in public mooring and fringing reef marker infrastructure. However, little such investment has been made within other areas of the region, and significant damage has been recorded from fringing reefs around the islands off Mackay (CREW, 2001). Nevertheless, the magnitude and distribution of current damage remains unclear.

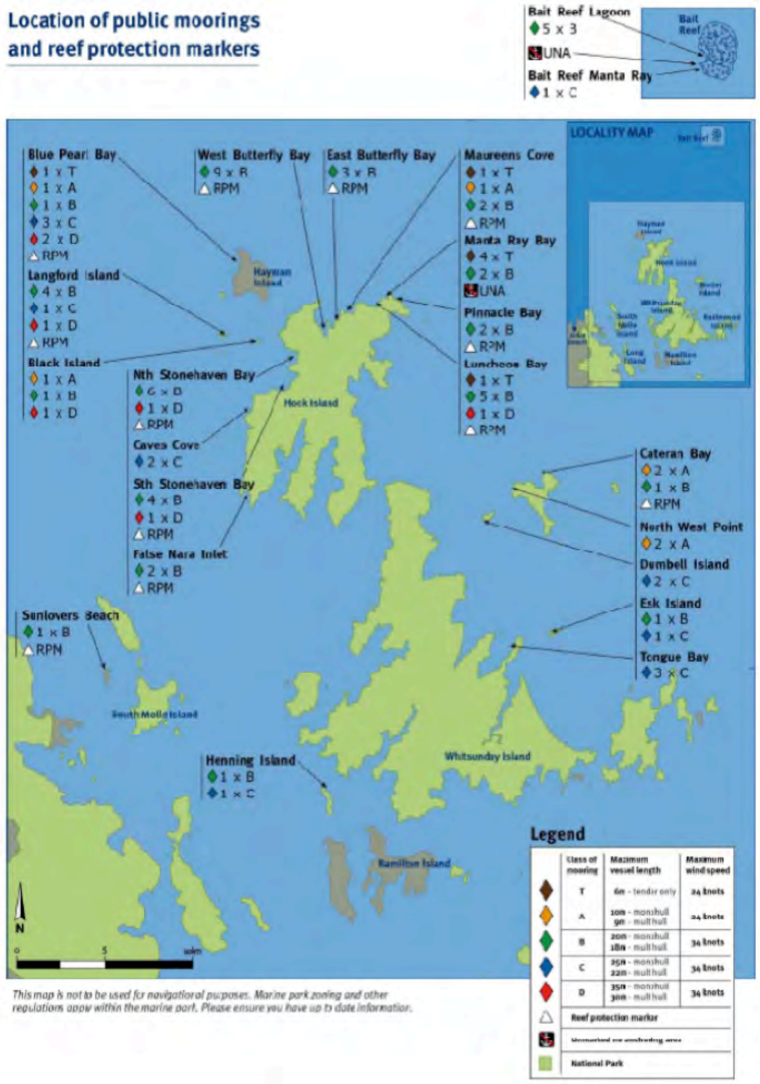


Figure 3 Reef protection infrastructure within the Whitsunday sector of the region

World Heritage Committee (WHC) and the International Union for the Conservation of Nature (IUCN) conducted a reactive monitoring mission in early 2012 that culminated in a report to the WHC (Douvere & Badman, 2012) co-authored by UNESCO and the International Union for the Conservation of Nature (IUCN). The conclusions of the report were that significant and positive steps towards effective management of the GBR had been undertaken by the state and federal governments to date including increasing no-take zones to 33% and the implementation of programs such as Reef Rescue to improve water quality. However, should the current impacts and proposed future development of coastal areas (in particular, coal ports and coal seam gas infrastructure) and greater measures not be taken to increase resilience of the reef to climate change continue, the GBR was on track to be included in the List of World Heritage in Danger under the World Heritage Convention.

In summary coral reef condition varies with time and coral cover is dynamic and driven by various factors. There is a great deal of information available on reef condition, much of it conflicting, but there is general agreement that coral cover reef wide has declined at least in the last 20 years particularly in inshore areas. Local reef specific data is available but is not an adequate reflection of the trend of coral generally within the region as the sites selected have not been monitored for long enough to show a reasonable trend (e.g. Penrith Island fringing reef has only been established for 3 years, Pompey 1 Reef for 4 years), or are poorly selected to adequately reflect the effects of changes in water quality within the catchment (e.g. inshore sites are located in the northern Whitsunday Islands aggregation and not adjacent to river mouths).

GOVERNANCE

Most of the GBR within the region lies within the Great Barrier Reef Marine Park (GBRMP) and is managed under the auspices of the Great Barrier Reef Marine Park Act 1975 and Regulations. The latest review of the Zoning Plan for this area was completed and gazetted in 2004. GBRMPA has management responsibility for the area in partnership with the Queensland Parks and Wildlife Service as set out in the Great Barrier Reef Intergovernmental Agreement. The agreement outlines the obligation of each party in managing the reef through the Field Management Program. The sections of the GBR which fall within Queensland State waters lies within the Great Barrier Reef Coast Marine Park (GBRCMP) which was formed, and is managed through the Queensland Marine Parks Act 2004 and Regulations. Rezoning of the GBRMP was mirrored within the GBRCMP in 2004. These marine parks combined form the Great Barrier Reef World Heritage Area for which Australia has international management obligations.

There are four Port areas within the region that are not part of either Marine Park; Abbot Point, Port of Bowen, Port of Mackay, and Hay Point/ Dalyrymple Bay. Coral reefs occur within the jurisdiction of the latter three areas.

Commercial and recreational fishing throughout the GBR is managed by the Queensland Department of Primary Industries and Fisheries under the Fisheries Act 1994. Management instruments notably include reef zoning, quotas, size and bag limits and seasonal closures. Compliance is undertaken by the Boating and Fisheries Patrol (DPIF), Marine Parks (QPWS) and the Queensland Water Police.

INDICATORS

Reef water quality is improved in line with the thresholds, indicators and mechanisms identified by the Mackay Whitsunday Isaac Water Quality Improvement Plan and the Water Quality Management Plan (in press) due for release in June 2014. The condition and resilience of offshore reefs will continue to be measured by the long term monitoring study (AIMS, 2013) using key indicators including coral cover and type, reef fish assemblages, presence of COTS, disease and bleaching.

Measurement of the condition and resilience of inshore reefs should be improved through the establishment of a monitoring project that assesses coral cover, coral diversity, (using growth form) and selected species of herbivorous fish (e.g. coral trout, sweet lip and other selected species that are considered good indicators of overall heath of coral colonies). This approach is desired as the current LTRM project does not have adequate coverage for the local area with monitoring sites locally in the northern Whitsunday Islands, well away from river mouths. Suggested sites for monitoring include those most influenced by outflows of the Pioneer River, the largest within the catchment, and could include, Flat Top, Keswick and Penrith Islands Derek Ball, Pers. Comm (2013).

COTS and/or other pressures continue to be monitored at key marine tourism settings using robust coral reef assessment techniques (AIMS, 2013).

Representative inshore reefs are assessed for condition using robust coral reef assessment techniques including assessment of anchor damage. Resilience of these reefs is increased by improved water quality, and reduction in unnecessary impacts such as anchor damage.

> "Fisheries catch data continue to demonstrate general sustainability of reef based fisheries with only one, the snapper (Pagrus auratus) considered overfished, however for many species the level to which they are fished sustainability is uncertain or not assessed"
>
> DEEDI, 2010; 5

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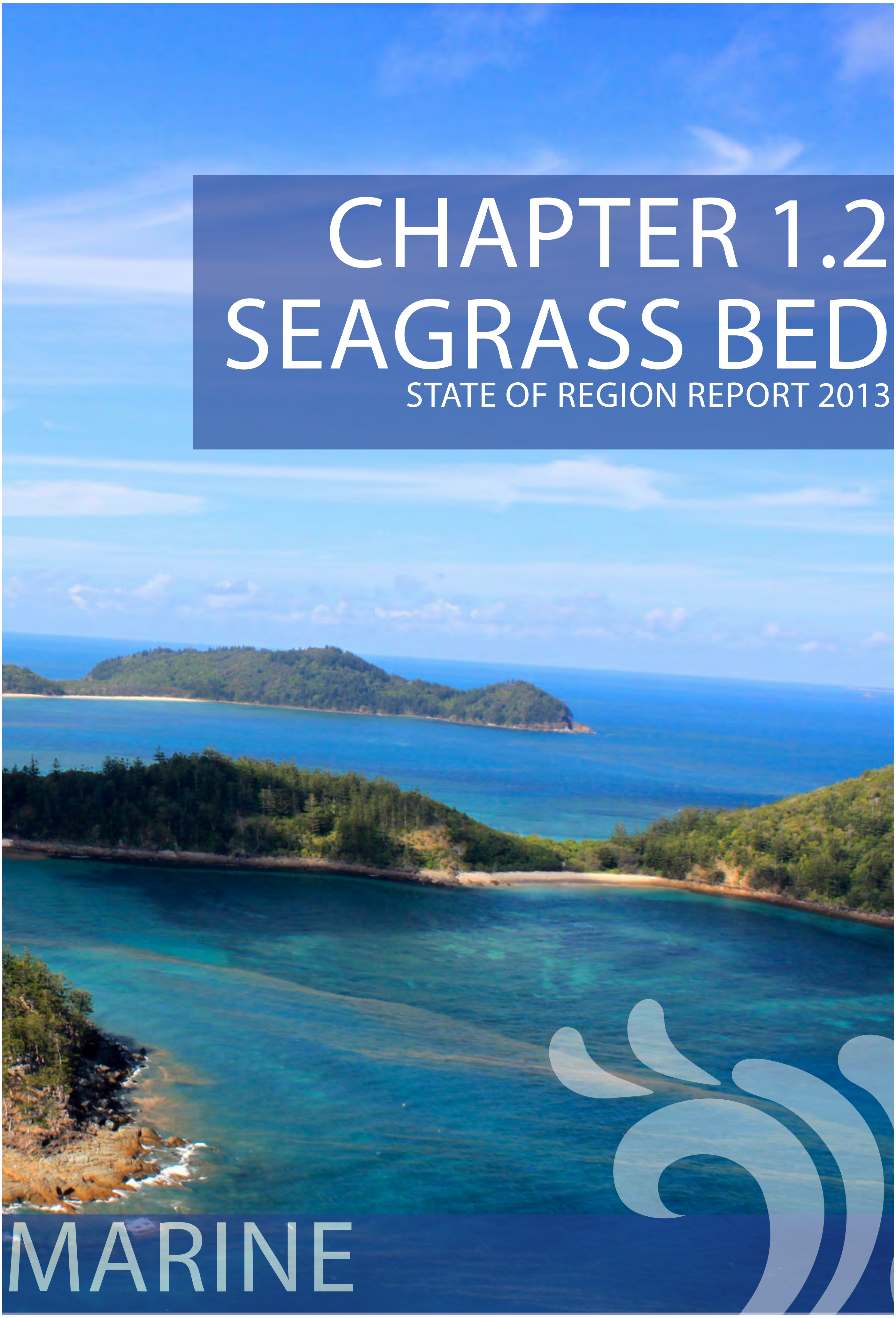
CHAPTER 1.2
SEAGRASS BED
STATE OF REGION REPORT 2013



MARINE

Seagrass Bed

REEF CATCHMENTS

SUMMARY

"Since the time of the dinosaurs, three groups of flowering plants (angiosperms) colonised the oceans. Known as 'seagrasses', they are the only flowering plants that can live underwater. More closely related to terrestrial lilies and gingers than to true grasses, they grow in sediment on the sea floor with erect, elongate leaves and a buried root-like structure (rhizome)"

Seagrass Watch (2013; n.d.)

Shallow seagrass beds cover approximately 13% or 6000 km² of the Great Barrier Reef World Heritage Area (Coles et al, 2003) and on an international scale, are at their most extensive and diverse in Australian waters (Connolly, 2012). Shallow sub tidal or intertidal seagrass beds occur along the entire length of the Mackay Whitsunday region (Map 2.1) with 14 species of seagrass recorded in this area (Coles et. al, 2007). Deep water habitats mainly occur in the northern part of the region in clear water lagoon areas associated with exposed mid shelf reefs and cover a further 40,000 square kilometres (Coles et al. 2003), though considerably less is known about these areas.

Seagrass beds change over time both in terms of cover and species composition. In intertidal areas between Bowen and Yeppoon, seagrass beds are dominated by Halodule spp. and Zostera spp. (GBRMPA, 2012) with a cover of between 10 and 50 % (GBRMPA, 2005). During surveys between 1984 and 1988, the Mackay Whitsunday Region was recorded as having 15,386 ha of seagrass beds, largely dominated by Halodule uninervis. Cover ranged widely but was generally high in Upstart Bay and around the Whitsunday Islands (Coles et al. 1987, 2001).

Dodds (2004) provides a synopsis of seagrass communities within the region. Within the Bowen area the most extensive seagrass beds are associated with Upstart Bay, while in Whitsunday 5,553 +/-1,182 ha of seagrass was found among 177 individual areas. Seagrass was found in water from 0.05m to 15m below mean sea level. The deeper sites (11-15m) were associated with clearer waters around the offshore islands, for example off Whitehaven Beach on the eastern side of Whitsunday Island. In more inshore areas habitat was limited to 11m in depth. The lowest diversity and abundance of seagrass was found in Repulse Bay, an area influenced by agricultural runoff. The first surveys conducted within the Mackay area identified 7,400 ha of seagrass of which 4,900 ha had a low cover and 2,500 ha a medium cover. Detailed surveys were conducted within the Newry Islands Dugong Protection Area in 1999 and these found 2,450 +/- 360 ha in winter and 2,451 +/- 345 ha in spring.

Interestingly, no seagrass was found in the Sand Bay Dugong Protection Area. Small seagrass beds were found associated with both Flat Top and Round Top Islands and also in deeper water (17.7 to 21.7m deep) offshore. Ince Bay supports extensive seagrass beds ranging from 1203.6 +/- 133.8ha in winter to 1572.8 +/- 187ha in spring). A total of 1880ha of seagrass was mapped in the Clairview area. Survey results clearly demonstrate the highly variable nature of seagrass beds.

Seagrass Bed

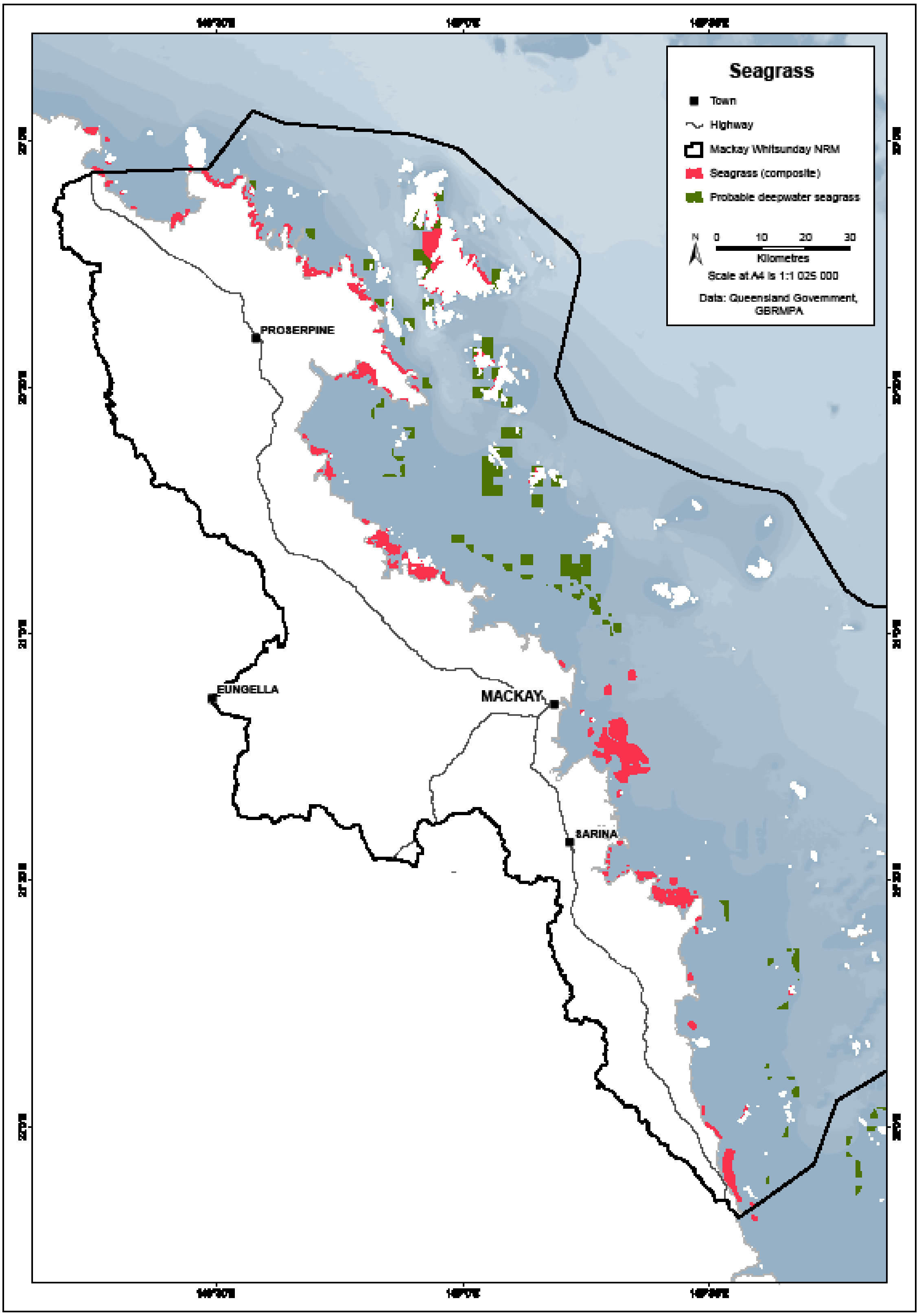


Figure 1 Extent of seagrass beds within the region compiled from all sources from 1984-2005

Biomass	Community	Mean Area May/ Oct 1999		May/ Oct 1999 % of study area	
Low	*Halophila ovalis*	8.8	0.3	<	< 1
Low	*Halophila decipiens* dominated	0.0	4.5	0	< 1
High	*Halophila spinulosa* dominated	2.9	4.4	< 1	< 1
Low	*Halophila tricosta* dominated	0.0	471.2	0	9
Low	*Halophila ovalis* and *Halodule uninervis*	6.41	122.74	< 1	2
Low	*Halophila* and *Halodule*	1694.3	1266.5	34	23
Low	*Halodule uninervis* (narrow)	1300.37	1440.6	26	27
Low	*Halodule uninervis* (wide)	14.2	25.01	< 1	< 1
Low	*Halodule uninervis* and *Halophila ovalis*	405	448.7	8	8
Low	*Halodule/ Halophila/ Cymodocera* mixed	650	0.0	13	0
Low	*Halodule/ Halophila/* Zostera *mixed*	48.5	106.6	1	2
High	*Zostera capricorni* dominated	0.9	204.6	< 1	4
Low	*Zostera capricorni* dominated	424.64	671.72	8	12
Low	*Zostera capricorni* and *Halodule uninervis* (narrow)	0.0	12.21	0	< 1
Low	*Zostera capricorni* and *Halodule ovalis*	0.0	17.3	0	< 1
Low	*Zostera/ Halophila/ Halodule/ Cymodocera* mixed	466.4	0.0	9	0
High	*Zostera/ Halophila/ Halodule/ Cymodocera* mixed	16.1	598.6	< 1	11
High	*Zostera/ Halophila/ Halodule* mixed	0.0	1.7	0	< 1
		5038.5	5396.7		

Table 1 Area and percentage area of 18 seagrass communities within the Region's Dugong Protection Zones.

During more detailed surveys, conducted within smaller areas of the region (Dugong Protection Areas) (Coles et al. 2001) seagrass beds were grouped into 18 communities (Table 2.1). There was considerable variation in distribution, extent, cover (biomass) and community composition (diversity) between winter and spring. The dominant seagrass community was Halodule uninervis and Halophila/ Halodule mixes. Comprehensive surveys such as these provide important baseline information on condition of key seagrass beds within the region, including expected seasonal change.

VALUES AND SERVICES

"Seagrasses have been ranked as one of the most ecologically and economically valuable biological systems on earth. They are widely referred to as "ecological engineers" because of their significant influence on their physical chemical and biological surroundings. They play an important role in:

- Regulating oxygen in the water column and sediments
- Regulating nutrient cycles
- Stabilising sediments
- Protecting shorelines through the restriction of water movements
- Providing an important food source for finfish, shellfish and mega-herbivores including green sea turtles and dugong.
- Providing habitat for microbes, invertebrates and vertebrates including commercially and recreationally important species, as well as crucial habitat for endangered species."

Marine Climate Change in Australia: Impacts and Adaptation Responses 2012 Report Card – Seagrass (extract) (Connolly, 2012; 178).

Habitat

Shallow seagrass beds cover approximately 13% or 6000 km^2 of the Great Barrier Reef World Heritage Area (Coles et al, 2003) and on an international scale, are at their most extensive and diverse in Australian waters (Connolly, 2012). Shallow sub tidal or intertidal seagrass beds occur along the entire length of the Mackay Whitsunday region (Map 2.1) with 14 species of seagrass recorded in this area (Coles et. al, 2007). Deep water habitats mainly occur in the northern part of the region in clear water lagoon areas associated with exposed mid shelf reefs and cover a further 40,000 square kilometres (Coles et al. 2003), though considerably less is known about these areas.

Seagrass beds change over time both in terms of cover and species composition. In intertidal areas between Bowen and Yeppoon, seagrass beds are dominated by Halodule spp. and Zostera spp. (GBRMPA, 2012) with a cover of between 10 and 50 % (GBRMPA, 2005). During surveys between 1984 and 1988, the Mackay Whitsunday Region was recorded as having 15,386 ha of seagrass beds, largely dominated by Halodule uninervis. Cover ranged widely but was generally high in Upstart Bay and around the Whitsunday Islands (Coles et al. 1987, 2001).

Both dugong and green turtles have highly significant cultural value to Indigenous Australians.

Seagrass beds are important fish nursery habitat, particularly for penaeid prawns and fish (Coles, 1992; Watson et al., 1993, Coles et al, 2004, Zeller et. al, 2012) that support the fishing industry. They also form the basis of an important detritus based food chain, which is in turn, the basis of a number of commercial and recreational fisheries (Dodds, 2004).

The availability of seagrass habitat could also affect giant mud crab (Scylla serrate, S. olivacea) numbers. Juvenille giant mud crabs are known to prefer to settle on sea grass rather than other benthic substrates and as such a reduction in seagrass habitat availability could reduce the population Grubert et. al (2012).

Ecosystem Services

Seagrass beds assist in maintaining coastal water quality by assimilating nutrients and stabilising sediments (Dodds, 2004, Coles et al, 2004). Tropical seagrasses are important in their interactions with mangroves and coral reefs. All these systems exert a stabilizing effect on the environment, resulting in important physical and biological support for the other communities. Seagrasses also trap sediment and slow water movement, causing suspended sediment to fall out, benefiting the coral by reducing sediment loads in the water.

The role of seagrass in mitigating climate change impacts is an emerging area of study. Seagrass, along with mangroves and salt marshes, are well known as highly efficient carbon sinks (Chmura et al. 2003; Duarte et al. 2005; Bouillon et al. 2008; Lo Iacono et al. 2008; Duarte et al. 2010; Kennedy et al. 2010) and are collectively referred to as 'Blue Carbon' (McLeod et al, 2011).

In a study of published reports Unsworth et. al (2012) suggest that seagrass may play a role in maintaining reef calcifiers (including corals and shellfish) that act as a carbon sink. Local variations in bathymetry and water residence time mean that the study implications are more relevant at a local scale and where seagrass meadows occur upstream of reef calicifiers.

Globally it has been estimated that seagrass may sequester as much as 15% of the oceans' carbon. The rate of long-term carbon storage in some seagrass species exceeds many terrestrial ecosystems, commensurate with wetlands (Kennedy & Bjork, 2009), and is made possible by the fact that seagrass communities do not become saturated with carbon (as do terrestrial ecosystems) as they accumulate sediment over time (McLeod et al, 2011, Bos et al, 2007).

Economic Value

The economic value of seagrasss beds is difficult to estimate because the links between particular species within the fisheries, and their use of seagrass resources, has not been completely clarified (Watson et al., 1993; FRDC, 2000). However, there are clear ecological links between seagrass and commercial prawn species. Dodds (2004) reports that during 2000, the prawn harvest within the region was over 400 tonnes, and produced revenue in excess of 7 million dollars.

In 2009-2010 Queensland caught 12,268 tonnes of prawns, nearly double all other states combined and over 45% of the total Australian catch. In total, the value of this catch was $31 million in 2009-10 – nearly a four fold increase on it's average value between 1989 and 2000. (ABS, 2012).

The commercial value of the crab catch for Queensland in 2009-10 was 28.5 million dollars, more than half the total Australian value (ABS, 2012).

PRESSURES AND THREATS

"There are many threatening human activities to seagrasses including direct threats such as land reclamation and chemical spills as well as diffuse threats such as water quality and the influence of climate variability. In the Indo-Pacific conservation activity is focused on coral reefs, with little conservation and emphasis and placed on interconnectivity with other marine environments such as seagrasses." Coles, et al (2011; 225)

The GBRMPA (2012) define the major pressures affecting seagrass communities in the GBR as:

- Poor water quality from catchment runoff (agricultural and urban/industrial).
- Habitat loss and modification from increasing coastal development
- Expansion in ports and shipping
- Increased intensity of storms, floods and cyclones
- Sea surface temperature and sea level rise.

In extreme conditions such as those that occur during flood events, seagrasses can be smothered by sediment, impacted by high nutrients and chemical loads or killed by a lack of light available in the turbid water. The value of seagrass in relation to other marine ecosystems in maintaining coastal water quality is a role that depends on the ability of seagrass to adapt to impacts, in particular climate change.

"Dugongs are also under threat from diminishing food sources. Seagrass meadows are being detrimentally affected by pollution (pollutants can include herbicide runoff, sewage, detergents, heavy metals, hypersaline water from desalination plants, and other waste products), algal blooms, high boat traffic and turbid waters. Today, dugongs need to rely on smaller seagrass meadows for food and habitat. When the seagrass habitat becomes unsuitable for foraging, dugong populations are displaced and placed under greater threat" DEHP, 2013a; web page.

In addition to the information provided by GBRMPA above, specific pollutants such as heavy metals, herbicides, and polycyclic aromatic hydrocarbons (residue from burning fuels) are also considered an issue (Schaffelke, 2001). These are derived primarily from urban and river runoff. Sewerage and aquaculture effluent discharges contribute a relatively minor amount of nutrients. However, they can have significant localised impacts (GBRMPA, 2012). This is particularly the case when discharges are made into estuaries during low, or no flow periods. Cyclonic flood plumes can significantly reduce water salinity in coastal areas, and can deposit large amounts of fine sediments over seagrass beds (Schaffelke, 2001).

Physical damage can be done to seagrass beds by trawling, although this is typically avoided by fishermen as it is counter-productive to fishing efforts when nets become clogged and inoperable (GBRMPA, 2005). In addition, the great majority of seagrass beds are now closed to trawling under zoning arrangements.

When seagrasses are subjected to temperatures outside of their tolerance, they can undergo 'burning' with subsequent degradation of the beds (Campbell et al., 2006). In this respect, warming of coastal waters as a result of climate change is now a significant concern.

Locally, Abbot Point (as well as Mourilyan near Innisfail) differs from other Queensland regions defined as the states most at risk seagrass locations due to its high distance from a major urban centre. The other locations include Gladstone, Townsville/Cleveland Bay, and Cairns/Trinity Inlet caused by cumulative impacts. The GBRMPA however acknowledge that local scale non-cumulative impacts may be significant in some areas (GBRMPA, 2012).

> "At the scale of the Great Barrier Reef, the most significant response to improve the resilience for seagrass meadows is to improve water quality. Therefore the most important action is to continue to implement the joint Australian and Queensland Government's Reef Water Quality Protection Plan to reduce pollutants released to receiving waters from diffuse sources. Actions to improve waterway stability, riparian and wetland condition and the maintenance of environmental flows are critical" GBRMPA, 2012; 3

CONDITION AND TRENDS

Condition of seagrass beds can be assessed and described by their distribution, extent, cover and species diversity. However, the nature of these communities is that they are highly variable in all these respects and as such, determining condition requires an understanding of their long-term dynamics. This view was supported by the Great Barrier Reef Outlook Report, released in 2009 that stated that although seagrass communities were affected by runoff from catchments, they mainly appeared to fluctuate due to natural cycles of decline and recovery. However since 2009, severe flooding and cyclonic activity have had a significant impact on seagrass communities.

The Great Barrier Reef 2011 Report Card (Queensland and Australian Governments, 2013) reports on the condition of seagrass meadows within the region in its summary for the Mackay Whitsunday area comparable to the 2009 baseline. In the baseline report the reproductive capacity of seagrass was considered very poor and the nutrient status and abundance poor. Results to the current year (2013) are unavailable. The level of abundance of seagrass was moderate and in decline in some areas (Queensland Government, 2009).

> "Inshore seagrass meadows along the developed Great Barrier Reef coast (i.e. south of Cooktown) have declined over the past three to five years and are in poor condition." Brodie et. al, 2013;3

STATE OF REGION REPORT

Seagrass Bed

REEF CATCHMENTS

The 2011 report card reflects the effects of the severe weather events during the period 2009–2011. These impacts fall on seagrass ecosystems that are already stressed following extended periods of cloud cover, limiting available periods of growth, as well as major freshwater inflow from flooding on a massive scale (GBRMPA, 2012). The reduction in reproductive capacity raises concerns about the regions seagrasses resilience to disturbance (Queensland Government, 2011) given they are sensitive to increased temperatures and extreme weather events (GBRMPA, 2009), which are forecast to increase in climate change scenarios (IPCC, 2007).

> "Inshore seagrass meadows remained in poor condition, having progressively declined since 2005-2006. This reflects long-term declines in abundance and reproductive effort, which is a concern in terms of capacity of local seagrass meadows to recover from disturbances. The nutrient status of seagrass tissue was rated as poor and reflected local water quality, particularly high concentrations of nitrogen" Queensland Government, 2013; 1

Increased levels of nitrogen have been observed in seagrass leaf tissue since 2005, which has resulted in an increase in epiphytes (suspended plants) growing on the leaves, reducing the light available to the seagrass to photosynthesise. This may be due to increased nutrient supply in the water.

The risk to seagrass communities and corals from different pollutants was reviewed through a risk assessment conducted as part of the Reef Plan 2013. The risk assessment investigated the relative risk of nitrogen, sediments and pesticides to catchment regions including the Mackay Whitsundays. The results of the assessment (Fig X) can be seen below.

Region	Overall relative risk	Priority pollutants for management		
		Nitrogen	Pesticides	Sediment
Cape York	LOW			
Wet Tropics	VERY HIGH			
Burdekin	HIGH	*		
Mackay Whitsunday	MODERATE			
Fitzroy	HIGH			
Burnett Mary	UNCERTAIN**			

* Lower Burdekin and Haughton focus
** Most reefs and seagrass meadows in this region were not included formally in the analysis and therefore the validity of the result has high uncertainty.

Table 2 Risk Assessment for Priority Pollutants for Management (Queensland Government, 2013)

As at 2013, the Mackay Whitsunday region is considered a 'Moderate' overall risk, however improvements in water quality from other pollutants and continued improvement against general water quality targets will still be required to assist seagrass communities within the local area to recover from recent flood and storm activity and remain resistant to climate change. A priority for the region will be reducing the risk of, in particular, pesticides (very high risk) and nitrogen (high risk) to seagrass and the marine environment in general.

However, the effects of land based pollution are not the only threat to seagrass communities. There are four port areas within the region; Abbot Point, Port of Bowen, Port of Mackay, and Hay Point/Dalrymple Bay. Seagrass is found both within and around port areas. Current and future expansion of these ports has and will continue to affect seagrass communities both within the ports jurisdiction and in the surrounding Marine Park through dredging, both within the construction phase and through on-going channel clearing. The effects of dredging (smothering from sediments and other decreases in water quality) compound the effects of poor water quality of terrestrial origin, increased urban expansion and climate change.

Despite the challenges faced by seagrass communities within the local area, on a reef-wide scale the Mackay Whitsunday region is under only moderate relative risk overall from priority pollutants. This level of risk is second only to the remote Cape York region.

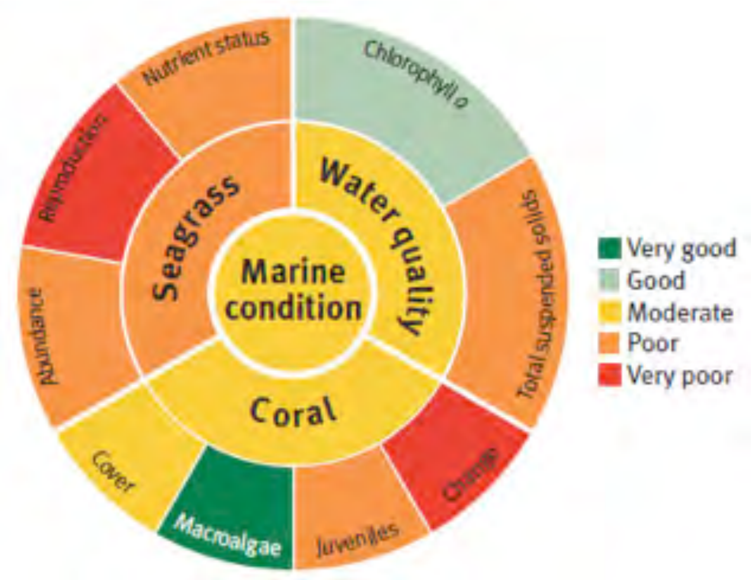


Figure 2 According to the second Reef Report Card (2010), overall condition of seagrass remains poor

Seagrass communities are known to fluctuate with natural cycles. Providing continued improvement in the management of pollutants, particularly pesticides, and continued uptake of Reef Plan activities the seagrasses of the region should be in a relatively good position to recover from their recent decline.

Long-term however climate change will continue to impact seagrass communities, primarily through rising seawater temperatures, changes in the East Australian Current and cyclone and storm activity moving further south and becoming more intense. The effects of climate change at a local scale are more poorly known.

"Improving water quality will also build resilience in inshore coastal and seagrass areas which support significant biodiversity such as turtles and dugongs, and drive fisheries productivity." Reef Water Quality Protection Plan, 2013. Queensland Government (2013;7)

GOVERNANCE

By area the great majority of seagrass beds within the region lie within the Great Barrier Reef Marine Park or the Great Barrier Reef Coast Marine Park. These areas lie under the jurisdiction of the Great Barrier Reef Marine Park Authority and/ or the Queensland Parks and Wildlife Service. The Queensland Department of Agriculture, Fisheries and Forestry (DAFF) enforce statutory provisions related to protection of marine plants, net fishing within Dugong Protection Areas, and the use of turtle excluding devices within the East Coast Otter Trawl Fishery. That organisation also administers the shark control program adjacent to some swimming beaches in the region.

Recently, research activities related to seagrass have been transferred from DAFF to James Cook University's Tropical Water and Aquatic Ecosystem Research (TropWATER) facility in Townsville.

The four port areas within the region that are not part of either Marine Park. These come under the jurisdiction of the various port authorities. Seagrass beds occur within the jurisdiction of these Ports although the geographical size of these is very small relative to areas within marine parks, however as discussed earlier their impact can be felt more broadly.

INDICATORS

Seagrass beds are distributed over very large areas, often in turbid coastal waters. Sometimes it is possible to accurately map these areas by aerial surveys using helicopters. However, other surveys rely on estimating actual distribution by sampling smaller areas (usually by divers) and then making broader assumptions based on these results. As this technique can only estimate the true distribution, ecologists use statistical analysis to 'estimate' the accuracy of the survey results. Thus the results of these figures are often given as the estimate +/- the likely error; e.g. 1234 +/- 234ha.

Suitable methods for surveying and monitoring of seagrass are available. The important indicators

are distribution, extent, cover and diversity. Depth range of seagrass beds is also useful as this allows development of a relationship between condition and water turbidity. The later is related to water quality, particularly near river mouths and smaller point sources of sediments and nutrients.

Aerial survey techniques have been developed and refined and can be used to gain reliable estimates of dugong numbers. However, such survey methods are less robust in areas of smaller population numbers.

Water quality targets for the next five years align with or exceed those in the Reef Catchments Water Quality Improvement Plan (in prep.) and contribute to the Reef-wide goal of Reef Plan by ensuring that by 2020 the quality of water entering the Great Barrier Reef has no detrimental effect on it's heath and resilience.

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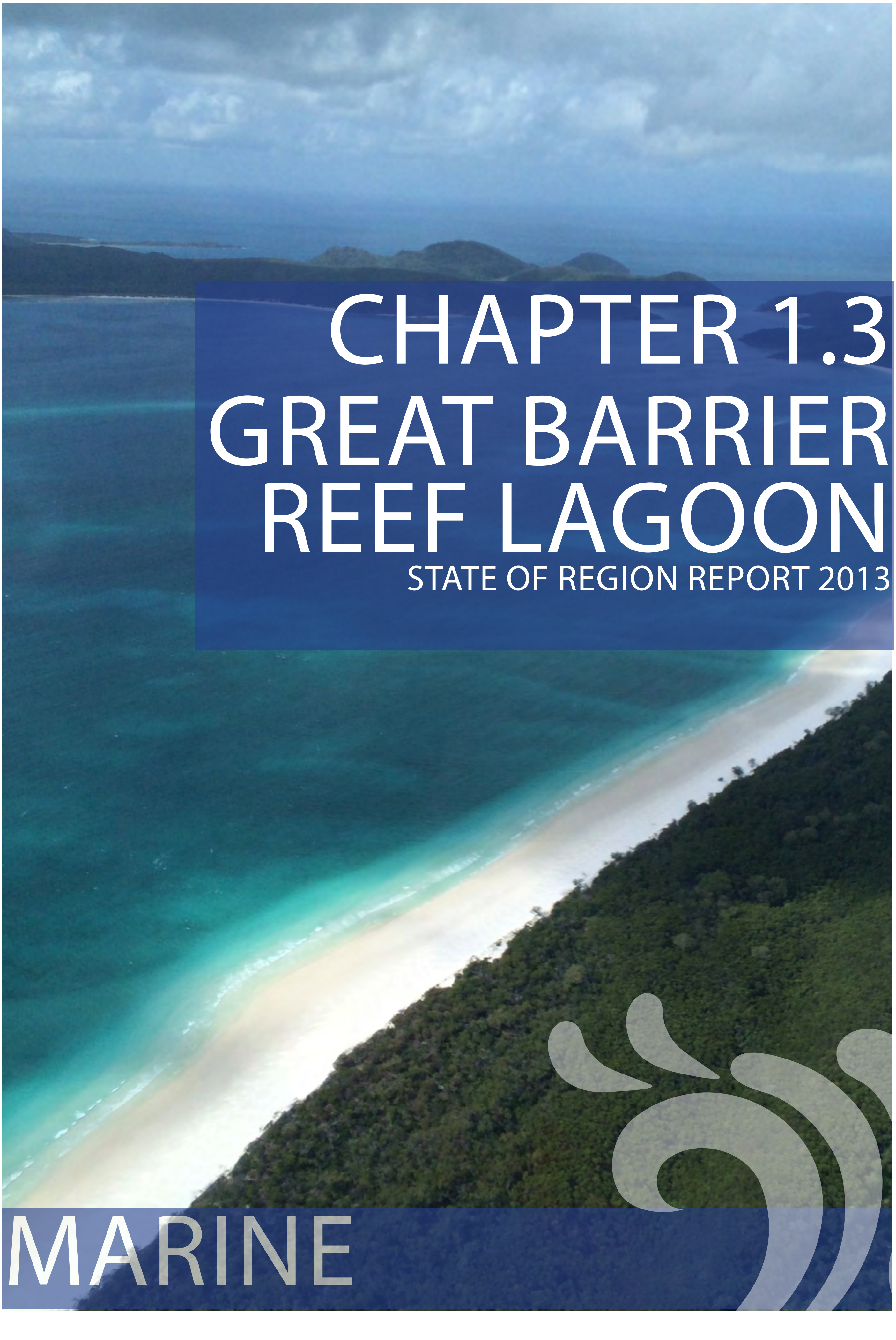

CHAPTER 1.3
GREAT BARRIER REEF LAGOON

STATE OF REGION REPORT 2013

MARINE

REEF CATCHMENTS

SUMMARY

The Great Barrier Reef lagoon consists of shallow coastal sea between the mainland and outer reefs, and the area separating individual reefs. Within the region there are extensive areas of shallow lagoon (< 20m deep) and a broad, deeper, offshore shelf. On the seaward edge of the GBR the continental shelf ends and the deeper waters of the Coral Sea begin. Within the Mackay Whitsunday Region, extensive reef development forms a barrier along the edge of the continental shelf (approximately 90% by area). This situation restricts water exchange between the lagoon and the Coral Sea to a few narrow passages (Furnas, 2003). Water circulation patterns within the lagoon are influenced by sub-surface circulation patterns, tides and wind. The East Australian Current broadly flows south at up to 48km per day within open waters of the central GBR (Furnas, 2003).

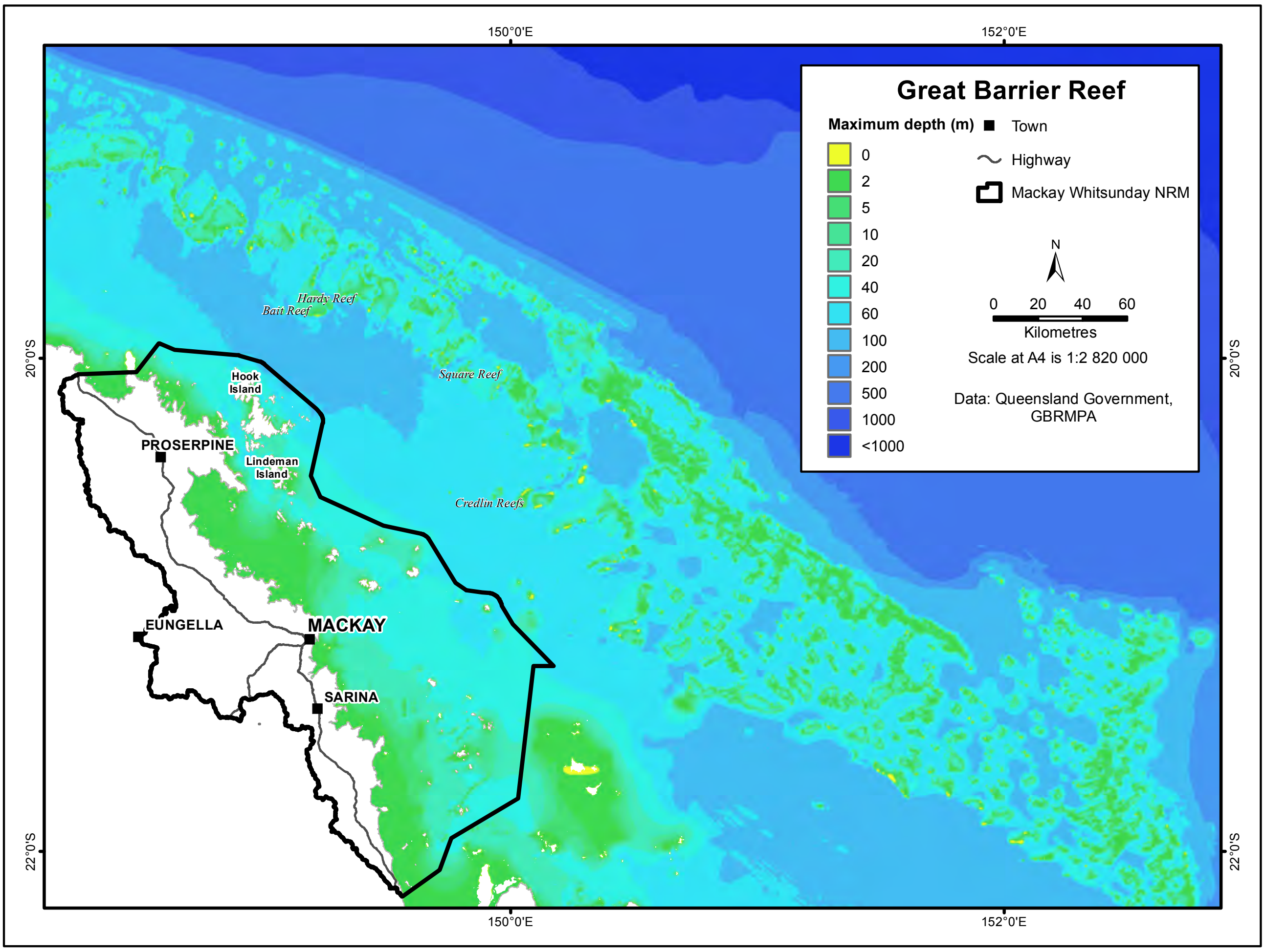

Figure 1 Great Barrier Reef Lagoon bathymetry

The region experiences some of the largest tidal ranges along the Queensland coast from about +/- 4m in the north to +/- 7m towards Broadsound. Generally, flooding (e.g. rising) tides produce southward flowing current, and ebb tides produce a northerly current. In addition, some cross shelf affects are evident. Superimposed on these diurnal tidal currents are surface and shallow currents produced by prevailing winds, typically from the south-east trade winds. Surface currents produced by these winds are an important consideration as they largely dictate transport of river discharges along the coast. In addition, they are responsible for long-shore transport of sediments along the coast (assisted by re-suspension of sediments by wave action). Long-shore transport is responsible for movement of in excess of 35,000 m_3 of sediment per annum along the coast with consequences for beach erosion and/or accretion (EPA, 2004).

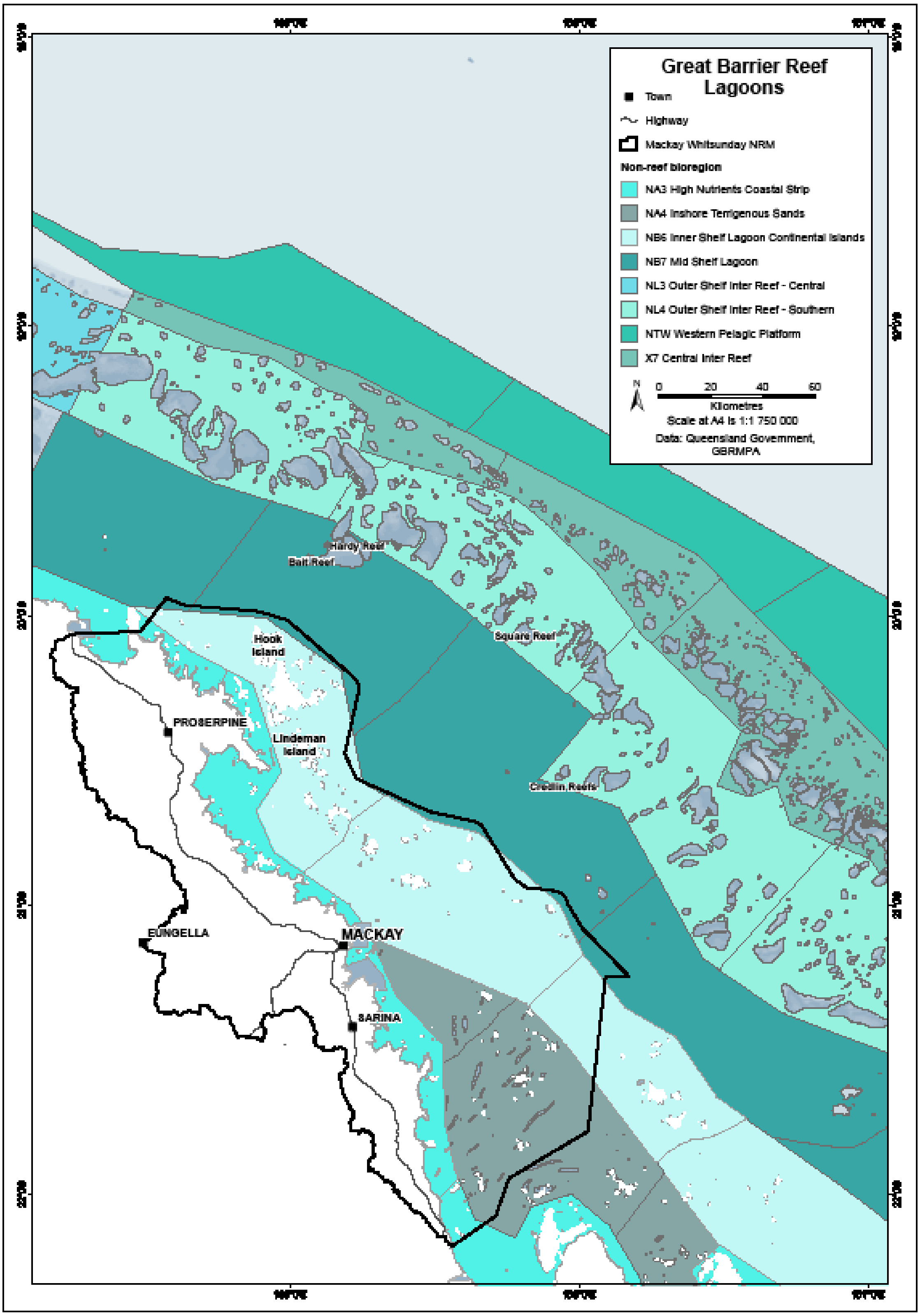

Figure 2 Non Reef Bioregions of the MWI GBR Lagoon area

Ecologically, the lagoon area within the Mackay Whitsunday Region is biodiverse, containing 7 (18%) of the 40 non-reef Bioregions found within the broader GBR region (Figure 2 and Table 1).

NON-REEF BIOREGION	BRIEF DESCRIPTION
NA3: High Nutrient Coastal Strip	The bioregion lies along the Queensland coast, varying in width. Water depth is generally < 20m and the region is highly influenced by nutrient outfall from the coast. Sheltered areas supports seagrass beds which in turn form habitat for marine turtles and dugong.
NA4: Inshore Terrigenous sands	A broad fan commencing in Broadsound and extending north to about the Pioneer River and east across Shoalwater Bay. Sediments on the seafloor are largely composed of terrestrially derived sands which are very mobile and tend not to support seagrass or algae.
NB6: Inner shelf lagoon Continental Islands	This bioregion lies directly to the east of the above near-shore regions, from Gloucester Island, through to the Whitsunday, Northumberland and Percy Islands. Some areas support hydroids and gorgonians.
NB7: Mid shelf lagoon	The mid-shelf lagoon lies between the island groups and the beginning of outer reef development. The bioregion is largely devoid of reef development. Sediments (sands) are influenced by the East Australian Current.
NL4: Outer shelf inter reef platform	The Outer Shelf includes lagoon areas interspersed among the major development of outer reefs along most of the offshore edge of the continental shelf.
X7: Central Inner Reef	This bioregion includes lagoon areas outside of the major development of the outer reef but includes lagoon areas around and interspersed among the Hardline Roofs.
NTW: Western pelagic platform	The Western Pelagic Platform overlies the transition zone between Continental Shelf and Slope waters and the Coral Sea.

Table 1 Non-reef bioregions represented within the Mackay Whitsunday Region.

VALUES AND SERVICES

Ecosystem Services

Collectively the oceans surrounding Australia are invaluable in the ecosystem services they provide. A report by the Centre for Policy Development (2011) concluded that Australia's oceans contribute around $25 billion per year to the economy through ecosystems services alone, in addition to the economic data, and calls to raise the profile of the marine sector in policy and investment decisions. This is considered critical in capturing the wealth from our oceans.

CPD (2011) also outlined that Australia's oceans provide, 'free of charge':

o $15.8 billion in carbon storage

o $6.2 billion a year in fish nursery services and pest and disease control – essential to sustain the commercial and recreational fishing industries and

o $1.85 billion a year in fish and recreation services.

Habitat

The sheltered waters of the GBR lagoon are an important calving area for humpback whales (Megaptera novaeangliae). The whales that utilize this area are from a distinct southern population known as Group V (Vang, 2002). Due to commercial whaling, the size of this population declined dramatically and remained very low until approximately 1985, when some recovery began (Figure 3.3). Although numbers remain low compared to the original population size, steady increases are apparent (Vang, 2002). The Whitsunday area represents the southern limit of the main calving grounds (Chaloupka and Osmond, 1999) and it appears that only mother - calf pairs remain in the area for any length of time during this period.

"Humpback whales come from Antarctic waters to the Great Barrier Reef World Heritage Area from May to September to calve and to build up strength over the winter before they return to the Antarctic in summer. Because of their status, and the fact that Great Barrier Reef World Heritage Area waters are nursery areas, the Great Barrier Reef Marine Park Authority (GBRMPA) is committed to ensuring that all whales are able to use the Great Barrier Reef waters without being pressured by human interference."

Whales and Dolphins, GBRMPA (n.d.)

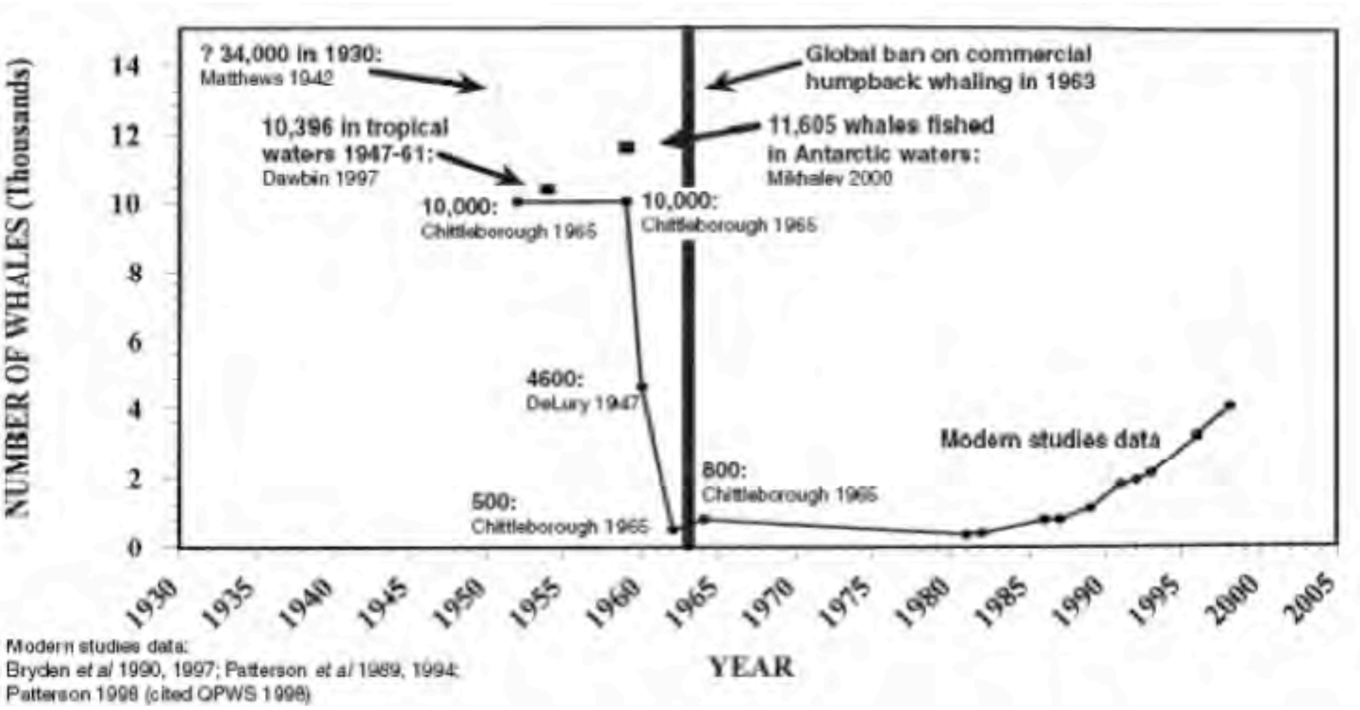

Figure 3 Summary of estimated population size of Group 5 humpback whales (reproduced from Vang, 2002).

Within the Townsville-Whitsunday and Mackay-Capricorn sections of the GBRMP, 21 commercial whale watching permits have been issued (GBRMPA, 2007). However, numerous other marine tourism operators opportunistically use the presence of humpback whales as an attraction. The two primary whale watching centres within the GBR (Cairns and the Whitsunday) provide for more than 40,000 whale watchers per annum creating a direct revenue of $3.25 million and a total contribution to the economy which is in the order of $12.9 million (Schaffar & Garrigue 2003).

Both Indo-Pacific humpback dolphins (Sousa chinensis) and the Australian snub-fin dolphin (Orcaella heinsohni) are present within the region. The latter species has only recently been discovered (Beasley, et al. 2005) and is considered threatened. Although these species are typically inhabitants of inshore areas, little is known of their population sizes, structure or distribution within the region.

Recreation

Recreational boating and fishing are popular pastimes with 19,303 vessels registered in the combined Mackay and Whitsunday local government areas in March 2013, or more than 20% of the vessels registered for the whole GBR (GBRMPA, 2011).

While the Mackay region has the lowest number of registered vessel in Queensland, anecdotal evidence suggests that the population increase will in turn enhance the recreational fishery of the local area, particularly the southern half of the catchment around Mackay region (Ball and Adams, 2010) and in the far north in line with the 'opening-up' of the Bowen Basin. As the resource sector has a large number of shift workers, the pressure placed on fisheries is spread throughout the week rather than confined to the traditional weekend (Ball and Adams, 2010). This has a two-pronged impact: there are more people fishing and the opportunity to take advantage of good weather windows may increase this activity in certain locations.

Economy

The AIMS Index of the Marine Industry (2012) highlights the important role Australia oceans play in livelihoods, the economy and environment. In 2009-10 Marine Based Industries contributed more than $42 billion to the Australian Economy, more than the agricultural sector.

The Australian economy obtains great benefit from the commercial fishing and recreational use of the GBR. According to GBRMPA (2010) commercial fishing reaped 139 million in 2006/2007 and recreational use (including recreational fishing,) 153 million.

As a proportion of the state total the GBR also supports:

- 95% of Queenslands reef line fishery,
- 60% of the trawl fishery,
- 40% of the net fishery and
- 40% of recreational fish.

Key commercial fisheries within the lagoon include pelagic fish (mackerel and shark), scallops and bugs. In 2000 catch from these fisheries attracted revenue of about $2 million (Dodds, 2004). However recreational fisheries which target pelagic fish, particularly prized species such as Spanish mackerel, are likely to be worth considerably more. For example the fishing charter industry alone, within the Mackay and Airlie Beach centres, have been estimated as attracting approximately $5 million per annum (Fenton and Marshall, 2001).

The region supports Australia's largest group of charter boat operators, with an annual turnover in excess of $100 million (Anon, 2006).

There are two major ports within the region, Hay Point and Mackay, with Abbot Point lying just outside of the northern catchment boundary, in addition to Bowen Harbour which hosts a major commercial fishing fleet. Hay Point which consists of Dalyrymple Bay Coal Terminal and Hay Point Coal Terminal and is the largest coal export port in the world with a output of nearly 90 million tonnes exported via 900 bulk carriers in 2012.

PRESSURES

Pests

Similar to terrestrial and freshwater areas, exotic pests invade marine ecosystems. Several such invasions have resulted in significant environmental and economic costs in Australia, such as the Northern Pacific seastar (Asterias amurensis) in Tasmania and Port Philip Bay; and the Black striped mussel (Mytilopsis sallei) in Darwin Harbour (NIMPIS, 2007). Introduction of exotic pests can occur through ship fouling and by release of ballast waters (Sliwa et al. 2006). However, species may also modify their range due to changing environmental conditions including temperature gradients or through changing current climate regimes (CSIRO, 2007).

"The economic cost of aquatic exotic species is significant. Pimental et al. (2000) estimated conservative economic costs attributable to exotic fishes in the United States at US$1 billion annually. 1993 estimates put damage caused by and control of zebra mussel (Dreissena polymorpha), Asiatic clam (Corbicula fluminea) and the European green crab (Carcinus maenas) at US$4.4 billion annually, while purple loosestrife cost US$45 million annually and aquatic weed control cost US$110 million annually"

(Hall and Mills 2000)" McEnnulty et al (2005)

Water Quality

Decline in the quality of water runoff into the GBR lagoon is documented as a major threatening process for marine ecosystems both as a direct impact and as one which lowers the resilience of ecosystems to climate change.

The Scientific Consensus Statement (Brodie et al. 2013) was developed to support the Reef Water Quality Protection Plan 2013 (Reef Plan), which aims to review and synthesise the significant advances in scientific knowledge of water quality issues in the Great Barrier Reef and to reach consensus on the current understanding of the system. According to this, from a combined assessment of relative risk of water quality variables in the Great Barrier Reef (using the total area of habitat affected in the areas identified to be of highest relative risk) and end-of-catchment anthropogenic loads of nutrients, sediments and photosystem II inhibiting herbicides, the regional ranking of water quality risk to coral reefs is (from highest risk to lowest): Wet Tropics; Fitzroy; Mackay Whitsunday; Burdekin; Cape York; Burnett Mary.

Priority areas for managing degraded water quality in the Great Barrier Reef are Wet Tropics for nitrogen management; Mackay Whitsunday and the lower Burdekin for photosystem II inhibiting herbicide management; and Burdekin and Fitzroy for suspended sediment management.

Of equal importance is the risk to seagrass from suspended sediments discharged from rivers in excess of natural erosion rates, especially the fine fractions (clays). Whether carried in flood plumes, or re-suspended by waves, suspended solids create a turbid water column that reduces the light available to seagrass and corals. High turbidity affects approximately 200 inshore reefs and most seagrass areas. Seagrass loss severely impacts green turtle and dugong populations (Brodie et al. 2013).

At smaller scales, particularly in coastal seagrass habitats and freshwater and estuarine wetlands, pesticides can pose a high risk. Concentrations of a range of pesticides exceed water quality guidelines in many fresh and estuarine water bodies downstream of cropping lands. Based on a risk assessment of the six commonly used photosystem II inhibiting herbicides, the Mackay Whitsunday and Burdekin regions are considered to be at highest risk, followed by the Wet Tropics, Fitzroy and Burnett Mary regions. Importantly in the Mackay Whitsunday region, 40 per cent of the seagrass area is in the highest relative risk class compared to less than 10 per cent for all other regions (Brodie et al. 2013).

"The overarching consensus is that key Great Barrier Reef ecosystems are showing declining trends in condition due to continuing poor water quality, cumulative impacts of climate change and increasing intensity of extreme events. The evidence base is synthesised in a series of five supporting chapters and the following conclusions are based on those detailed reviews:

1. The decline of marine water quality associated with terrestrial runoff from the adjacent catchments is a major cause of the current poor state of many of the key marine ecosystems of the Great Barrier Reef.
2. The greatest water quality risks to the Great Barrier Reef are from nitrogen discharge, associated with crown-of-thorns starfish outbreaks and their destructive effects on coral reefs, and fine sediment discharge which reduces the light available to seagrass ecosystems and inshore coral reefs. Pesticides pose a risk to freshwater and some inshore and coastal habitats.
3. Recent extreme weather—heavy rainfall, floods and tropical cyclones—have severely impacted marine water quality and Great Barrier Reef ecosystems. Climate change is predicted to increase the intensity of extreme weather events.
4. The main source of excess nutrients, fine sediments and pesticides from Great Barrier Reef catchments is diffuse source pollution from agriculture.
5. Improved land and agricultural management practices are proven to reduce the runoff of suspended sediment, nutrients and pesticides at the paddock scale." Scientific Consensus Statement, Brodie et al. (2013; 1)

Pollutants can directly affect dugong in a number of ways. Hormonal impacts can be caused by a range of contaminants known to act as endocrine disruptors, in particular organochlorines. Reproductive disorders such as reduced reproductive rate and success are especially caused by PCBs and DDT. Tumour development (both benign

Coastal Development

An emerging pressure of international significance is the expansion of port and shipping activities in the GBR World Heritage area, driven by the global demand for coal and minerals. Coal contributes to almost half of Australia's total exports by value, and significant coal reserves exist in areas adjacent to Mackay, Whitsunday and Isaac. Port capacity in the GBR region is expected to triple by 2020 to support the predicted growth in Queensland's annual coal production (BREE 2012). Major expansions are underway and proposed for the Ports of Hay Point near Mackay (the world's largest coal export port), Abbot Point, Townsville and Gladstone.

The failure to inform the World Heritage Committee of several proposed liquefied natural gas plants at the Port of Gladstone, together with reported declines in biodiversity, prompted a United Nations Educational, Scientific and Cultural Organization-International Union for Conservation of Nature (UNESCO-IUCN) reactive monitoring mission in 2012 (Brodie 2012; McGrath 2012). The mission highlighted the possibility of adding the GBR to the List of World Heritage in Danger because the number and extent of port developments presents 'a significant risk to the conservation of the Outstanding Universal Value and integrity of the region' (Douvere and Badman 2012).

According to a report by Grech et al (2013), the key issue stems from weaknesses in the governance arrangements surrounding port developments within the GBR region due to a lack of transparency and rigour in the decision processes that is not being addressed by the Australian or Queensland Governments. The paper calls for "better alignment of purpose and approach of Governments" to "reduce tension between managing authorities, necessitating substantial changes to the current governance arrangements", however warns that "changing the current governance arrangements, however, would not necessarily lead to positive biodiversity outcomes if the alignment of purpose was pro-development" (2013; 10). Instead, Grech et al suggest a mandatory, independent peer-review process for Environmental Impact Assessments, and greater stakeholder involvement to ensure greater impartiality and transparency in decision making, while increasing public confidence.

"Ports and shipping exert a variety of pressures across multiple temporal and spatial scales with diverse impacts on biodiversity in the GBR region. Port infrastructure, port-related boat traffic, and dredging are localised to designated port areas and disposal sites, within and adjacent to the GBR World Heritage Area. Shipping lanes extend along the entire length of the region, exposing a wider area to shipping-related pressures. Pressures exerted by ports occur within the construction phase (e.g. reclamation) and during operation (e.g. introduction of contaminants from storage facilities and maintenance dredging of channels). Capital (initial) dredging during construction establishes shipping lanes, swing basins and berth pockets that require maintenance dredging during the operational life of the port. Capital and maintenance dredging exert similar pressures (although over different spatial and temporal scales), including the removal of benthic biota, smothering in spoil dumping areas, and elevated turbidity around dredging and dumping sites. Pressures from shipping and port-related boat traffic include noise, abrasion from grounding, scarring from anchoring and propeller turbulence, introduction of non-native (pest) species, and leaching of toxic anti-foulants into coastal waters. Pressures related to ports and shipping range from acute (e.g. ship grounding) to chronic (e.g. port illumination)"

(Foster et al. 2010)", Guiding Principles for the Improved Governance of Port and Shipping Impacts in the GBR, Grech et al. (2013; 7).

Other Impacts

A significant potential impact on dugong and green turtles is drowning after becoming tangled in set fishing nets or shark control program nets. This threat has been largely countered by establishment of Dugong Protection Zones, which regulate set net fishing to significantly reduce dugong deaths (Map 2.2). However, this does not negate the threat from the shark control program.

Also, since 1999 turtle excluding devices have been mandatory in the east coast otter trawl fishery. Incidental capture and mortality has now decreased substantially (Anon, 2005). Another impact on green turtles and dugong is boat strike by fast moving vessels, particularly over shallow seagrass beds.

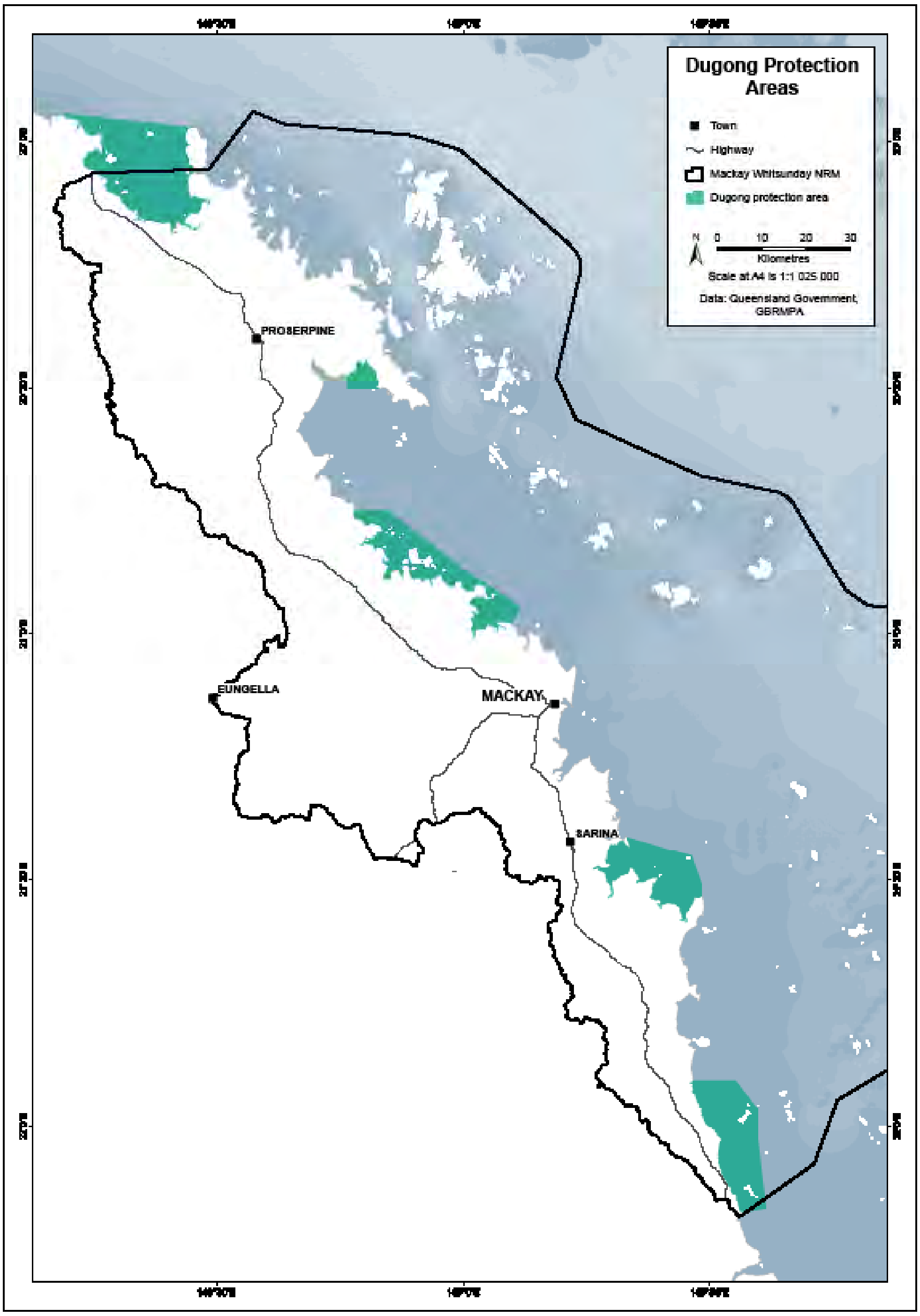

Figure 4 Dugong protection areas in MWI region

"A more serious threat posed by an increased frequency in cyclones and associated rain and flooding is an increase in the transport of pathogens and agricultural and urban-sourced pollutants into coastal waters of the GBR. As top-level predators, dolphins concentrate contaminants through bioaccumulation. High concentrations of heavy metals and persistent organic compounds containing halogens have damaging effects on marine mammals. Recent studies have shown that pathogen pollution may have considerable negative effects on populations of coastal marine mammals. The carcasses of three humpback dolphins recovered in the Townsville region between 2000 and 2001 were infected with Toxoplasma gondii, a terrestrial parasite that can be fatal or have deleterious effects to the health of marine mammals (e.g. infection with T. gondii is one of the leading causes of mortality of southern sea otters along the California coast). The introduction of this parasite to the coastal ecosystem appears to be linked to runoff of contaminated water with cat faeces or litter carrying oocysts of T. Gondii."

Extract from Lawler et al. 2004. Great Barrier Reef Marine Park Authority

Figure 5 Long-shore drift replenishes beaches with sediments supplied by coastal rivers from higher up in the catchment. Extensive sand deposits associated with Bakers Creek pictured.

CONDITIONS AND TRENDS

Despite the prevailing pressures and threats, the decline of loggerhead turtles and dugongs is believed to have halted and some species, such as the humpback whale, are increasing in numbers in the GBR (GBRMPA, 2009).

Comprehensive surveys of Abbot Point, Hay Point and the Mackay Port have detected introduced marine animals and plants and cryptogenic species (i.e. species whose natural range is not yet known) (CRIMP, 1998; Hoedt et al. 1999). However, none of these species are on the Australian Ballast Water Management Advisory Council list of targeted species (e.g. those with potentially significant environmental impacts).

Seven areas within the region are designated as Fish Habitat Areas (Dodds, 2004) (Table 3.2). These are designed to protect fisheries habitats from direct physical disturbance and coastal development.

DECLARED FISH HABITAT AREA	SIZE (HA)
Repulse Bay	6,162
Midge Point	798
Sand Bay	2,640
Bassett Basin	371
Cape Palmerston	895
Rocky Dam	1,549
Marion	493

Table 2 Regional Fish Habitat Areas

Available data (summarised by Dodds, 2004) illustrates stability in the Spanish mackerel fishery for the period 1989 to 2000 (Figure 3.5). However, trawl fisheries such as bugs and scallops show considerably more variability over that period (Figure 3.6). Interpretation of these data should be done with caution as catch effort is not constant among years.

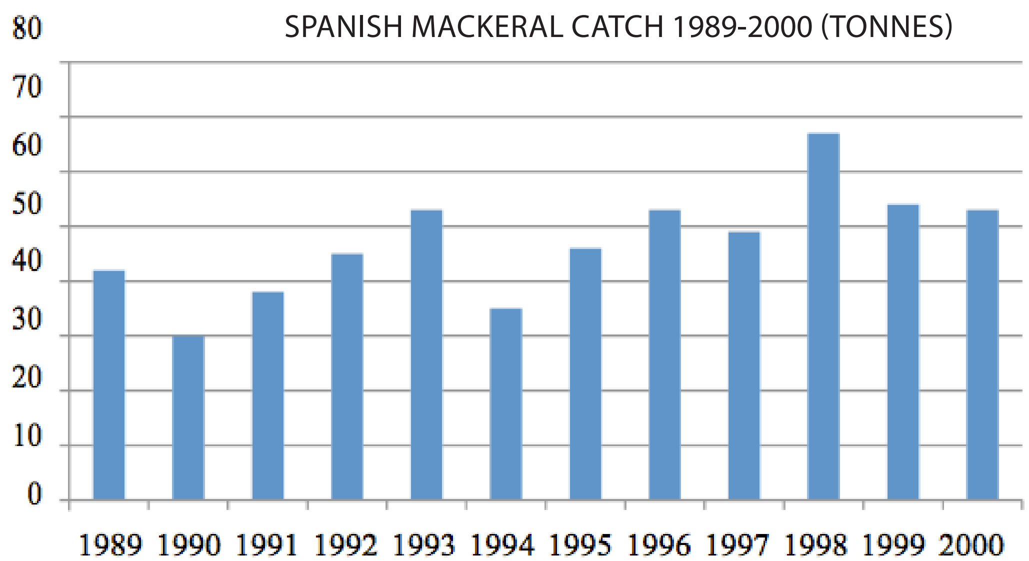

Figure 6 Spanish mackerel regional catch 1989-2000

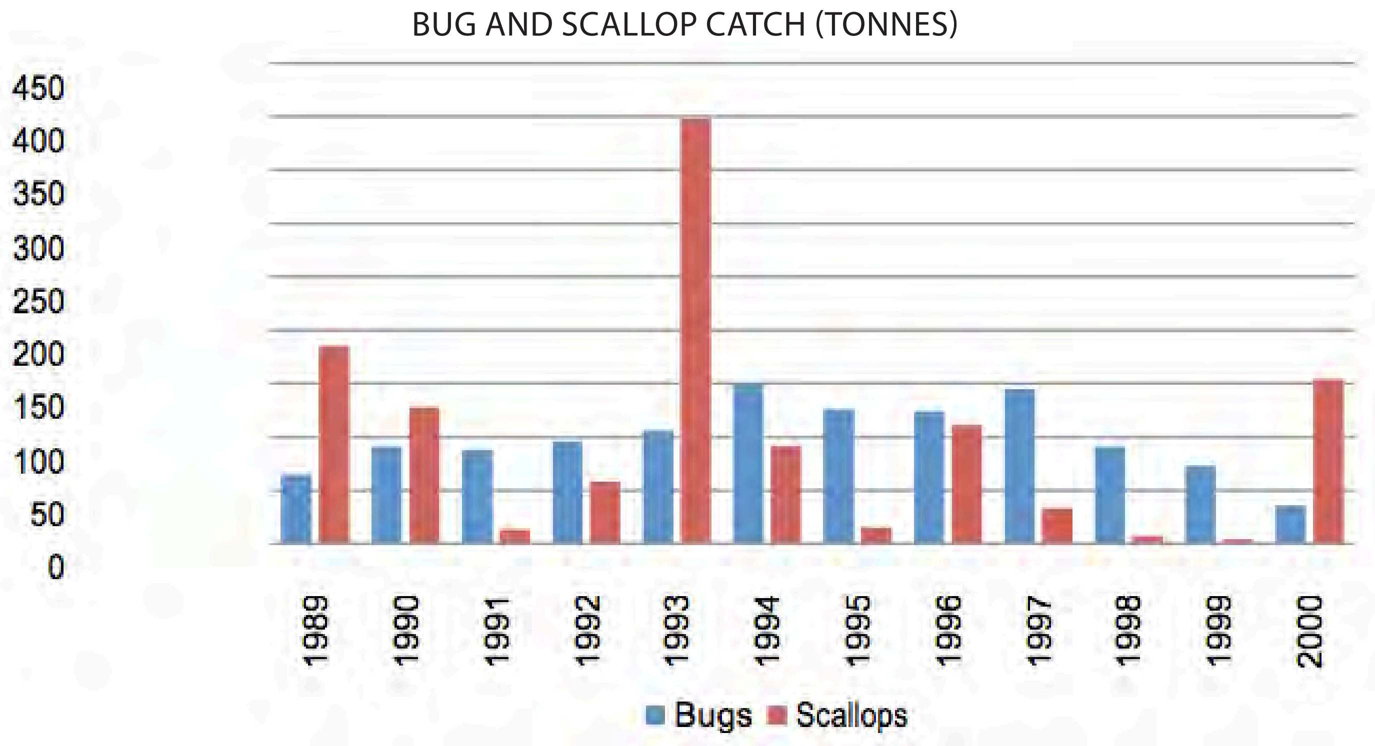

Figure 7 Bug and scallop (meat) regional catch 1989-2000

The region's catchments (Don, Proserpine, O'Connell and Pioneer Rivers and Plane Creek) historically contributed about 1161 tonnes of nitrogen (dissolved inorganic fraction) to the GBR lagoon annually, about 9% of the total outfall from the reef catchments (Furnas, 2003). Phosporous (dissolved inorganic fraction) outfall was approximately 130 tonnes per annum or 13% of the total from all reef catchments (Furnas, 2003). Herbicide residues are present within all major waterways of the region but little is known in relation to presence of pathogens.

The Reef Water Quality Protection Plan (Reef Plan) was first endorsed by Queensland and Commonwealth governments in 2003, updated in 2009 and recently updated in July 2013. Reef Plan represents a coordinated and cooperative approach to improve the water quality in the GBR from agricultural activities. It focuses on achieving clear goals and specific targets regarding pollutant levels, groundcover, wetland extent and adoption of better management practices. A monitoring and evaluation program, Paddock to Reef, assesses the success of Reef Plan actions. Paddock to Reef issues a baseline report in 2009, and subsequently report cards measure progress yearly.

To this date, report cards tracking progress for the periods 2009-2010 and 2010-2011 have been published. Report cards for 2011-12 and 2012-13 will expectedly be published in 2014. So far the report cards indicate that management changes and water quality improvements are on a positive trajectory and progress toward Reef Plan targets (Figure 8). Albeit not at the rate needed to achieve the 2013 targets set in Reef Plan 2009, progress is encouraging, particularly the on-ground management practice changes which are the key to reducing pollutant loads entering the reef.

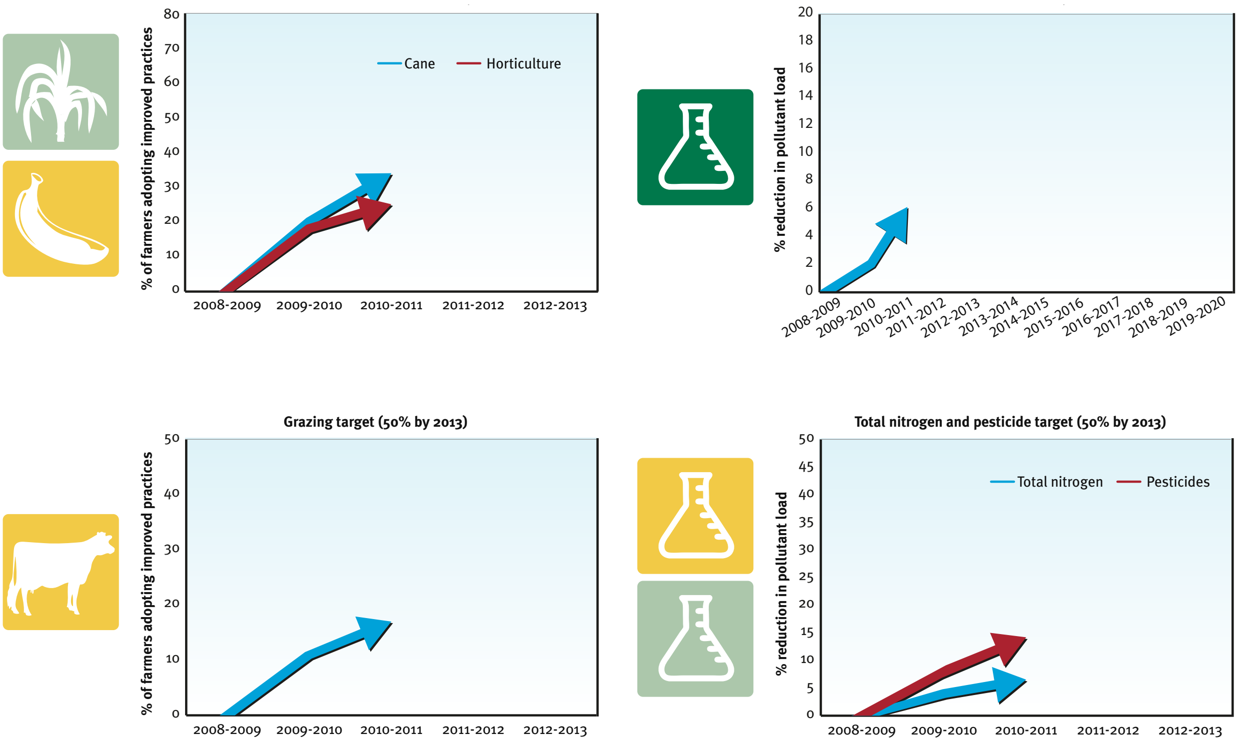

Figure 8: Trends in the adoption of best management practices for sugarcane, horticulture and grazing (the two graphs on the left), and in the concentration of pollutants (the two graphs on the right) (Report Card, Reef Plan Secretariat 2013b)

Due to lag effects, it will take time to see the results of improved land management practices translated in improved marine condition. In addition, extreme weather events in recent years have led to the discharge of higher than average loads of sediment, nutrients and pesticides, negatively impacting the reef and obscuring the benefit of improved practices. High rainfall in 2010-2011 caused higher than average discharge especially the Fitzroy and Proserpine Rivers. Also in 2011, tropical Cyclone Yasi caused significant damage to seagrass meadows and reefs from Cooktown to Mackay. These extreme weather events significantly impacted the overall condition of the marine environment. As a result, in 2010-2011, The Mackay Whitsunday's marine condition declined from moderate to poor. Inshore water quality also declined from moderate to poor, inshore seagrass meadows declined from poor to very poor and coral reefs remained in moderate condition.

Reef Catchments enables the implementation of Reef Plan in the Mackay Whitsunday region by managing the Reef Rescue water quality grants and contributing to promoting improved sugarcane and grazing practices. In addition, Reef Catchments since 2009 has contributed directly to the Paddock to Reef program by managing key monitoring sites and collecting data on practice adoption. Since 2008, Reef Catchments has facilitated the investment in the Mackay Whitsunday region of $27.5 million into improved agricultural practices achieving: 918 projects in 3 industries, $29.5 million co-investment by farmers, 93,000ha of improved soil management, 59,000ha of improved nutrient management and 95,000ha of improved pesticide management.

Thirty four per cent of sugarcane growers, 17 per cent of graziers and 25 per cent of horticulture producers adopted improved management practices by June 2011. The highest regional level of adoption in the grazing and horticulture industries was in the Mackay Whitsunday region and the highest level of adoption in the sugarcane industry was in the Burnett Mary region. The estimated annual average sediment load reduced by six per cent with good to very good progress across all regions. The total nitrogen load reduced by seven per cent; however dissolved nitrogen, the key pollutant of concern, reduced by 13 per cent. The pesticide load reduced by 15 per cent, with a 31 per cent reduction in the Mackay Whitsunday region.

GOVERNANCE

Most of the GBR lagoon within the region lies within the Great Barrier Reef Marine Park (GBRMP) and is managed under the auspices of the Great Barrier Reef Marine Park Act 1975 and Regulations. The latest review of the Zoning Plan for this area was completed and gazetted in 2003. The Great Barrier Reef Marine Park Authority has management responsibility for the area in partnership with the Queensland Parks and Wildlife Service under the Day to Day Management Program. The sections of the GBR which fall within Queensland State waters lies within the Great Barrier Reef Coast Marine Park (GBRCMP) which was formed and is managed through the Queensland Marine Parks Act 2004 and Regulations. Rezoning of the GBRMP was mirrored within the GBRCMP in 2004. These marine parks combined form the Great Barrier Reef World Heritage Area for which Australia has international management obligations.

Jurisdictions include local governments, State (Queensland) lands and waters, the Commonwealth (Australian) Great Barrier Reef Marine Park (GBR Marine Park), and the Great Barrier Reef World Heritage Area (GBR World Heritage Area).

The GBR Marine Park Authority, Australian Maritime Safety Authority, and Maritime Safety Queensland jointly manage shipping under domestic laws and regulations as well as international treaty law, such as the United Nations Convention of the Laws of the Sea and MARPOL. The GBR region is listed as a Particularly Sensitive Sea Area by the International Maritime Organization. All large vessels are monitored by a vessel traffic system (REEFVTS) and ships are only permitted to transit through Designated Shipping Areas (Figure 9). Much of the region requires the compulsory pilotage of large vessels.

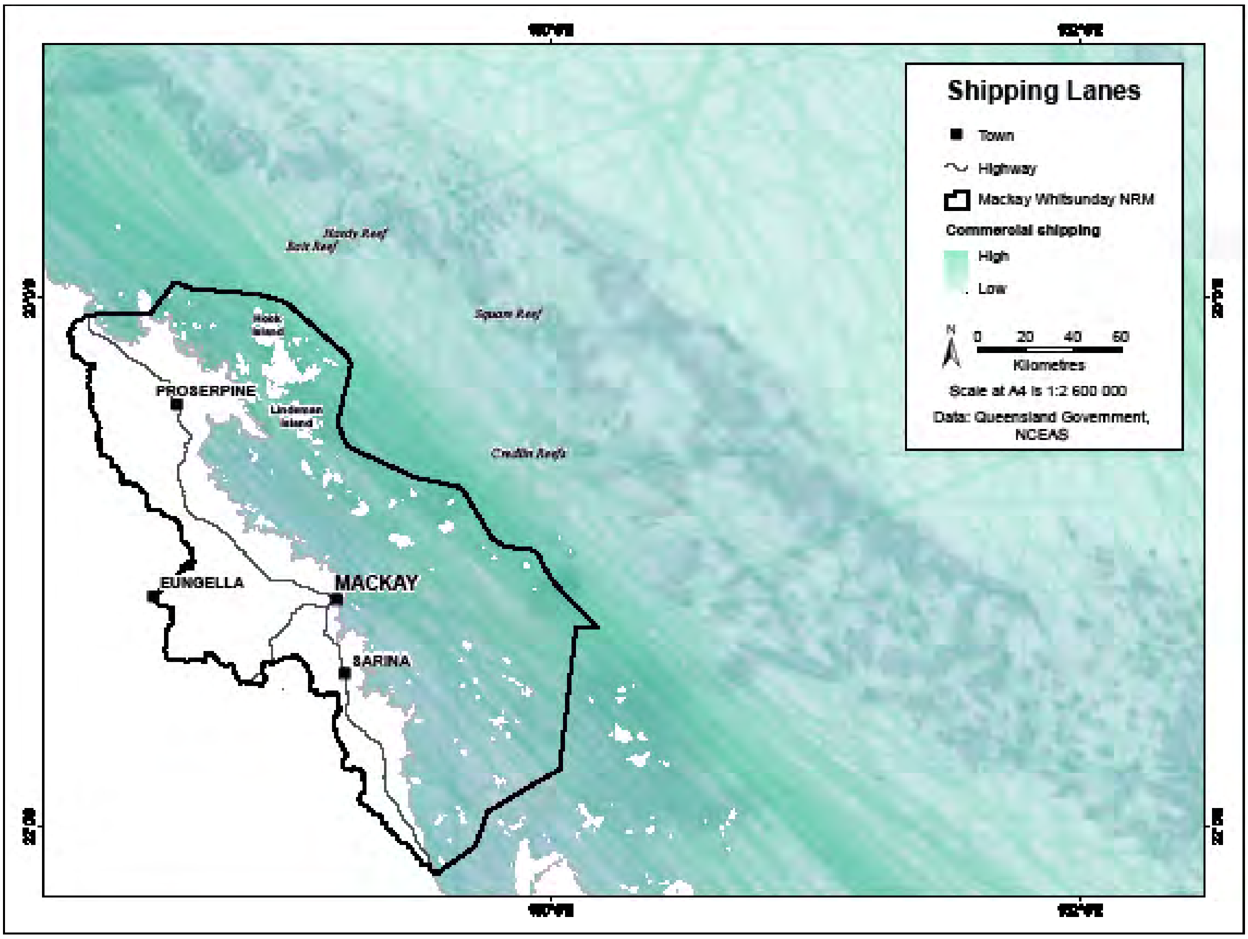

Image 9 Designated Shipping areas in MWI region

There are four Port areas within and adjacent to the region that are not part of either Marine Park; Abbot Point, Port of Bowen, Port of Mackay, and Hay Point/ Dalyrymple Bay.

Commercial and recreational fishing throughout the GBR is managed by the Queensland Department of Primary Industries and Fisheries under the Fisheries Act 1994. Management instruments notably include reef zoning, quotas, size and bag limits and seasonal closures. Compliance is undertaken by the Boating and Fisheries Patrol (DPIF), Marine Parks (QPWS) and the Queensland Water Police.

"There are more than 30 pieces of legislation at both the State (Queensland) and Commonwealth (Australia) levels that administer and regulate the assessment and decision processes of port developments in the GBR region. Management and environmental plans by Local Government and Port Authorities can also influence the approvals process. The spatial overlap between jurisdictions is complex. For example, 10 of the 12 GBR ports are excluded from the GBR Marine Park but some of these remain within the World Heritage boundary, and all are within State (Queensland) waters.

This complexity of legal constraints is characterized by divergence of purpose and approach within the decision processes for major projects by State and Commonwealth Governments, especially in the administration of Environmental Impact Assessments (EIAs). EIAs for significant port developments in the GBR region are directed by the Queensland Coordinator General in the Department of State Development Infrastructure and Planning. This department is also broadly responsible for facilitating economic development and ensuring the management, delivery and facilitation of high priority commercial projects. The GBR Marine Park Authority's goal is the long-term protection and ecologically sustainable use of the GBR Marine Park, whilst the Commonwealth Government is focused on legal process and administering the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act). These differences in expectations and needs create tension between managing authorities"

Guiding Principles for the Improved Governance of Port and Shipping Impacts in the GBR, Grech et al. (2013; 9).

INDICATORS

The quality of water flowing into the GBR lagoon has been improved since 2008 in line with the thresholds, indicators and mechanisms identified by the Mackay Whitsunday Water Quality Improvement Plan (Drewry et al., 2008).

A key part of the Water Quality Improvement Plan implementation strategy has been ABCD Management Frameworks. These provide a way of classifying different suites of agricultural and urban practices on the basis of water quality benefits. They are valuable tools in communicating to policy makers, investors and farmers and the framework has been adopted across all the Great Barrier Reef catchment regions. The Water Quality Improvement Plan set scientifically robust targets that were supported by practical on ground solutions.

Fisheries catch data continue to demonstrate sustainability of lagoon based fisheries. Cetacean populations are monitored by a combination of incidental sightings records and dedicated aerial surveys.

Areas with a high potential for marine bio-invasion are monitored using the methodology designed

by the CSIRO Marine Research Centre for Research on Introduced Marine Pests. No further net loss of foreshore vegetation to beach erosion.

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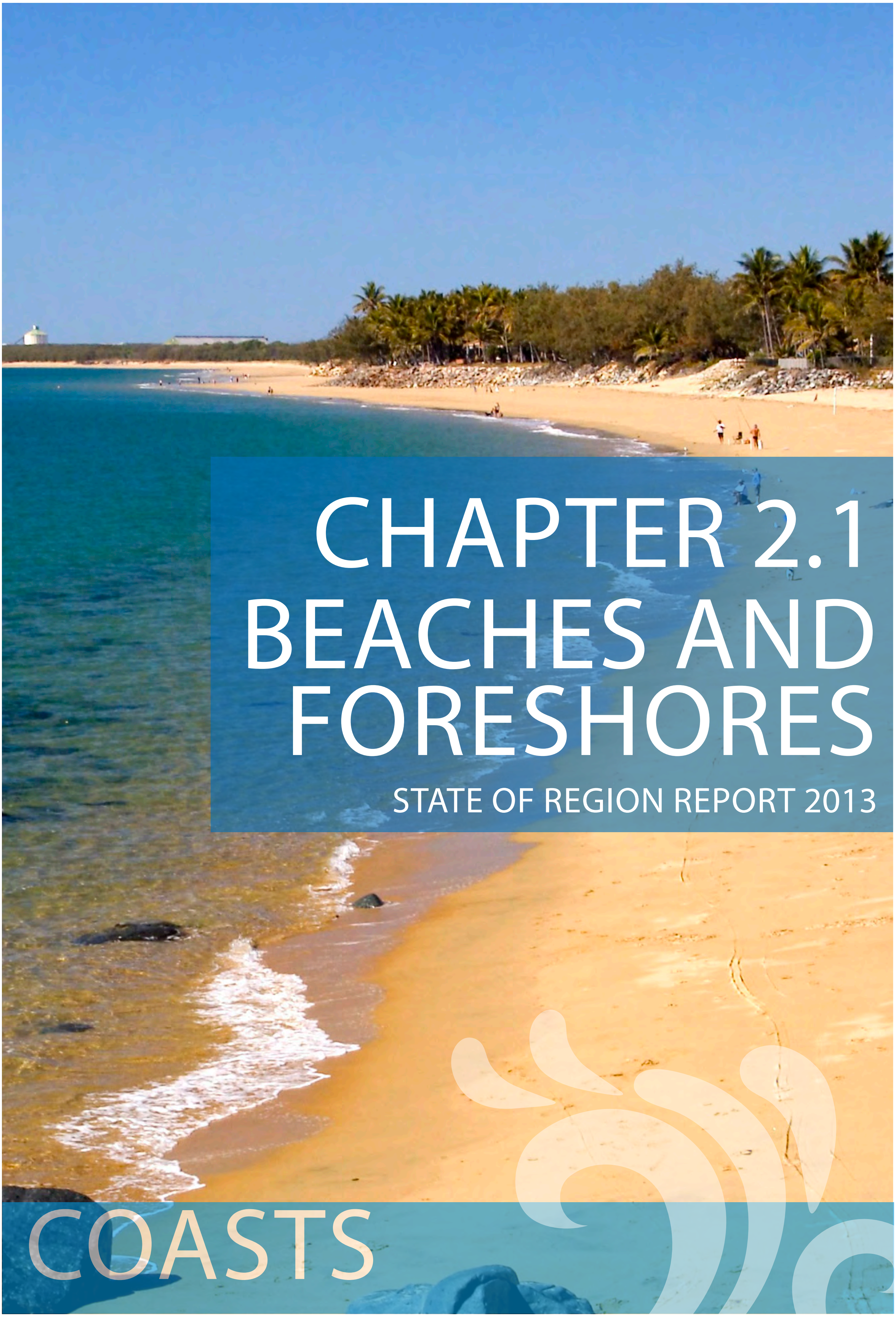


CHAPTER 2.1 BEACHES AND FORESHORES

STATE OF REGION REPORT 2013

COASTS

Beaches and Foreshores

REEF CATCHMENTS

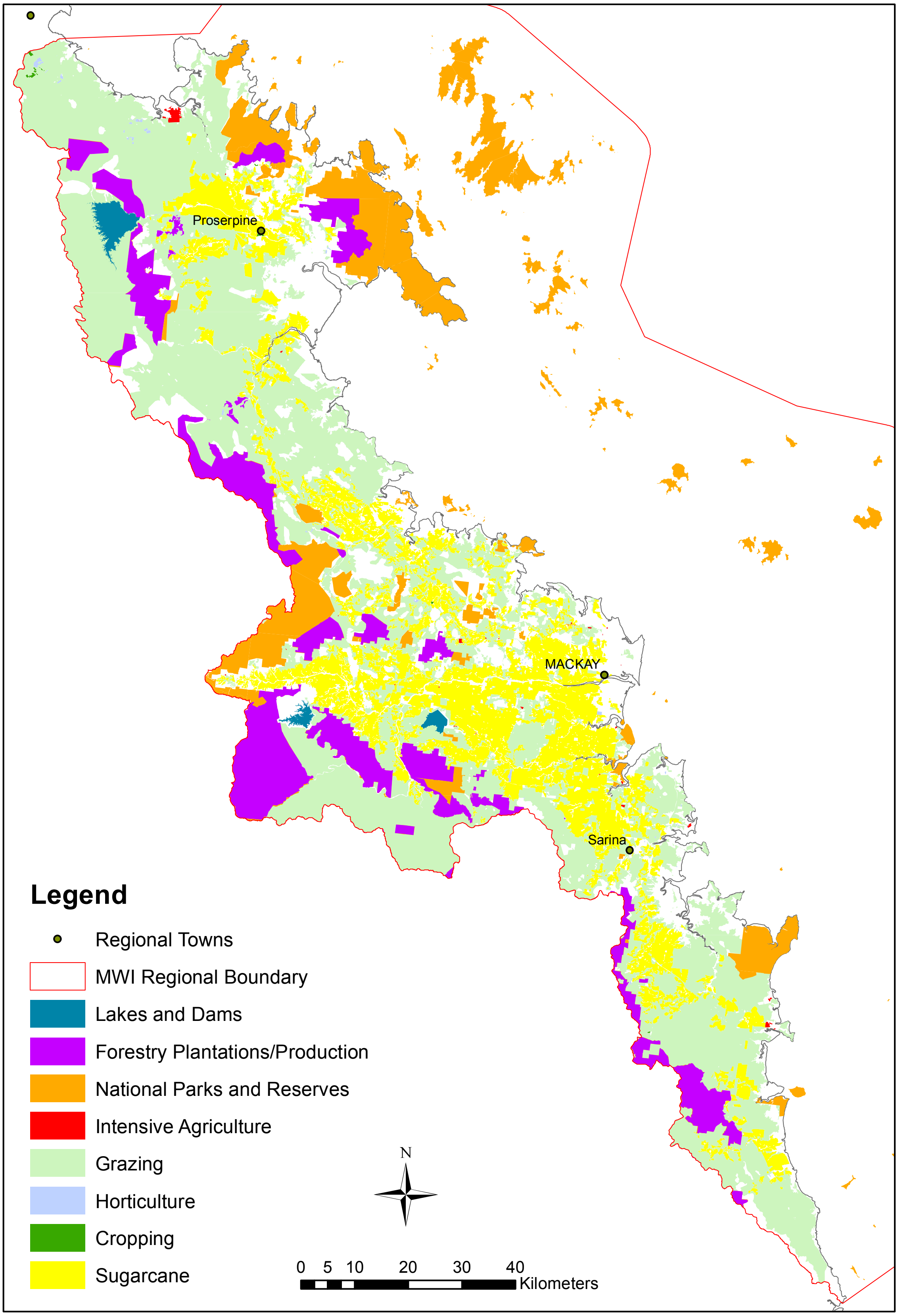


Figure 1 Replace with beaches map

Beaches and Foreshores

REEF CATCHMENTS

SUMMARY

The Mackay Whitsunday Isaac region includes approximately 900 kilometres of mainland coastline, stretching from Clairview in the south to just south of Bowen in the north. The coastline is nearly 2,000 kilometres when islands are included. The region experiences some of the largest tidal ranges that occur along the Queensland coast ranging from approximately +/- 4m in the north to +/- 6m in the south. As such, much of the regions foreshores are characterised by extensive intertidal sand and mud flats which become exposed at low tide.

Most of the region's coastline lies within the Central Queensland Coast Bioregion, predominantly within the Sarina to Proserpine Lowlands sub-region but also sections of Debella and Whitsunday sub-regions. Rainfall along this stretch of coastline varies significantly; 1200mm per annum at Clairview, increasing to 1600mm in the high rainfall belt from Mackay to Airlie Beach. Different rainfall patterns, geological make-up and history, and varying exposure of the coastline results in a very high diversity of coastal landscapes. These include for example:

- Extensive, exposed muddy to sandy flats associated with the Clairview coast.
- Rocky promontories and foreshores of Cape Palmerston.
- Sandy beaches interspersed with rocky headlands and mangrove inlets in the Sarina area.
- Long sandy beaches and parabolic dunes of Harbour and Northern Beaches.
- Dramatically folded geological landscapes of the Cape Hillsborough and Seaforth areas.
- Isolated beaches from Mentmore to Goorganga Plain and to Repulse Bay interspersed by small rocky headlands and mangrove lined estuaries.
- Extensive rocky and shingle foreshores of the Conway Peninsula through to Hydeaway Bay and Dingo Beach.
- Granitic headlands and associated beaches from Cape Gloucester to Bowen.

Beaches and foreshores are a highly valued part of the region's landscape for multiple reasons that include social, environmental and economic values. Iconic beaches, such as Whitehaven Beach on Whitsunday Island, are some of the most renowned in Australia.

There are also multiple, often competing, uses of these ecosystems and as such they are being faced with increasing pressures from natural and anthropogenic forces. Beaches and foreshores are subject to complex management arrangements which provide additional challenges to achieving environmental sustainability.

Regional Ecosystem	Biodiversity Conservation Status	Extent Protected in Conservation Reserves
8.2.1 Beach foreshore vegetation in Central Queensland Coast: *Casuarina equisetifolia* open forest to woodland with *Ipomoea pes-caprae* and *Spinifex sericeus* dominated ground layer on foredunes.	Of concern	High
8.2.2 Beach scrub in Central Queensland Coast: Microphyll vine forest on coastal dunes.	Endangered	Medium
8.2.6 Open woodland on sand dunes: *Corymbia tessellaris* + *Acacia leptocarpa* + *Banksia integrifolia* + *Melaleuca dealbata* + beach scrub species open forest on coastal parallel dunes.	Of concern	High
8.2.7 Melaleuca and swamp mahogany woodland to forest: *Melaleuca* spp. and/or *Lophostemon suaveolens* and/or *Eucalyptus robusta* open woodland to open forest in wetlands associated with parabolic dunes.	Endangered	High
8.2.8 Eucalypt and heath: Variable eucalypt woodland often with heathy elements on parabolic dunes and beach ridges.	No concern at present	High
8.2.9 Grassland: *Heteropogon triticeus*, *Imperata cylindrica* and *Themeda triandra* grassland on coastal dunes.	Endangered	Medium
8.2.11 Melaleuca swales: *Melaleuca* spp. woodland in parallel dune swales (wetlands).	Of concern	High
8.2.13 Eucalypt and cabbage palm forest: *Corymbia tessellaris*, *Melaleuca* spp., *Livistona decipiens* and/or *Acacia* spp. and/or *Lophostemon suaveolens* open to closed forest on dune sands mixed with alluvial material ± marine sediments.	Endangered	Low
8.2.14 Open woodland on dunes: *Banksia integrifolia* and/or *Corymbia tessellaris* and/or *Acacia disparrima* +/- rainforest spp. tall shrubland, on Holocene parabolic dunes.	Of concern	High
11.2.3 Beach Scrub in the Northern Brigalow Belt: Microphyll vine forest (beach scrub) on sandy beach ridges.	Of concern	High
11.2.5 Open woodland on dunes: *Corymbia Melaleuca* woodland complex of beach ridges and swales.	No concern at present	Medium

Table 1 Beach and foreshore regional ecosystems occurring within the Mackay Whitsunday region (Queensland Herbarium, 2013; Accad *et al.*, 2012).

VALUES AND SERVICES

ECOSYSTEM SERVICES

Beaches and foreshores are critical buffers between the sea and terrestrial environments. This landscape provides vital ecosystem services, such as disturbance, climate and nutrient regulation, which are of significant financial value and require minimal service costs (Millennium Ecosystem Assessment, 2005; SEQ Catchments, 2013). The capacity of these areas to provide these services hinge on factors such as replenishment of sand through long-shore drift processes, presence of stabilising vegetation, and reservoirs of sand held within both foredune and hind dune areas.

Foredunes act as barriers against the action of waves and tides, and are a source of sand for the beach during periods of erosion. They protect areas behind them from wave damage and saltwater intrusion during storms and are inherently flexible. If they are damaged by storm waves, the remaining vegetation traps sand blown from the beach and the dune is reformed, thus providing protection against future wave attack. Vegetated foredunes are protective and restrict wind, sand and salt spray intrusion into hind dune areas allowing development of a more complex plant community on the hind dunes. Parallel dunes landward of the foredune are protective to a lesser degree. If they are well stabilised, they serve as a second line of defence against water and wind erosion, should the foredune be destroyed by the action of storm waves.

HABITAT

The region's foreshores and beaches are habitats of international significance. The Mackay region is the fifth most important area in Queensland for shorebirds, and is among the 25 most important sites for shorebirds in Australia (Tucker et al., 2006). The regional shorebird survey in October 2012 found that the region is of international importance (>1% flyway population) for six species (Harding, 2012). Significant roost sites have been clearly identified and mapped for the Mackay Whitsunday region (Queensland Wader Study Group and Reef Catchments, 2012). Additionally, Important Bird Areas have been identified along the Mackay Whitsunday coast. These are internationally recognised sites of importance for bird conservation, which meet global criteria (BirdLife Australia, 2013). Foreshore areas are also essential habitat for the Vulnerable Beach Stone-curlew (Esacus giganteus).

All sandy beaches within the region are potential nesting sites for marine turtles. Of the world's seven species of marine turtles, six are found in the waters of the Great Barrier Reef. While Green Turtles (Chelonia mydas) may occasionally nest on mainland beaches within the region, the vast majority of nesting activity is by Flatback Turtles (Natator depressus) which only nest on Australian beaches. Figure 4.2 illustrates nesting activity of marine turtles within the region (Limpus, 2013).

Rocky foreshores provide markedly different habitats than sandy beaches, particularly in association with rocky headlands such as those found at Cape Hillsborough and Cape Palmerston. These areas form important potential roosting habitat for the little known and Vulnerable Coastal Sheathtail Bat (Taphozous australis). The species occurs only in Queensland from Shoalwater Bay in the south to Torres Strait in the north (Chimimba and Kitchener 1991, Catling et al., 1994) within a narrow coastal band, extending no more than a few kilometres inland (Richards 1995).

Beaches and Foreshores

The region's coastal zone supports approximately 1,069 hectares of beach scrub (also known as microphyll vine forest on coastal dunes, regional ecosystem [RE] 8.2.2) (Accad et al., 2012). This ecological community is listed as Critically Endangered nationally (Environment Protection and Biodiversity Conservation Act 1999), owing to its fragmentation, small patch size, demonstrable threats and reduced in integrity (Australian Government, 2009). Beach scrub only occurs in the coastal zone and provides habitat for threatened plants and animals and is an important buffer to coastal erosion and wind damage.

Allow space for 3 x maps:

Figure 2 Recorded shorebird roosts and Important Bird Areas in Mackay Whitsunday region (Queensland Wader Study Group and Reef Catchments, 2012; BirdLife Australia, 2012).

Figure 3 Recorded marine turtle nesting activity 1915-2012 (Limpus, 2013).

Figure 4 Coastal Sheathtail Bat (Taphozous australis) Essential Habitat (Queensland Government, 2013d).

Beaches and Foreshores

“Cane growing and sugar production underpins the economic stability of many coastal communities. It is the social fabric that has woven itself through the development of coastal townships up and down the coast.”

Cane Growing in Australia, Canegrowers (2013, 1)

ECONOMIC VALUE

The coastline provides for cargo and people via the development of ports and associated infrastructure, which are of significant economic and social importance in the region. There are many ports in the region ranging from small community ports to one of the largest coal export ports in the world, at Hay Point. During 2012-13, Hay Point had the highest value of exports among all Queensland ports at over $13 billion (Queensland Government, 2013a). The Port of Hay Point comprises two coal export terminals, Dalrymple Bay Coal Terminal (DBCT) and Hay Point Coal Terminal. Dalrymple Bay Coal Terminal is leased from the State Government by DBCT Management Pty Ltd and Hay Point Coal Terminal is owned by BHP Billiton Mitsubishi Alliance-owned and operated by Hay Point Services. Together these coal terminals service the mines in the Bowen Basin in central Queensland. The mines are linked to the port terminals through an integrated rail-port network (North Queensland Bulk Ports Corporation, 2012). Beaches and foreshores in the region also provide sand and gravel for commercial infrastructure needs (Queensland Government, 2004).

Human settlement patterns along the coast closely mirror attractive and accessible beaches. These areas have very high recreational values and make major contributions to the lifestyles of communities within the region. They are also major attractions which encourage more people to settle within the region. An additional 100,000 people are expected in the region (Mackay, Whitsunday, Isaac) by 2031, with the coastal areas of urban Mackay, Sarina and the Whitsundays absorbing the vast majority of this growth (Queensland Government, 2012).

The region’s beaches are major drawcards for tourism. In the year ending June 2013, the Mackay and Whitsunday tourism region recorded a total domestic and international visitor expenditure of $1,156 million (Tourism and Events Queensland, 2013).

INDIGENOUS VALUES

Beaches and foreshores supply vital resources to Aboriginal people and retain considerable cultural significance. The region contains a large number of middens and stone built fish traps which are tangible reminders of the traditional way of life.

PRESSURES AND THREATS

INCREASED USE OF COASTAL ZONE

With a rapidly growing regional population, there is an ongoing increase in urban development and associated commercial and industrial development to cater for continuing population growth in the region (Queensland Government, 2006).

An expanding urban footprint can result in loss of vegetation, wildlife corridors, and other areas of high biodiversity value along beaches and foreshores. In addition, changes in hydrology, loss of connectivity, encroachment and pollution from development in the coastal zone all threaten the condition and ecological integrity of coastal ecosystems (Schaffelke et al., 2005). Vegetation thinning associated with urban developments and cattle grazing in the coastal zone are practices which can cause incremental but significant damage, particularly in sensitive foreshore environments (Queensland Herbarium, 2013).

Ports and extractive industries impact beach and foreshore ecosystems both directly by replacing or removing coastal habitats and indirectly by altering coastal hydrology. For example port infrastructure and the extraction of sand and gravel change current patterns and littoral drift, altering sediment supply, which may lead to beach erosion or accretion in adjacent areas (United Nations Economic and Social Commission for Asia and the Pacific, 1992; Queensland Government, 2004). Other indirect pressures are construction and dredging, ship traffic and discharges and cargo operations and waterfront industry (United Nations Economic and Social Commission for Asia and the Pacific, 1992).

Recreational use of beaches and foreshores increases with population growth, with most recreational activity in the coastal zone considered sustainable if managed correctly. However, inappropriate use of motorised vehicles on vegetated sand dunes results in the removal of stabilising vegetation and subsequent erosion or physical degradation of these areas. Off-road vehicles and unleashed dogs can also cause disturbance to migratory shorebirds and nesting and hatching turtles. For both shorebirds and turtles, the primary concern is over the summer months (October to April) when migratory shorebirds are visiting coastal areas to feed and roost before returning to the northern hemisphere to breed, and turtles are nesting on the beaches.

INVASIVE SPECIES

Pest plants compete with native vegetation, reduce biodiversity, and generally detract from the environmental and aesthetic value of coastal ecosystems. Non-native vegetation may change the fire regime of coastal ecosystems by increasing fuel loads thus increasing frequency and intensity. Pest plants are often typified by shallow root systems which do not stabilise sand dunes as effectively as the extensive root systems of native foreshore plants (Beach Protection Authority and Queensland Government Department of Environment, 2003). Many of the vegetation communities associated with beaches and foreshores are sensitive to fire and even low intensity, low frequency fires can cause dieback of stabilising vegetation (Reef Catchments, 2010). Fire allows pest plants to establish or increase in density, and in turn the presence of pest plant species can increase the fire risk to fire sensitive ecological communities.

SPECIES SPECIFIC THREATS

Marine turtles nesting on mainland beaches are known to be subject to threats such as disturbance during nesting, illegal harvesting of eggs, predation on eggs by feral animals, drowning in fishing gear, pollution and changes to important turtle habitats, impacts of vehicles on beaches, and light pollution (Environment Australia, 2003). Likewise, The Coastal Sheathtail Bat (Taphozous australis) is suspected to be easily disturbed when at roost, and likely suffers from loss of, and fragmentation of foreshore and near coastal foraging habitats. There is currently no widespread decline documented for the species, however, at one site in the Cape Hillsborough National Park an observed decline may be due to human visitation (Hoye 1985, cited in Australian Government, 2011). The loss of foraging habitat through coastal development and sand mining, and roost disturbance (with increasing human access to the coast) may pose threats to this species in the central and southern parts of its distribution (Australian Government, 2011).

CLIMATE CHANGE

The Central Queensland Coast has classic tide-dominated coasts with wide gently sloping intertidal flats that are prone to storm tide inundation, and the Mackay region is identified as one of the most vulnerable sections of the Queensland coast in this sense (Queensland Government, 2011; Harper, 1998 cited in Queensland Government, 2004). Climate change will result in sea level rise, increased storm events, erosion, and damage to sandy coasts, causing them to retreat inland. This is especially problematic where the sandy dune ecosystems are not free to move inland due to constraints imposed by the built landscape, known as the 'coastal squeeze'. The result may be a direct loss of coastal ecosystems and critical habitat for species such as marine turtles (nesting areas), shorebirds, and intertidal species that form the basis of fisheries food chains.

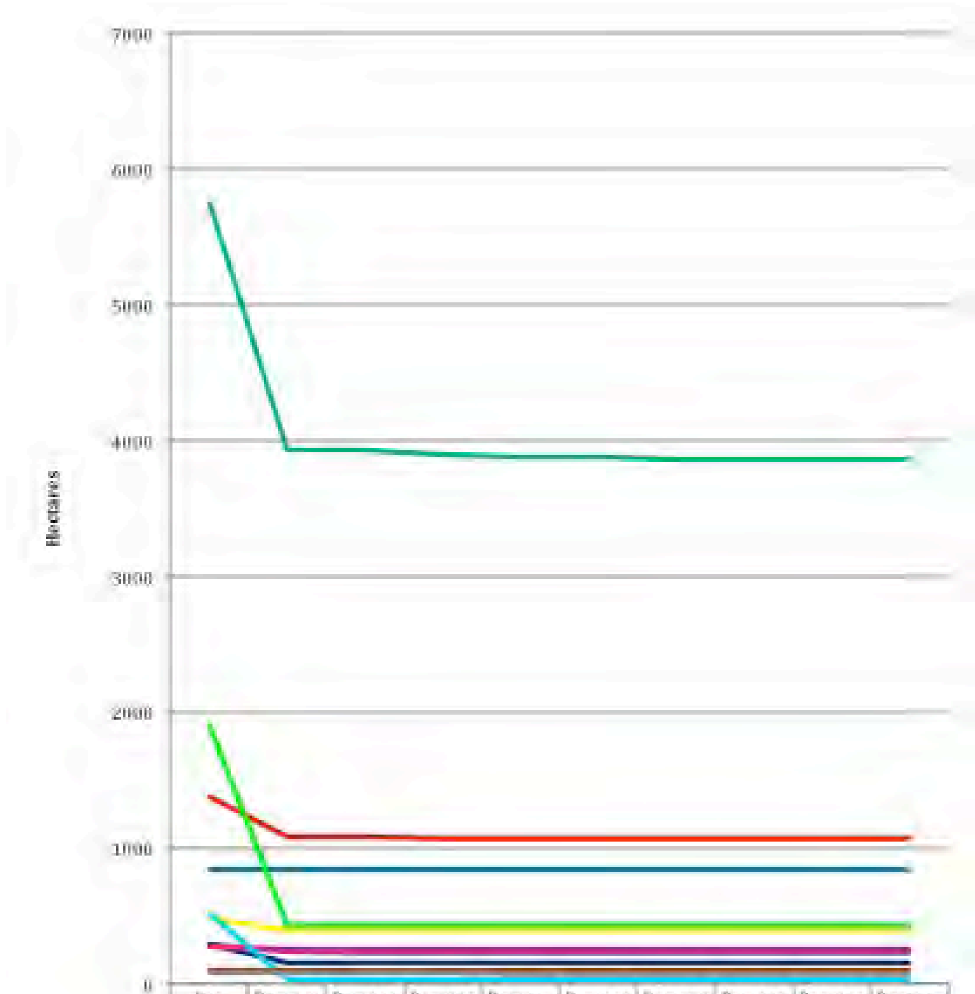
CONDITION AND TRENDS

Over 37% (4,485 hectares) of remnant vegetation has been cleared across the region's beach and foreshore regional ecosystems (Table 4.2, Accad et al., 2012), the majority of which was cleared before 1997 prior to vegetation clearing legislation. This included approximately 2,000 ha of open woodland on sand dunes (Regional Ecosystem 8.2.6), 1,500 ha of eucalypt and cabbage palm forest (RE 8.2.13), 500ha of open woodland on dunes (RE 8.2.14), and 250ha of beach scrub (RE 8.2.2).

Although there has been relatively little broad scale clearing of dune ecosystems since 1997, there has been incremental loss of vegetation due to increasing populations in the coastal zone.

As a result, 9 out of the 11 beach and foreshore regional ecosystems have a biodiversity status of either Endangered or Of Concern, which by area accounts for 88% of remnant vegetation being threatened in this landscape (Figure 4.5). The biodiversity status takes into consideration not only the extent of clearing that has occurred, but the extent of degradation and threatening processes that the regional ecosystem is subject to.

Approximately 30% of the remnant vegetation remaining in beaches and foreshores across the region is protected within National Parks and other Conservation Reserves (Figure 4.6). These areas include Cape Hillsborough National Park, Cape Palmerston National Park, Bakers Creek Conservation Park, Sandringham Bay Conservation Park, and Skull Knob Conservation Park.



	Pre clear extent	Remnan t extent 1997	Remnan t extent 1999	Remnan t extent 2000	Remnan t extent 2001	Remnan t extent 2003	Remnan t extent 2005	Remnan t extent 2006	Remnan t extent 2007	Remnan t extent 2009
8.2.1	486	395	395	394	394	394	393	393	392	388
8.2.2	1373	1088	1088	1072	1072	1071	1070	1070	1070	1069
8.2.6	5743	3931	3928	3892	3882	3872	3856	3856	3855	3855
8.2.7	293	229	226	226	226	226	225	225	225	225
8.2.8	832	832	832	832	832	832	832	832	832	832
8.2.9	294	153	153	153	153	153	153	153	153	153
8.2.11	278	248	248	246	246	246	245	245	245	245
8.2.13	1891	430	430	430	430	430	429	429	429	429
8.2.14	510	32	32	32	32	32	32	32	32	32
11.2.3	98	96	96	96	94	94	94	94	94	94
11.2.5	80	77	77	77	71	71	71	71	71	71

Table 2 Clearing rates of beach and foreshore vegetation; pre-clearing, 1997 – 2009 extent in Mackay Whitsunday NRM region (Accad et al, 2012).

Of primary concern are ecosystems which are both endangered, and with low to medium representation within the protected area estate. These include beach scrub (RE 8.2.2), grassland on coastal dunes (RE 8.2.9), and eucalypt and cabbage palm forest (RE 8.2.t13).

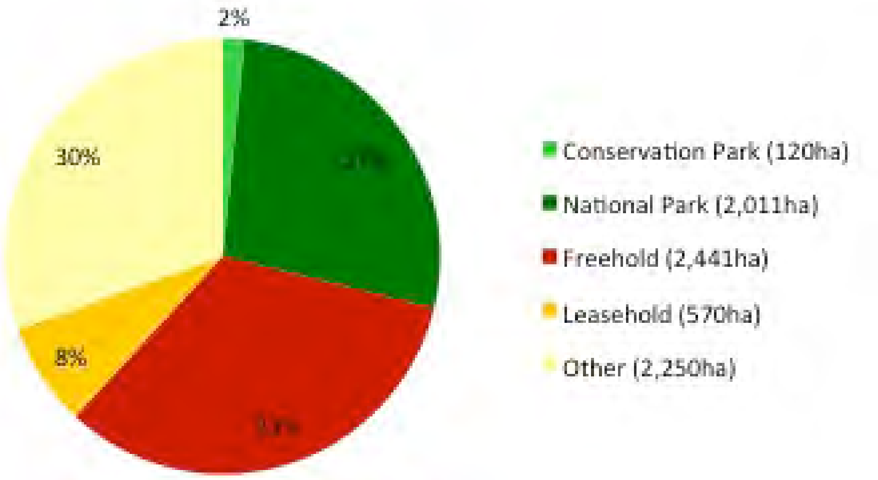


Figure 5 Tenure of beach and foreshore remnant vegetation (Accad et al, 2012)

The Queensland Wader Study Group has undertaken shorebird surveys within the region since 2003 on a near biennial basis (Figure 5). The most recent survey in October 2012 recorded 16,568 shorebirds of 32 species, comprising 21 migratory species and 11 resident species. Based on these current survey results, the region is of international importance (>1% flyway population) for six species (Harding, 2012). Migratory shorebirds move along flyways which span the northern and southern hemispheres and in doing so overfly or visit numerous countries during each migration.

Because these species encounter numerous and varied pressures during their life cycle, it is difficult to establish firm links between population numbers, and management of foreshores within the region, for example controlling threats such as degradation of feeding sites, pollution and hunting/disturbance of shorebirds (Environment Australia and Wetlands International, 2002). However, ongoing monitoring suggests that human disturbance does influence roosting populations, particularly foreshores adjacent to suburban areas that are easily accessible for recreational activities (Harding, 2012; Milton and Harding, 2011).

Figure 6 Mackay Whitsunday regional shorebird survey results (Queensland Wader Study Group, 2012).

Records of nesting marine turtles across beaches in the Mackay region (Newry Island in the north to Freshwater Point in the south) have been collected since 1992 (Figure 4.8). However, it is also difficult to establish firm links between population numbers and management of foreshores within the region given the marine, migratory nature of these species.

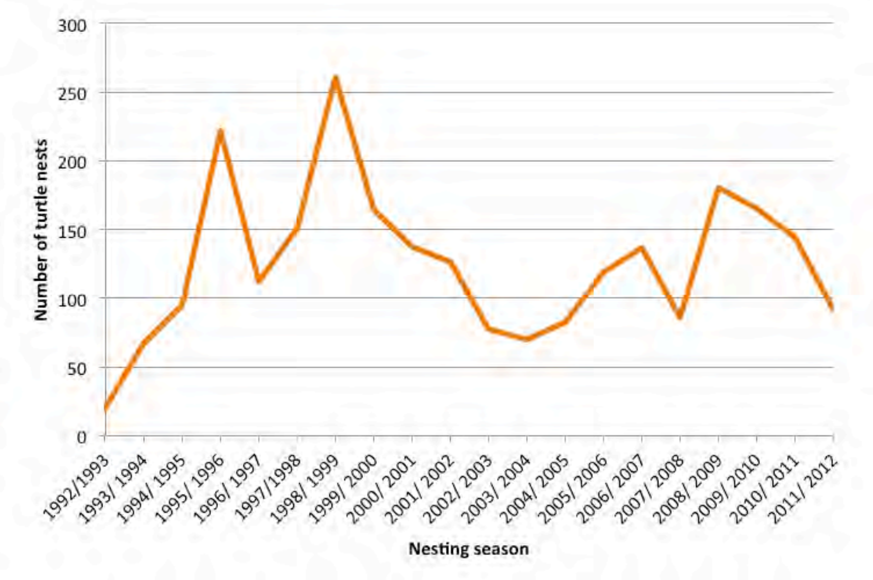
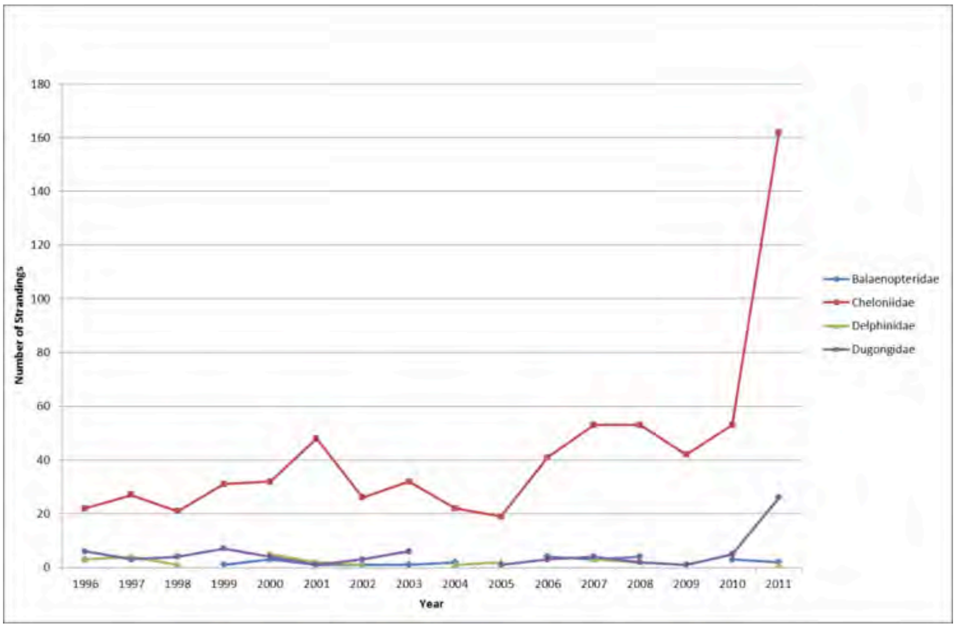


Figure 7 Recorded numbers of marine turtle nests on beaches across the region from Newry Island to Freshwater Point, 1992-2012 (Mackay and District Turtle Watch Association, 2012). Note: This data does not include a measure of volunteer effort which may vary seasonally.

There has been a trend of increased turtle strandings and mortalities since 2011 (Figure 4.9), thought to be related to major flooding events in Queensland which have damaged seagrass beds along the Queensland coast (Queensland Government, 2013b). However, the greatest impact has primarily been on non-breeding immature Green Turtles, so there is little to suggest that this will have a long-term effect on Queensland's Green Turtle population south of Cairns to the New South Wales border at this stage (Queensland Government, 2013b). The loss of seagrass through flooding as a cause of increased strandings and mortality is supported by the concurrent increase in Dugong strandings and mortality over the same period given their reliance on seagrass as a primary food source.

Figure 8 Number of strandings for the Families; Balaenopteridae (baleen whales), Cheloniidae (sea turtles), Delphinidae (dolphins), and Dugongidae (dugongs) by year for the Mackay Whitsunday region (Department of Environment and Heritage Protection, 2013).

Note: Only cases confirmed in the field by a trained person, and later verified by an expert are included.



GOVERNANCE

There are multiple, often overlapping, jurisdictions responsible for management of the coastal zone. With the exception of Ports (Mackay Harbour, Hay Point and Dalrymple Bay) all coastal waters within the region lie within the Great Barrier Reef Coastal Marine Park. This area generally extends to the high water mark and includes all tidal waters and tidal land.

The Coastal Protection and Management Act 1995 gives power to the State Policy for Coastal Management which provides direction for natural resource management decision-makers about land on the coast, such as coastal reserves, beaches, esplanades and tidal areas. However, a Draft Coastal Management Plan has been prepared and will be a statutory amendment to the existing coastal plan under the Coastal Protection and Management Act 1995. The objective of the Coastal Management Plan is to provide policy guidance for managers of coastal land and waters in relation to their natural resource management activities and management of recreational use. The Draft Coastal Management Plan does not address land-use planning or development regulated under the Sustainable Planning Act 2009 (Queensland Government, 2013c),

Development within the coastal zone is regulated under the Sustainable Planning Act 2009 (SPA). The Integrated Development Assessment System (IDAS) of the SPA provides the statutory process for development applications to be made, assessed and decided.

As at 1 July 2013, coastal development will be assessed by the Department of State Development, Infrastructure and Planning (DSDIP) against:

The Coastal Protection State Planning Regulatory Provision (Coastal SPRP)—directs land use planning by local and state governments, and is used for assessing master planned and impact assessable development in the coastal zone and the coastal management district. It suspended the operation of the Queensland Coastal Plan-State Planning Policy for Coastal Protection (SPP 3/11) in October 2012.

It is intended that the Coastal SPRP will be replaced by the single state planning policy (single SPP) during 2013. A draft single SPP has been released for public consultation. The draft single SPP includes policies articulating the state's interests in planning and development including revised coastal SPP 3/11 policies (Queensland Government, 2013c).

On-shore development of new Port facilities or significant expansion of existing facilities currently requires environmental assessment processes either under the State Development and Public Works Organisation Act 1971 (Qld) and/or the Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) if they are likely to have an impact on a Matter of National Environmental Significance (MNES). MNESs include the Great Barrier Reef World Heritage Area (Queensland Government, 2013e).

Beaches and Foreshores

Some areas of beaches and foreshores within the region lie within National Park or Conservation Park with management responsibility lying with the Queensland Department of National Parks, Recreation, Sport and Racing. These areas are required to be managed by principles outlined within the Nature Conservation Act 1992. However, most of the region's beaches and foreshores lie within esplanade or other tenure and are governed by the Land Act 1994. Some beaches and foreshores within the region are State Land or have been dedicated as Reserves. Esplanades and Reserves are generally under trusteeship of the respective local Government, which each have their own structure for managing public coastal land (see box below).

There are extensive areas of land behind the primary beach-line, which are held in freehold tenure.

Coastal Management in the Mackay Regional Council area

The Coasts and Communities program is a joint initiative of Reef Catchments and Mackay Regional Council. The Program uses the principle of integrated coastal management to plan, implement, and maintain coastal projects in partnership with multiple agencies, community groups, and individuals to maximise outcomes and ensure the long term sustainability of coastal environments in the Mackay Regional Council area.

The Coasts and Communities program has four key elements;

- *Planning; Coastal Management Guidelines and Beach Plans guide the management of coastal foreshores and reserves under MRC jurisdiction, in line with the existing State Policy for Coastal Management.*
- *Prioritising; a quantitative conservation framework is used to determine which on-ground projects are the highest priority for implementation annually, depending on funding availability.*
- *Implementation and monitoring of on-ground works; Council staff, contractors, community volunteer groups and local residents contribute to the implementation and monitoring of on-ground works selected to be undertaken. A monitoring database collects information on on-ground works completed.*
- *Community engagement and education; occurs throughout all stages of the program. A program of Coastcare activities is run at local beaches to provide community the opportunity to get involved in on-ground coastal conservation initiatives.*

INDICATORS

Key indicators of the condition of beaches and foreshores include:

- Current biodiversity status of regional ecosystems
- Fire frequency and extent
- Level of physical disturbance
- Weed density and diversity
- Percentage extent of physical disturbance by recreational vehicles and stock
- Level of erosion
- Amount of habitat available for marine turtle nesting and feeding and roosting shorebirds

Aerial imagery (low level 1:12,000 series) is suitable to detect and monitor mid-term changes in condition (>3 years).

BioCondition assessments were carried out in selected beach scrub remnants along the Central Queensland Coast in 2007 using a developed methodology (Cali and Woodcock, 2008). These baseline results could be used for monitoring for quantitative improvements over time (Woodcock, 2008).

Shorebird populations are monitored biennially by Queensland Wader Study Group. This data resides with them and to date they initiate and fund the monitoring program using experts who visit the region, with the support of local agencies and volunteers from BirdLife Mackay.

Monitoring of turtle nesting is undertaken in by volunteers of Mackay and District Turtle Watch Association from Newry Island in the north to Freshwater Point in the south. This data is contributed to the Queensland Turtle Research Program, and to local coastal managers. Draft Whitsunday Region Marine Turtle Management Plan (Hardy and Stoinescu, 2012) collates some data on the relative importance of sites in the Whitsunday region. All beaches in the Mackay Whitsunday region would benefit by the establishment of coordinated nesting turtle monitoring program and data collection.

Marine Stranding Data is coordinated and collected by Queensland Government with information provided by the community and local government.

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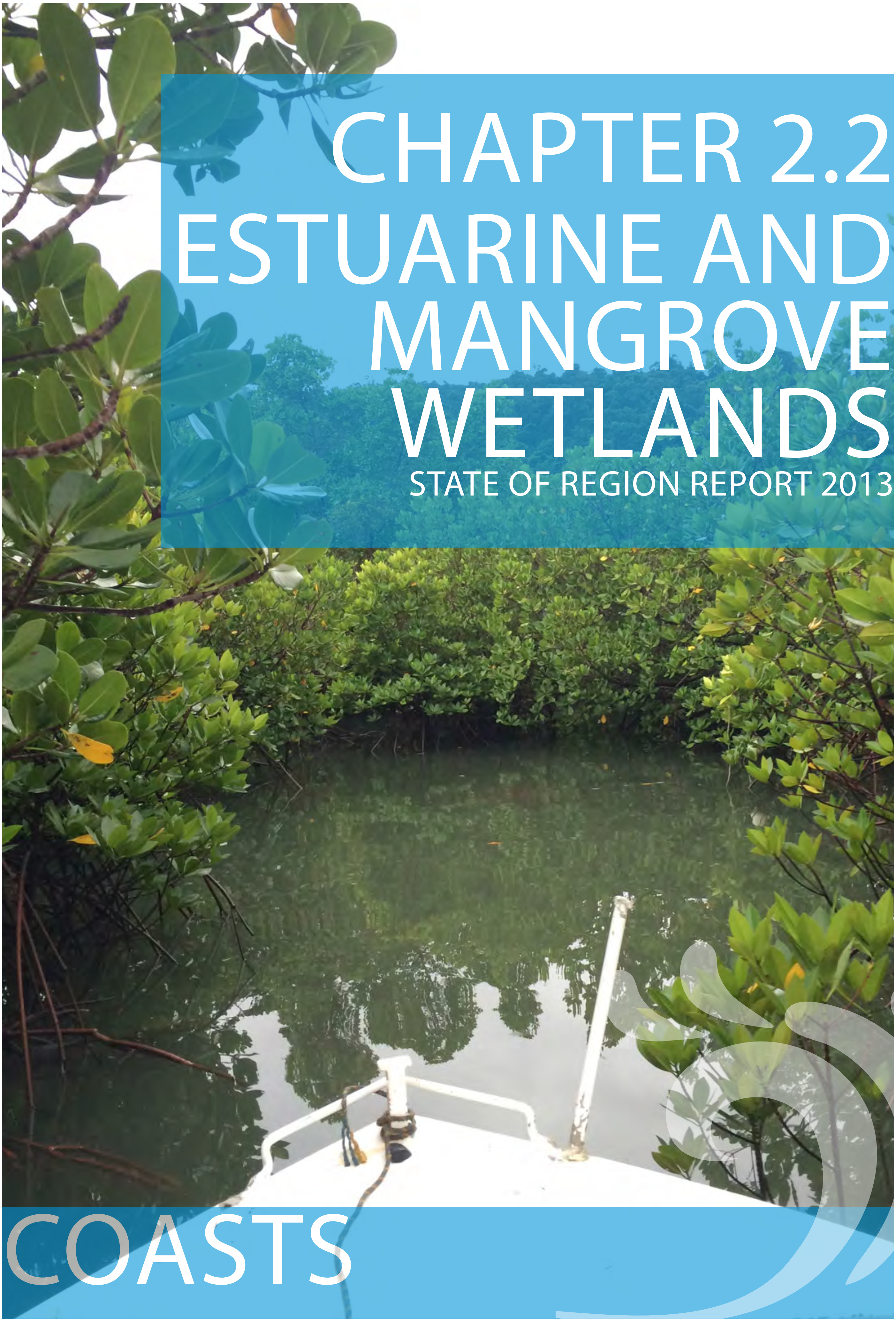
CHAPTER 2.2 ESTUARINE AND MANGROVE WETLANDS

STATE OF REGION REPORT 2013



COASTS

Estuarine and Mangrove Wetlands

REEF CATCHMENTS

SUMMARY

The region supports extensive areas of estuarine and mangrove wetlands, these being dominant features of the coastal landscape. Mangroves and associated communities cover 62,094 ha of tidal land in the region, which contains nine wetland areas recognised as nationally important (Environment Australia, 2001).

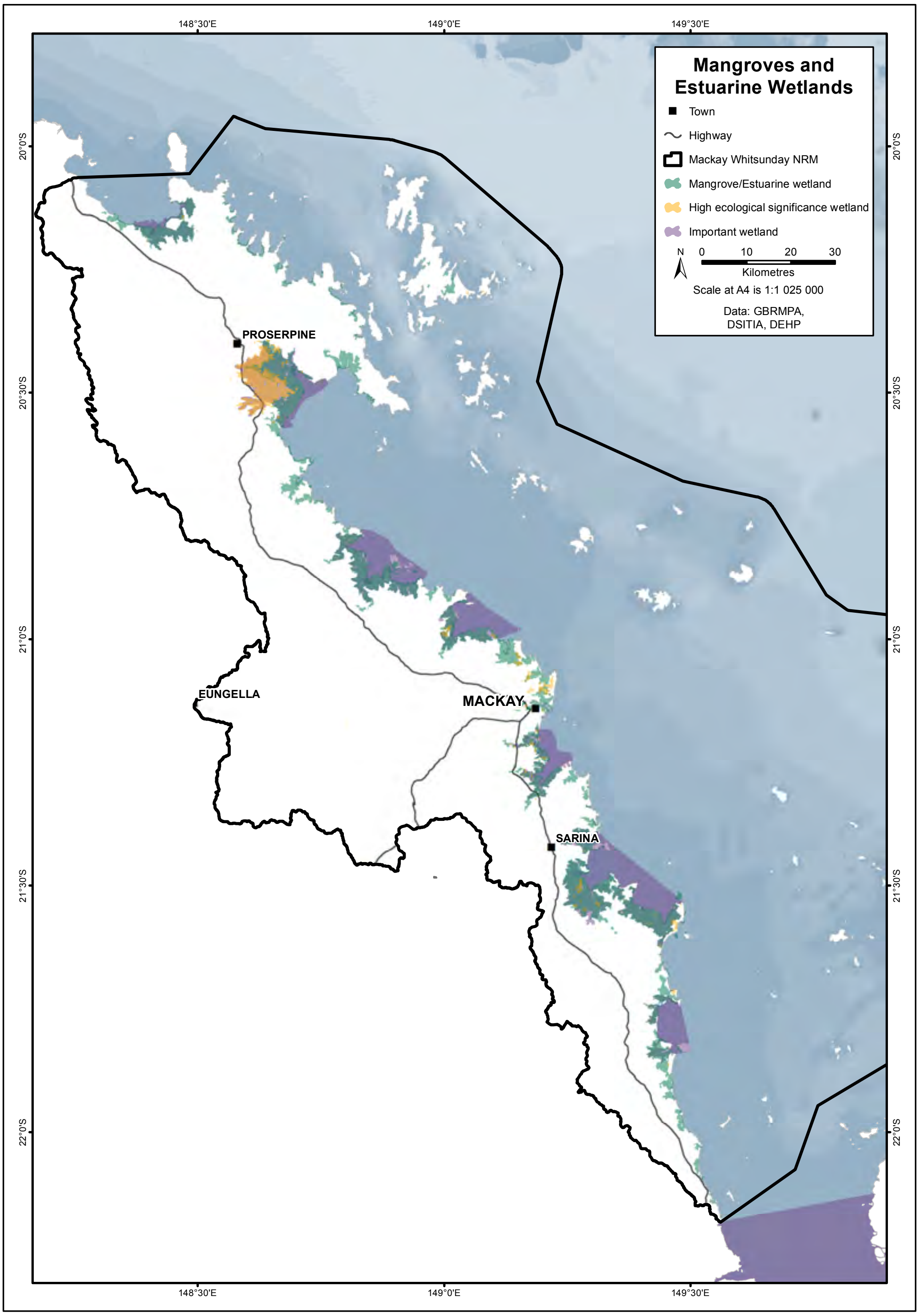


Figure 1 Mangrove and estuarine wetlands,and Nationally important wetland areas within the region.

R E CODE	Regional Ecosystem	Preclear Extent (ha)	2005 Extent (ha)
8.1.1	Mangrove vegetation of marine clay plains and estuaries. Estuarine wetland	33701	32907
8.1.2	Samphire open forbland to isolated clumps of forbs on saltpans and plains adjacent to mangroves	10271	9682
8.1.3	*Sporobolus virginicus* grassland on marine sediments. Estuarine wetland	4133	3458
8.1.4	Paspalum spp. and *Fimbristylis ferruginea* sedgeland/grassland (estuarine wetland). Includes areas of deep open water with clumps of *Schoenoplectus littoralis* ± *Eleocharis dulcis*	1779	1263
8.1.5	*Melaleuca* spp. and/or *Eucalyptus tereticornis* and/or *Corymbia tessellaris* woodland to open forest (estuarine wetland) with a ground stratum of salt tolerant grasses and sedges, usually in a narrow zone adjoining tidal ecosystems	1779	1263
11.1.1	*Sporobolus virginicus* grassland on marine clay plains	555	451
11.1.2	Samphire forbland on marine clay plains	8560	8129
11.1.4	Mangrove forest/woodland on marine clay plains	5830	5540

Table 1 Types and extent of mangrove and associated regional ecosystems occurring within the region

There are six criteria by which areas are assessed for inclusion in the listing of nationally important wetlands. Within the region, while not listed as nationally important wetlands; Goorganga Plain, Sand Bay, Sandringham Bay - Bakers Creek Aggregation and Sarina Inlet – Ince Bay Aggregation meet all of the ecological and biological criteria as below.

"The criteria for determining nationally important wetlands in Australia, and hence their eligibility for inclusion in the Directory, are those agreed to by the ANZECC Wetlands Network in 1994.

A wetland may be considered nationally important if it meets at least one of the following criteria:

1. It is a good example of a wetland type occurring within a biogeographic region in Australia.
2. It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.
3. It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail.
4. The wetland supports 1% or more of the national populations of any native plant or animal taxa.
5. The wetland supports native plant or animal taxa or communities which are considered endangered or vulnerable at the national level.
6. The wetland is of outstanding historical or cultural significance"

Directory of Important Wetlands (Environment Australia, 2001;11)

Seven broadly recognised mangrove communities occur within the region. Within the high rainfall areas of the central Queensland coast bioregion, estuarine wetlands are about equally dominated by salt pan and samphire flats along the high intertidal area; yellow and orange mangroves (Ceriops tagal and Bruguiera spp) along the mid-intertidal; and stilted mangroves (Rhizophora stylosa) in the lower intertidal.

Vegetation Community	Percentage Extent within the region	
	Central Queensland Coast	Brigalow Belt North
Closed shrub-land of *Aegiceras corniculatum*. This community is rare within the study area and typically occurs as a thin linear fringe on the landward side of other communities.	< 1%	1%
Open to closed forest of *Avicennia marina*. This community occurs at both landward and seaward margins, and is often structurally variable at any given location.	3%	2.5%
Open to closed forest of *Ceriops tagal* +/- *Bruguiera* spp. Two forms of this community are readily recognised. One forms a tall (to 12m) forest near the supra-littoral zone and tends to contain *Bruguiera* spp as co-dominants or rarely, dominant canopy species. The second is a low open to closed forest or shrub-land occurring near the supra-littoral margin, or on low rises surrounded by saltpan.	25%	6%
Mixed species closed forest.	13%	5%
Closed forest of *Rhizophora* spp typically R. *stylosa*. These forests typically occur on seaward margins or in areas close to, or within regular tidal flows.	31%	22%
Saline grassland (dominated by *Sporobolus virginicus*). Saline grasslands are typically supra-littoral communities that grade into adjacent samphire flats and/or terrestrial vegetation.	3.5%	<1%
Salt-pan and samphire flats. The level to which salt-pans are vegetated by samphire is highly variable and in many areas no vegetation is present.	23%	65%

Table 2 Major inter-tidal vegetation communities within the region: CQC = Central Queensland Coast

VALUES AND SERVICES

The region's estuaries directly support several commercial fisheries. The economic value of the mud crab (Scylla serata) fishery in 2000 was $1.35 million and the estuarine finfish fishery comprised principally of barramundi, salmon and mullet, was $0.47 million (Dodds, 2004). More recent catch data does not appear to be available for the region, however species are considered as being sustainably fished (Trestrail et al, 2013).

Estuaries also contribute significantly to recreational fisheries with fishers spending approximately $42 million annually on this pursuit (Dodds, 2004). 28% of residents of the Mackay region fish recreationally, a number significantly higher than the state average of 17% (Department of Employment, Economic Development and Innovation, 2010).

The real economic value of mangroves is however much higher than these combined fisheries, as mangroves act as nursery habitat for numerous other species which are subsequently harvested in different habitats. Estuaries within the region are highly valued by communities particularly for recreational fishing and crabbing opportunities and these are important part of the lifestyle of the region's communities.

In addition to their economic and social values, mangroves provide essential ecosystem services. These notably include coastal protection functions through which the affects of storm surges and cyclones are reduced (Bridgewater and Cresswell, 1999), nutrient retention (Clough et al, 1983), and detoxification of storm water (Anon, 2005). These functions will become increasingly important because of climate change induced sea level rise and increased storm activity (Bridgewater and Cresswell, 1999). The importance of mangroves and saltmarsh in carbon sequestration ('blue carbon') has become increasingly understood (McLeod et al. 2001) and this will be vital in consideration of ongoing management of these systems within the region.

Indigenous Australians with traditional links to the region maintain an overriding interest in sustainable management of natural resources. Fishing remains an essential and integral part of life.

Estuarine crocodiles (Crocodylus porosus) inhabit estuarine areas throughout the region and have breeding populations within Proserpine River and associated tributaries, and Rocky Dam Creek. This species remains vulnerable to extinction as a result of dramatic population decline associated with intensive harvesting in the mid 20th century. Based on a Queensland wide study, the broader region from Cape Bowling Green to Shoalwater Bay supported approximately 10% of the Queensland hatchling population during the period 1994 – 2000 (Read et al. 2004). The lack of greater breeding activity is due to suboptimal temperatures and destruction of nesting habitat through clearing and hydrological modification of floodplain based nesting sites. Translocation has been used in the past to alleviate the issue of crocodiles near human settlements, although this may be misguided management tool, as translocated crocodiles return rapidly and purposely to their capture locations for distances up to 411km (Read et al., 2007). The Mackay Whitsunday region does not currently have a crocodile management plan (DEHP, 2013a).

The Mackay area is the type locality for the vulnerable false water rat (Xeromys myoides), now more commonly known as the mangrove or water mouse, which was first discovered in Mackay. More recent scientific review considered the species to be endangered (Dickman et al. 2000). Comprehensive study (Ball, 2004) determined that within the region, the mangrove mouse only occurs in supra-littoral communities dominated by yellow and orange mangroves (Ceriops tagal, Bruguiera spp.) which make up only around 25% of all mangroves present. Subsequent study (Ball, unpublished data) confirmed that the species is very rare and numbers fluctuate markedly among years.

PRESSURES AND THREATS

The major pressures which have and/or continue to act on mangroves and associated estuarine areas are clearing (through urban, port and industry development), dieback, changes in hydrology (e.g. restriction or alteration of flows) and pollution (Schaffelke et al. 2005). In addition to these, overfishing, cattle grazing, pest animals, use of recreational vehicles and fire, have impacts on some components of mangrove and estuarine systems (EHP, 2013b). Some of these pressures are more subtle but may be resulting in considerable changes in ecosystem functioning.

Urban development is becoming increasingly common along mangrove margins and results in increased impervious surfaces, which collect and facilitate discharge of storm-water at point locations into littoral mangrove margins. In contrast, natural storm-water inputs into mangroves are largely diffuse flows. Grapsid crabs are considered 'ecosystem engineers' as they perform roles that have considerable influence on ecosystem processes such as leaf litter processing, soil aeration and nutrient cycling. A comprehensive study within the region found significantly fewer, and sometimes no grapsid crabs in areas influenced by urban stormwater.

Increased understanding of these ecosystems has led to concerns about decreasing connectivity from supra-littoral saltmarsh areas to other coastal ecosystems notable seagrass beds. Bridgewater & Creswell (1999) note that the interlinkage between mangrove saltmarshes and partially of totally submerged seagrass is critical. A study confirmed and partially quantified these linkages (Saintilan et al., 2007), providing support for the hypothesis that fish which reside primarily in seagrass beds, move to saltmarsh to feed during spring high tides. Therefore any loss or decline of either saltmarsh or seagrass habitats within or adjacent to estuarine areas is of concern. Irlandi and Crawford (2007) recommend that to optimise outcomes for fish habitat, mangrove and saltmarsh restoration projects should either be prioritized to locations where available seagrass exists, or should have seagrass restoration incorporated as an objective.

Some fish species such as barramundi, mangrove jack and striped mullet live out part of their life cycle in freshwater before moving into marine and estuarine areas to spawn (Marsden et al., 2006). Thus estuary-freshwater connectivity is crucial for the long-term sustainability of populations of these species. Numerous barriers to fish movement have been identified in the region (Marsden, et al. 2006).

Seven major threats to regional ecosystems which form the region's mangrove and estuarine wetlands are illustrated by Figure x. These threats are often related. For example; hydrological change (including development of ponded pasture) may significantly alter water quality, and heavy and sustained grazing pressure of marine grasslands can dramatically alter ground cover and thus both habitat value, and the filtration and retention capacity of those areas.

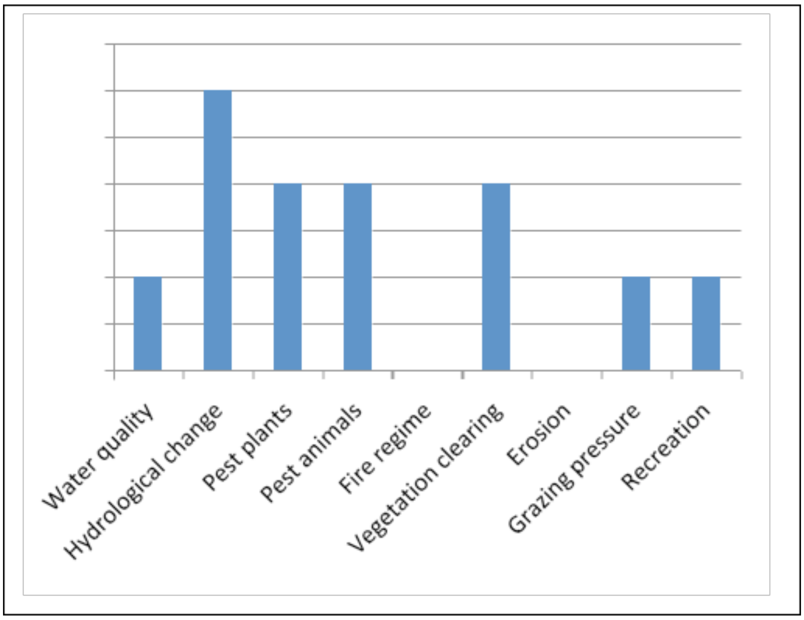


Figure 3 Percentage of mangrove and estuarine regional ecosystems affected by major threats

"Given their geomorphic situation within narrow elevation ranges in the intertidal zone, saltmarshes are sentinel ecosystems in the coastal zone and already the impacts of relative sea-level rise are being manifest. Elevated atmospheric carbon dioxide, temperature rise, altered fire regimes, and a range of hydrological changes may also impact on saltmarshes, compounding the pressure of coastal development, vehicular impacts, pollution and invasive species" (Staintilan and Rogers, 2013; 2)

CONDITION AND TRENDS

The National Land and Water Resources Audit (Australian Government 2001) provides condition reports for all estuaries within the region with exception of several very small areas (e.g. Eimeo Creek) . Most estuaries are in either near pristine or largely unmodified condition. One (Pioneer River) is extensively modified, and five (Bakers Creek, Don River, Proserpine River, Rocky Dam Creek, and the un-named estuary Q223) are modified.

The original area of mangroves within the central Queensland coast bioregion was 50,780 ha, of which 47, 984 ha remained as at 2003 (i.e. a loss of 2796 ha or 6%; refer to Figure 6). It is important to note however that the vast majority of vegetation clearance occurred prior to 1997; 55 ha had been lost between 1997 and 2003 (or 0.2 % of the original extent) and another 10ha between 2003 and 2005. Most of the original loss was of mangrove, samphire and grassland (2056 ha) however a greater proportion of the original extent of the supra-litoral communities (sedgeland/ grassland and fringing forest) was lost. Accordingly these later two communities are considered endangered, a situation made worse by lack of protection for the remaining areas (see below).

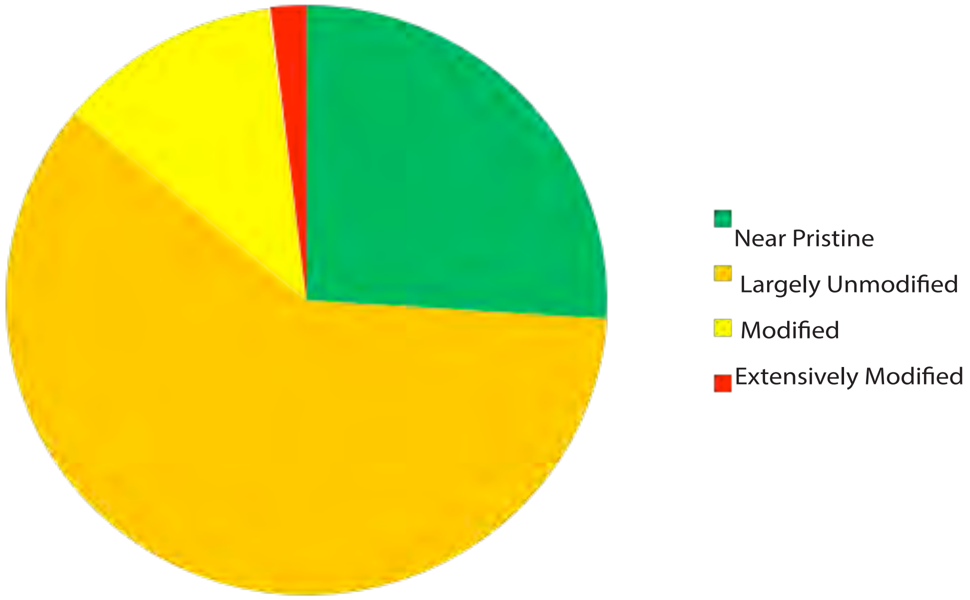


Figure 4 Condition of the region's 42 estuaries

Of the five regional ecosystems which comprise estuarine and mangrove wetlands within the central Queensland coast bioregion; two are considered endangered, two 'of concern' and the other secure. Only two ecosystems (mangroves and samphire) are adequately represented within protected areas (Figure5). The three regional ecosystems within the brigalow belt are not currently threatened although they have a low representation within protected estate.

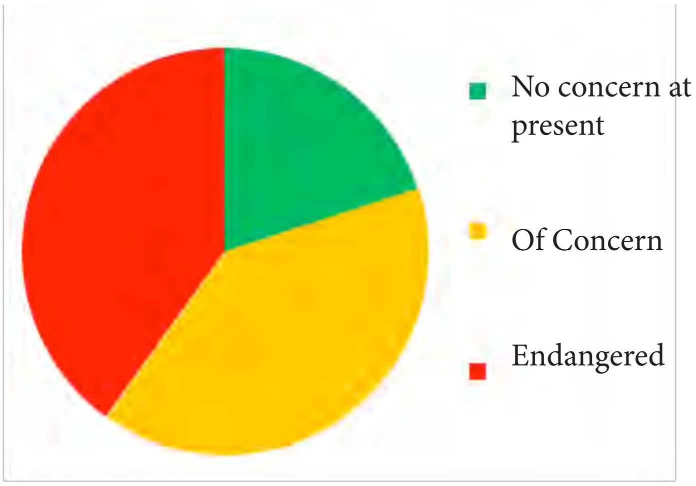


Figure 5 Conservation status of mangrove and estuarine regional ecosystems.

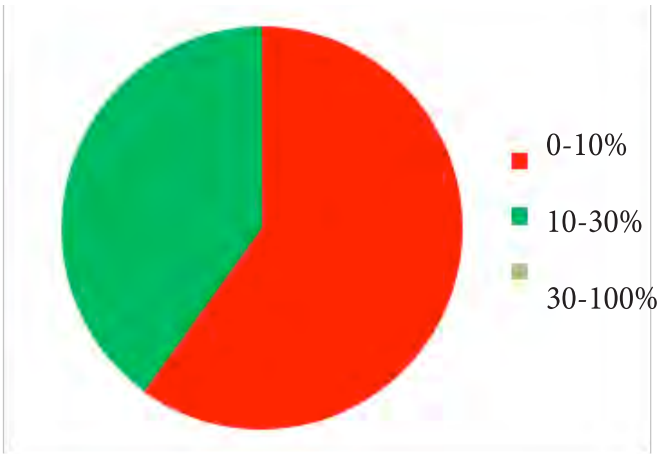


Figure 6 Percentage of pre-clearing extent of mangrove and estuarine regional ecosystems within protected areas

	Regional Ecosystem	Preclear Extent (ha)	2003 Extent (ha)	Area Protected (ha)	% Protected	Biodiversity Conservation Status
8.1.1	Mangrove vegetation of marine clay plains and estuaries. Estuarine wetland	33702	32907	4143	12.3	No concern at present
8.1.2	Samphire open forbland to isolated clumps of forbs on saltpans and plains adjacent to mangroves	10270	9683	1293	12.6	Of concern
8.1.3	*Sporobolus virginicus* grassland on marine sediments. Estuarine wetland	4129	3455	54	1.3	Of concern
8.1.4	Paspalum spp. and *Fimbristylis ferruginea* sedgeland/grassland (estuarine wetland). Includes areas of deep open water with clumps of *Schoenoplectus littoralis* ± *Eleocharis dulcis*	1779	1276	14	0.8	Endangered
8.1.5	Melaleuca spp. and/or *Eucalyptus tereticornis* and/or *Corymbia tessellaris* woodland to open forest (estuarine wetland) with a ground stratum of salt tolerant grasses and sedges, usually in a narrow zone adjoining tidal ecosystems	900	663	17	1.9	Endangered

Table 3 Historical and current extent of estuarine vegetation, percent protected and conservation status (Central Queensland Coast Bioregion).

Dieback of one mangrove species; Avicennia marina has occurred in several estuaries within the region. Schaffelke et al. (2005) reported that 96.9% of the cover of this species was affected in the Pioneer River and 61.3% in Bakers Creek, but only 16.8% in McReady's Creek and none within Bucasia/ Eimeo Creeks (for a total of 1474 ha affected within the region) . The cause of this dieback has not been satisfactorily clarified; Schaffelke et al. (2005) support a link between herbicide pollution and dieback however further investigation (Wake, 2006) does not appear to support the proposed relationship between herbicide concentration and mangrove dieback.

Investigation into the impact of changed hydrology on mangroves communities within the region has largely focused on the impact of urban storm-water run-off (Ball, 2004). This investigation provides strong evidence for a decline in mangrove crab (Family: Grapsidae) abundance in the presence of urban storm-water point discharge. This finding is concerning as grapsid crabs are well recognised as keystone species, and any substantial impact on their populations may have broader consequences to the mangrove community. The actual consequences of a decline in grapsids may include a substantial decline in leaf litter processing and disruption to the flow of organic carbon from mangroves to other coastal ecosystems. For example, within the region crabs removed 4.10 to 5.76 t/ha/year (37-63% of total leaf litter fall) and 1.96 to 6.35 t/ha/year (8-42% of total leaf litter fall; wet season). In the case where crab abundance is reduced a significant amount of this organic carbon will not reach coastal food chains.

GOVERNANCE

In Queensland, mangroves and all other marine plants are completely protected under the Fisheries Act 1994. The protection extends to seagrasses, salt couch and plants such as melaleuca that grow adjacent to tidal lands. Any disturbance (such as trimming, mowing or removal) of marine plants requires an approval from Fisheries Queensland.

Whilst the primary jurisdiction for protection of marine plants lies with Fisheries Queensland, mangroves also lie within Marine Parks and within protected areas under the umbrella of the Nature Conservation Act. Further protection, particularly from downstream impacts as a result of changed land use within coastal catchments, could be afforded by the Coastal Protection Act through development of regional coastal management plans. However, this is currently not the case and less obvious but important impacts such as changes to hydrology, are not currently regulated.

INDICATORS

Periodic reviews of regional ecosystem mapping can be used to track changes in the geographical extent of mangrove and saltmarsh regional ecosystems. Recently completed coastal LIDAR mapping could also be used to predict the potential (or lack thereof) for migration of these ecosystems under sea level rise scenarios.

Aerial photography and site specific monitoring will enable tracking of the recovery of saltpan, saltmarsh and marine grasslands. Property management planning and reporting can provide clear guidance on improved protection of marine plains from grazing pressure.

A greater understanding is needed of the impacts of changed hydrology on mangroves systems, and their capacity to provide functional ecosystem services in terms of water quality. In particular it would be useful to undertake a quantitative assessment and ongoing monitoring of the geographical area of mangroves influenced by urban storm-water runoff.

Reef water quality is improved in line with the thresholds, indicators and mechanisms identified by the Mackay Whitsunday Water Quality Improvement Plan (Drewry 2007).

REEF CATCHMENTS

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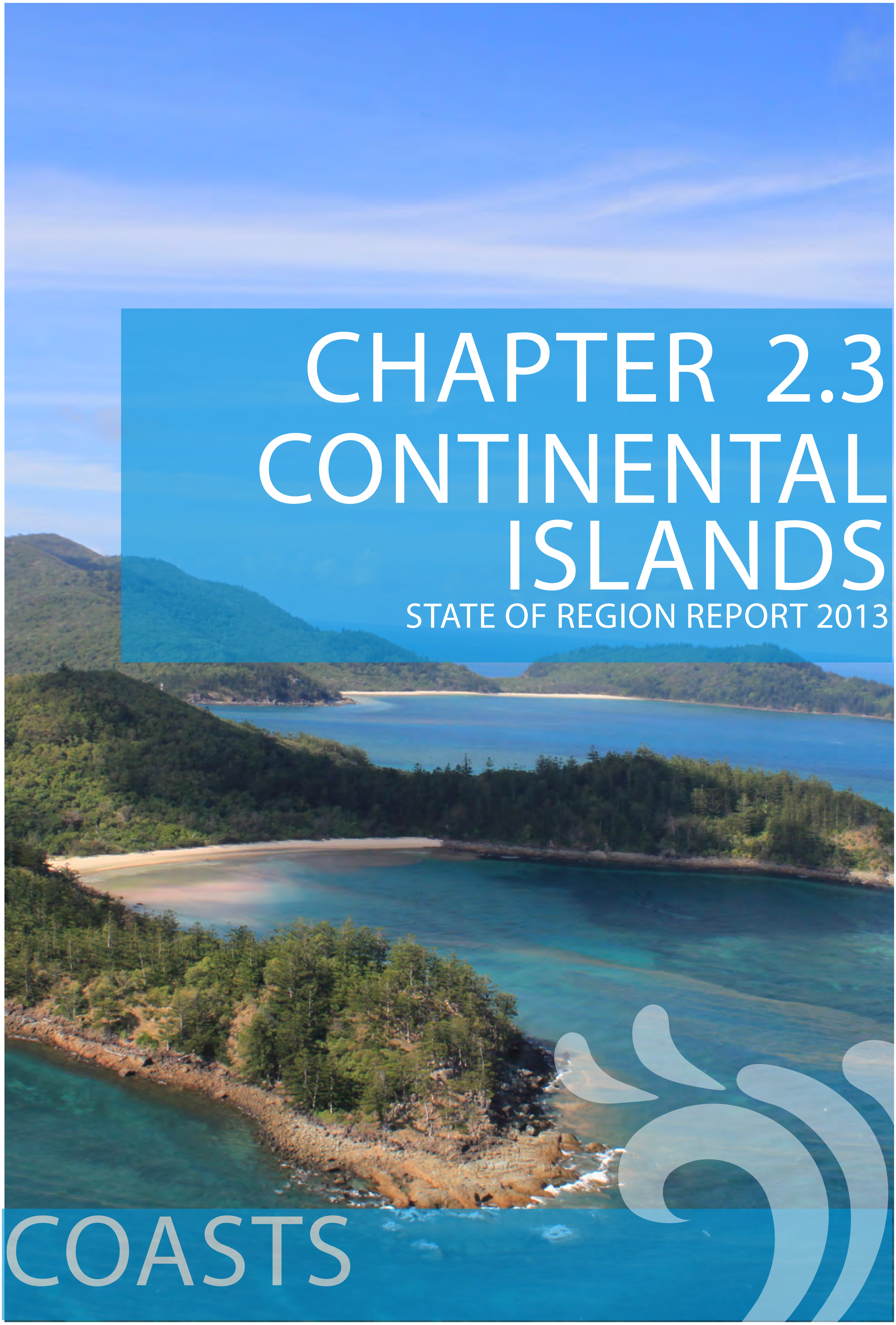

CHAPTER 2.3
CONTINENTAL ISLANDS

STATE OF REGION REPORT 2013

COASTS

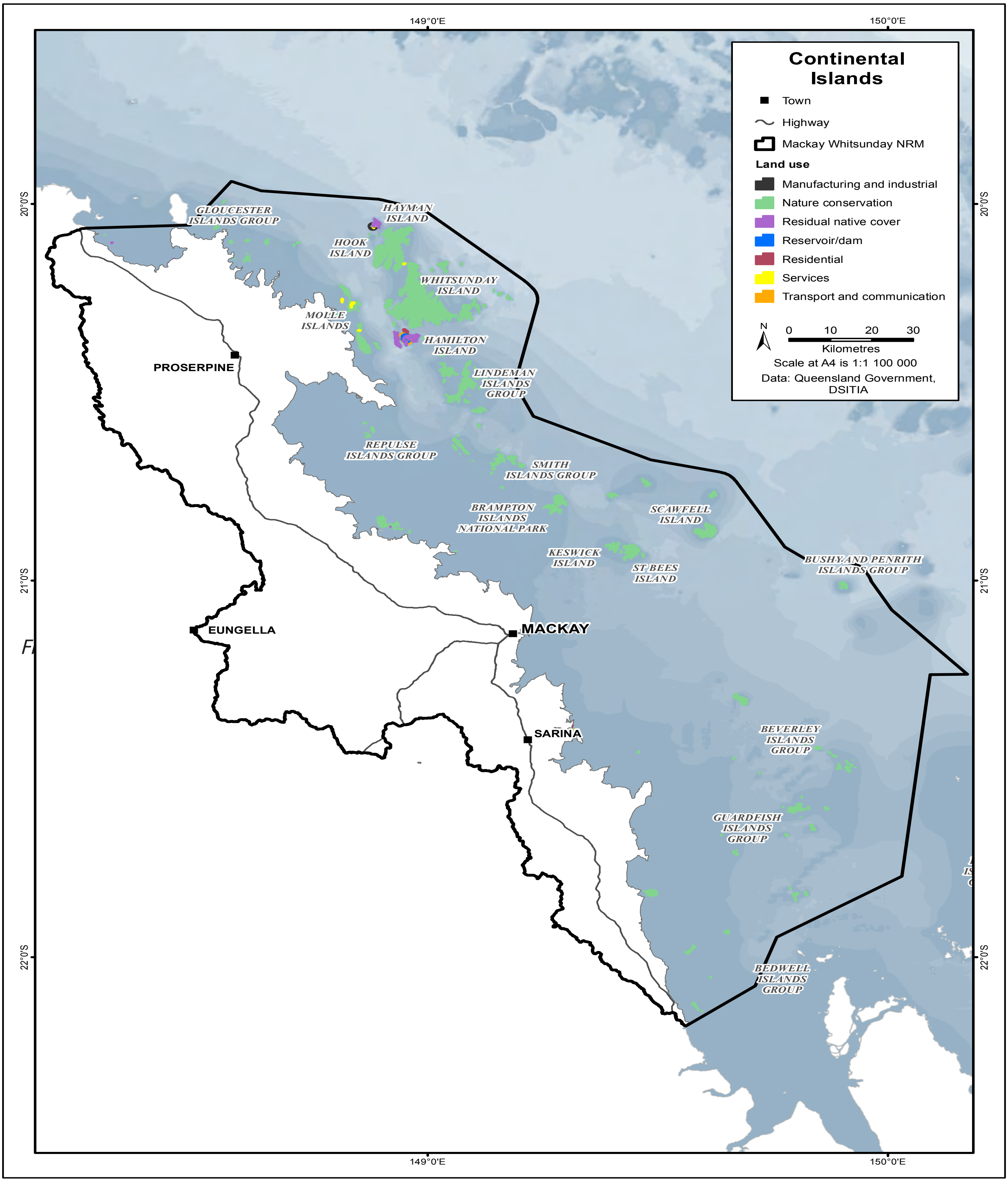

Figure 1 Islands of the region

Continental Islands

REEF CATCHMENTS

SUMMARY

The region contains one hundred and forty five islands, of which all but eighteen are protected as National Parks, in addition to numerous smaller islets and exposed rocks. In this respect the region contains almost 25% of all the continental islands that occur along the Queensland coast.

Of the National Park islands, five (South Molle, Long, Hook, Lindeman and Brampton Islands) have been partly developed as tourism resorts on land leased from the National Park. However, most of these are not currently operating largely because of market downturns, for example Lindeman Island and Hook Island resorts. Two resorts are on fully leased islands (Hayman and Hamilton), and resort infrastructure is currently being developed on Dent Island. Middle Percy Island has recently been converted to National Park, with a smaller area as Conservation Park with previous lessee's appointed as caretakers and trustees. A small leased area also exists on St Bees Island and a larger area of Keswick Island is partly developed as a satellite suburb of Mackay City. Several islands remain as unallocated State land where little or no active management is being undertaken.

"It is wrong to think of the individual islands or groups of islands as remnants of particular individual volcanoes. During the 100 million years after eruption, there was sufficient time for the volcanic terrain to erode into a landscape of mountains, hills and valleys only tenuously related to its origins. The present islands and adjacent mainland are simply the mountain tops and ridges of this old landscape, which has been inundated by the sea in more recent times.No one knows for certain when this 'drowned' landscape first came about. Certainly at the depth of the last ice age 19,000 year ago, the sea level was about 150 m lower than present, and the coastline was about 140 km farther east (east of the outer Barrier Reef). As the climate subsequently warmed, the level of the ocean rose rapidly, and from 10,000 to 6,000 years ago the coastal fringe was progressively inundated and the higher hills became isolated as the islands we see today."

(Willmott, 2006; 107-108)

The islands have strong affinities with natural systems on the adjoining mainland. The Northern Group; Whitsunday, Molle, Lindeman, Repulse, Smith Islands and those of the southern Gloucester Islands aggregation, are closely similar to, and lie within the Whitsunday sub-region of the Central Queensland Coast Bioregion. The few small islands lying adjacent to the Don Basin are within the Townsville Plain sub region of the northern Brigalow Belt Bioregion. The Newry, Cumberland and Brampton Island groups have affinities with coastal hills on the adjoining Mackay coast. There is a strong environmental gradient between the Northumberland and Percy Islands which corresponds largely to a latitude change related to decreasing rainfall in the south, but also an east-west gradient as a result of sea exposure.

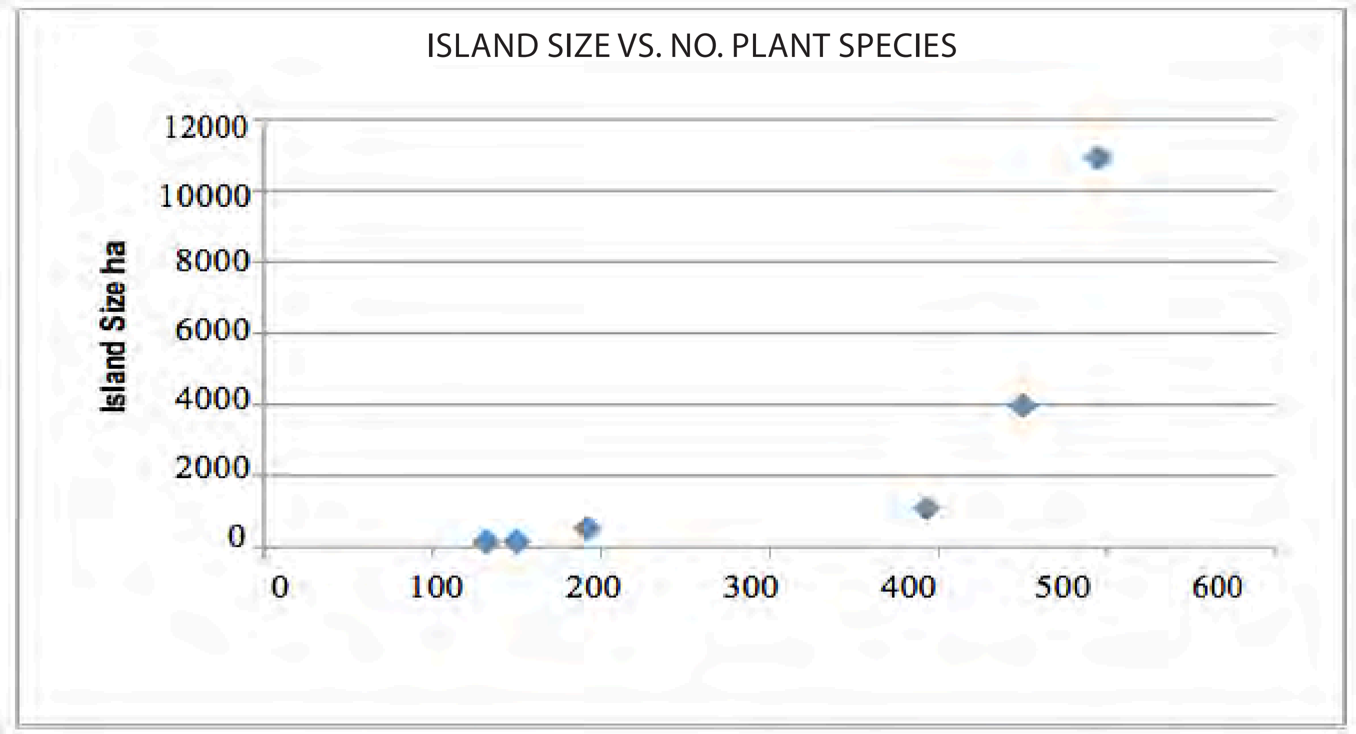

Figure 2 Island size vs. Species richness.

Several Islands are worthy of particular note as they have unique biophysical characteristics. Bushy Island is the only vegetated sand cay within the central region of the Great Barrier Reef. This island is also unique as it has developed on a reef which has formed around Redbill Islet. South Percy Island is the only continental island which is largely formed by serpentinite rocks, a rare and highly geographically restricted geological type. South Percy and Whitsunday Island are also partly formed by extensive sand dune deposits. Rabbit Island in the Newry Group has extensive areas of low lying mangroves and smaller but notable areas of lowland melaleuca wetland (Queensland Herbarium, 2013).

While little documentation exists which describes the terrestrial fauna that inhabits the continental islands, it is well accepted that few large mammals (e.g. macropods, possums, dingos) naturally occur, although some introduced populations exist (e.g. brushtail possums on Hayman, grey kangaroos on Brampton). The exception is presence of the endangered Proserpine rock wallaby on Gloucester Island and possibly unadorned rock wallabies on Whitsunday Island. In addition, goats were introduced to many of the islands, although most populations have either been eradicated or are under current control efforts.

Considerably more information is available regarding island flora (e.g. Batianoff; 1987, 1992, 1995; Batianoff & Dillewaard, 1997). Generally there is a strong relationship between species richness and island size, with larger islands having more diverse flora. While islands do support some rare species, they generally have fewer than adjacent coastal mainland areas. There are only three plant species known to be endemic to Queensland's islands, two of which are supported within the region.

Importantly however, the region's islands support several regional ecosystems that have no or very little representation on the mainland. These include grasslands on island slopes and headlands, woodlands to closed forest of ironbark (E. Drepanophylla) and brushbox (Lophostemon confertus), and woodlands of hybridised blue gum (E. tereticornis) and poplar gum (E. Platyphylla).

WHITSUNDAY ISLANDS

- Bird
- Black
- Border
- Buddlibuddli
- Cid
- Cow and Calf
- Cowrie
- Deloraine
- Dent #
- Dumbell
- Dungarra
- Esk Fitzalan
- Hamilton#
- Harold
- Haselwood
- Hayman #
- Henning
- Hook #
- Ireby
- Langford
- Long #
- Lupton
- Nicolson
- East Repulse
- North Repulse
- South Repulse
- Perseverance
- Plum Pudding
- Sillago
- Teague
- Titan
- Whitsunday
- Wirrainbela
- Workington
- Yuindalla

LINDEMAN ISLANDS

- Baynham
- Cornston
- Gaibirra
- Triangle
- Keyser
- Lindeman #
- Little Lindeman
- Maher
- Mansell
- Pentecost
- Seaforth
- Shaw
- Thomas
- Volskow

MOLLE ISLANDS

- Daydream #
- Denman
- Goat
- Mid Molle
- North Molle
- Planton
- South Molle #

NORTHERN GROUP

- Armit
- Double Cone
- Eshelby
- Gloucester
- Grassy
- Gumbrell
- Olden
- Rattray
- Saddleback

SMITH ISLANDS

- Allonby
- Anchorsmith
- Anvil
- Bellows
- Blackcombe
- Blacksmith
- Goldsmith
- Hammer
- Ingot
- Ladysmith
- Linne
- Locksmith
- Pincer
- Silversmith
- Tinsmith

NEWRY ISLANDS

- Acacia
- Mausoleum
- Newry
- Outer Newry
- Rabbit

OTHER ISLANDS

- Carpet Snake
- Camp
- Cave
- Green
- Gould
- Midge
- Pigeon
- Stone
- Holbourne

BRAMPTON ISLANDS

- Brampton #
- Carlisle
- Wedge
- Round Top
- Flat Top

SOUTH CUMBERLAND ISLANDS

- Aspatria
- Bushy
- Calder
- Cockermouth
- Derwent
- Keswick #
- Penrith
- Scawfell
- Snare Peak
- St Bees #
- Wigton

PERCY ISLES

- Hotspur
- Middle #
- North East
- Pine Peak
- South
- Vernon Rocks
- Beverlac
- Bluff
- Calliope
- Connor
- Curlew
- Digby
- Dinner
- Douglas
- Double
- George
- Henderson
- Hirst
- Hull
- Innes
- Irving
- Keelan
- Knight
- Minster
- Noel
- Penn
- Poynter
- Prudhoe
- Renou
- Still
- Temple
- Thonee Peak
- Treble
- Wallace

Table 1 Island occurring within the region. Shaded are non-protected areas. # = Resort Island

VALUES AND SERVICES

During 2012 643,000 people visited the Whitsunday area, an increase of 2% on the previous year (Tourism and Events Queensland 2012). In 2004 when data was last gathered, 31% of visitors stayed at least one night on an island and 34% visited islands by boat (Anon, 2004). These figures clearly demonstrate the attractiveness of the Whitsunday Islands to tourists, and the contribution they make to local economies. A wide range of tourism experiences are available ranging from 'backpacker' accommodation, to Hayman Island Resort, which is consistently recognised as Australia's premier luxury resort by international standards. Figure 6.2 outlines some recreational opportunities within the Whitsunday area.

The region's islands support over 1000 species of vascular plants, well over 10% of all the plants found in Queensland. Gloucester Island supports the endangered Proserpine rock wallaby (Petrogale persephone), the only naturally occurring island population. Recent survey found this population to be healthy but nevertheless limited in abundance by its required rainforest habitat (Ball, 2012 pers obs). A trans-located population of this species occurs on Hayman Island, having been introduced as 'insurance' against declines in mainland populations.

Other threatened species occurring on the islands include the death adder (Acanthophis antarcticus), coastal sheath-tail bat (Taphozous australis) and beach stone curlew (Esacus neglectus) (Wildnet, 2007). Shorebirds and sea birds are particularly notable island fauna with islands such as Eshelby, Tern, and Redbill Islet known nesting areas. Bushy Island supports a large colony of common noddies (Anous stolidus), numbering in the thousands despite the relatively small size of the island. Many of the continental islands and rocky islets are important nesting habitat for the migratory pied imperial pigeon (Ducula bicolour) during its seasonal movement patterns along the Queensland coast. Marine turtles including flatback turtles (Natador depressa), loggerhead turtle (Caretta caretta) and green turtles (Chelonia mydas) nest on islands within the region (Anon, 2005). Significant green turtle rookeries occur on Bushy, Pine Peak and South Percy Islands. Bushy Island is the northern limit for loggerhead turtle nesting and some also occurs on South Percy Island (Anon, 2005).

Islands are of significant scientific interest as they are living examples of the results of climate change and consequent sea level rise. The different diversity supported by islands of different size, location, altitude and exposure offers opportunity to understand how further climate change may affect other natural systems. In addition, islands with relatively simple ecosystems offer learning opportunities in terms of management of more complex areas. One of the key values of islands is that they can be more easily maintained in natural condition, particularly if robust bio-security measures are put in place to restrict the arrival of pest species (Island Arks 2013). In addition, unlike mainland areas, it is often possible to eradicate feral animals and to a lesser degree some exotic plants. Islands also offer significant opportunities for translocation and management of threatened species populations which otherwise may not survive in mainland situations.

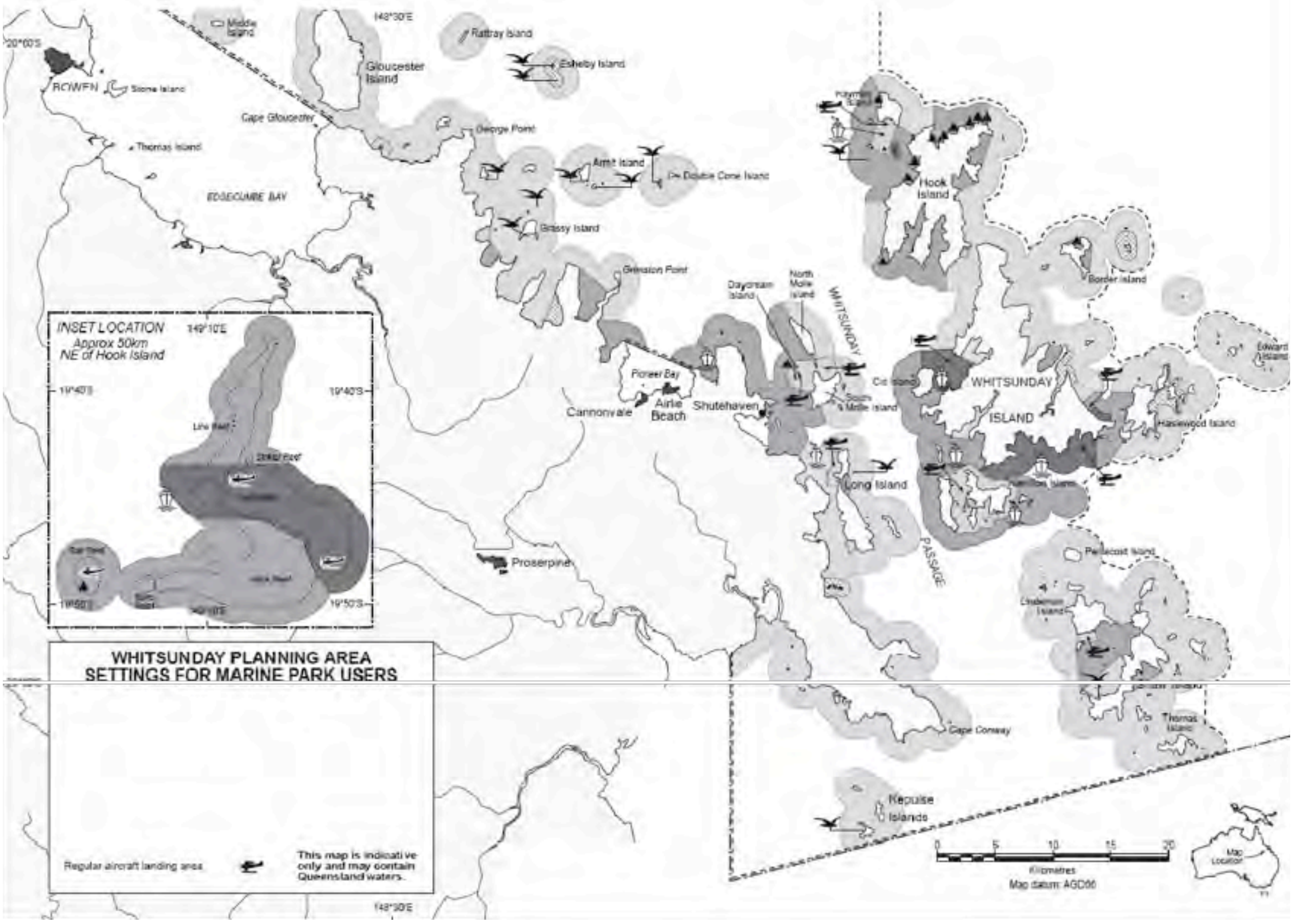

Figure 3 Recreational opportunities and constraints in the Whitsunday Islands (reproduced from the Whitsunday Plan of Management EPA/QPWS, 2008)

PRESSURES AND THREATS

Fire is an integral component of the Australian landscape and has been widely used by both traditional and contemporary land managers for a large range of purposes. However, the science of fire use is in many respects in its infancy, and opinions vary about its appropriate application, particularly on islands. Comparison of historical and more recent aerial photography makes it clear that vegetation patterns on some islands have changed markedly this century (Ball, unpublished data). This is particularly the case on inshore islands, with those further offshore exhibiting significantly more stability. This situation is almost certainly related to both fire management and exposure to marine influences such as wind and a salt laden atmosphere.

The Whitsunday Islands experience significant visitation from tourists and built infrastructure such as fencing, toilets and camping facilities have been provided to reduce impacts from visitors. However, islands off Mackay have relatively less visitation and fewer facilities. There exists continual risk of introducing exotic plants and disease such as the root rot fungi (Phytophthora cinnamomi). This is an important consideration for more remote, less visited areas as these tend to have less management presence and thus unwanted introductions could go unnoticed for longer periods of time, allowing pests to become well established. There is also potential for exotic garden plants to 'escape' from island resorts, lighthouses and other gardens into adjoining National Park areas.

In addition to these challenges, resourcing for management of the islands has declined considerably, particularly those off Mackay. However, emergent conservation based tourism is beginning to provide additional resourcing models, for example voluntary groups Wildmob who participate in land management and education activities, and Ecobarge Clean Seas who specialise in the collection of marine debris.

"The role of Aboriginal peoples in the relationship between rainforest and sclerophyll forest is controversial. There were a number of good reasons for Aboriginal peoples to burn islands regularly, i.e. to facilitate travel and food gathering (Brennan 1986). Perhaps mainland tradition alone may well have been enough reason to burn (Haynes 1985). In our view there is a tendency to overestimate the importance of Aboriginal fire regimes on islands. Not all of the 552 continental islands have good access for landing and many are too isolated, small and rocky to offer food or water. We speculate fewer Aboriginal induced fires occurred on islands than on the adjacent mainland. Burning by Aboriginal peoples may have led to changes in the floristic composition and structure but confined to larger islands with fresh water and possibly smaller islands with easy landing. After studying anthropogenic modifications of vegetation on continental islands in the Whitsunday region, Brennan (1986) suggested that much of the Araucaria cunninghamii (fire sensitive species) distribution may reflect extensive use of fire by Aboriginal peoples. He cites that most of the Araucarian forests occur on the steep rocky slopes and/or protected gullies of 'togographic refugia'. Brennan (1986) also found that most of the islands supporting large areas of grassland in the Whitsunday region were remote, smaller, offshore islands. Brennan (1986) concluded that most of these grasslands occur on southeast sides of the islands and were natural formations maintained by windshear and salt spray."

Batianoff & Dillewaard, 1997; 307

Some islands have populations of feral animals present, for example goats, cane toads, cats and on Haslewood and Long Islands, feral pigs. In addition, native species such as brush tail possums (Trichosurus vulpecula) and macropods have been introduced to some islands with detrimental impacts to natural systems. This is most likely due to the lack of a population of regulating predator species, which are not present on the islands.

CONDITION AND TRENDS

Visitation to the islands in the Whitsunday area continues to rise as indicated by tourist expenditure increases of approximately 30% between 2004 and 2006 (Anon, 2007), however this increase is beginning to stabilise. The Whitsunday Plan of Management (GBRMPA, 2008) and Whitsunday and Mackay Islands Visitor Management Strategy (EPA, 2007) provide a structured management of visitation, and many islands remain protected from intensive use.

The Whitsunday Islands Visitor management Strategy (EPA, 2007) to provide structure and guidelines for managing visitor use to the region's islands and applies a level of setting to a particular location. For example, high-use sites such as Whitehaven Beach are designated "High-use" setting. Large-scale infrastructure and site hardening strategies such as raised wooden access ramps, picnic tables extensive interpretative signage and a large toilet block is present to cope with the higher visitation. These sites provide a focus for tourism and a site specific strategy is in place to provide management guidance and determine appropriate development. In contrast, undeveloped, rarely visited sites such as Carlisle Island are managed primarily as a 'Protected' setting, where the focus is conservation orientated. "Protected" areas are defined as "Natural areas set aside for conservation with minimal visitor use" (EPA 2007; 13) with a small area of 'Natural' setting surrounding Neil's campground on the south-western edge allowing for basic infrastructure such as signage. Sites in the "Natural" setting are "Visitor sites generally free of facilities…unless they are essential to minimise visitor impacts" (EPA, 2007; 16).

	Visitors	Holiday	VFR	Business	Expenditure ($m)
Domestic overnight	480,000	319,000	82,000	50,000	$509
Annual % change[1]	▼ -9%	▼ -4%	▲ n/p	▲ n/p	▼ -7%
Trend % change[2]	▲ 4%	▲ 3%	▲ n/p	▲ n/p	▼ -2%
International overnight	163,000	155,000	5,000	1,000	$108
Annual % change	▼ -2%	▼ -3%	▲ n/p	▲ n/p	● 0%
Trend % change	▼ -10%	▼ -11%	▲ n/p	▲ n/p	▼ -13%
TOTAL	643,000	474,000	87,000	51,000	$617
Annual change	▼ -7%	▼ -3%	▲ n/p	▲ n/p	▼ -6%

Figure 4 Tourism Whitsunday End of Year Snapshot (2012)

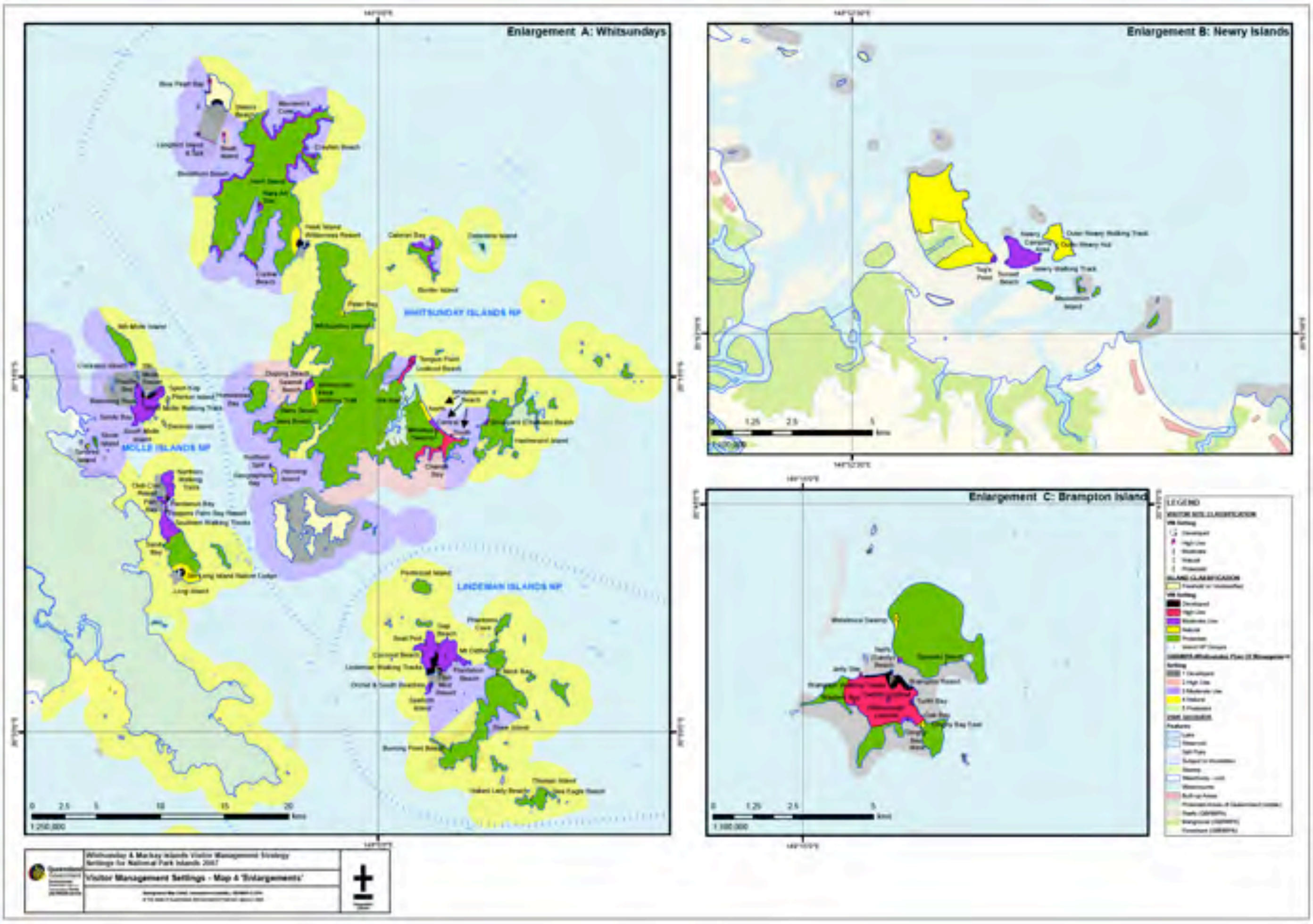

Figure 5 Whitsunday and Mackay Islands Visitor Management Settings for the Whitsunday, Brampton and Newry Island Aggregations (VMS, 2007). Note: Carlisle Island is the most northerly of the Brampton Islands Group (Enlargement C).

At least 163 exotic plants are known on the region's islands. Many of these do not have the capacity to significantly displace other species or modify habitats. However some such as Guinea grass can smother other ground covering species and significantly increase fuel loads with subsequent changes to fire patterns.

Other exotic plants such as sisal hemp aggressively out complete native species through prolific reproduction. Sisal hemp propagules are also able to float and can sustain extreme conditions and continue to germinate (K. McCallie, pers. ob). This species is found in most areas frequented by visitors. Others species such as rubber vine, present on Gloucester Island, have the potential to dramatically dominate native vegetation and substantially reduce habitat condition for the Proserpine rock wallaby. Increased use of the islands by people will present the Queensland Parks and Wildlife Service with increased weed control challenges.

Fauna species not naturally occurring on the islands (including native species from mainland systems) can cause significant damage. Damage includes over grazing/browsing, subsequent weed infestation, erosion, damage to wetlands and soaks and alterations to fire patterns. Goats are a major issue on some islands and a population of feral pigs has established on Long Island. However, this is not the case for introduced koala populations, which appear to have developed balanced populations on Rabbit and St Bees Island. Similarly, the Proserpine rock wallaby population on Hayman Island is not having any known detrimental impact.

A number of endemic species exist within the Whitsunday Islands. Carlia pectoralis inconnexa is a species of skink known only from Whitsunday Island (Hobson, 2008) while two subspecies of the Queensland leaf-tail gecko are also found on Whitsunday Island, one of which was only recently described (Couper & Hoskin, 2013).

It is clear that the distribution of vegetation types on some islands has changed significantly as a result of prevailing fire regimes. These changes may result in loss of some vegetation types from some islands, notably grasslands and open sclerophyll woodlands (McCallie, 2009., Ball, 2003).

Given the lack of quantitative baseline data and subsequent monitoring, the status of all key fauna species on the islands cannot be determined. Proserpine rock wallaby populations are actively monitored and indications are that the Gloucester Island population is stable, and numbers are increasing on Hayman Island (Nolan, pers. comm.). Limited seabird and shorebird surveys on outer islands off Mackay indicate that populations are stable, and turtle nesting although variable, does not display any consistent downward trend (Ball, unpublished data).

GOVERNANCE

National Park islands are to be managed in accordance with the Nature Conservation Act 1992. The management principles provided by this act are to:

- Provide, to the greatest possible extent, for the permanent preservation of the area's natural condition and the protection of the area's cultural resources and values;
- Present the area's cultural and natural resources and their values; and
- Ensure that the only use of the area is nature based and ecologically sustainable.

Management responsibility for National Park Islands lies with the Queensland Parks and Wildlife Service.

Resort and several private leases on the islands are administered by the provisions of the Land Act 1994. Conditions of these leases include both general requirements for 'Duty of Care' and also specific management requirements. Some islands remain as Unallocated State Land and are the responsibility of the Department of Natural Resources and Mines. A small number of islands e.g. Pine Islet, once supported lighthouses, and remain under Commonwealth control.

INDICATORS

Tenure of islands, and the negotiation and gazettal of nature conservation covenants, can be readily tracked by the Department of Natural Resources and Mines and the Department of National parks, Recreation, Sport and Racing.

Exotic plants are in most cases more likely to be prevalent in areas of higher visitation. These areas can be used as sentinel sites within monitoring programs. Infestation of exotic animals are normally reported by members of the public as regular surveys, while ideal, are not feasible.

Knowledge relating to the historic distribution and condition of vegetation types, habitats and flora and fauna populations on the islands needs to be reviewed, and acceptable thresholds of change around those conditions adopted and monitored. Current vegetation mapping, while recently updated for the Central Queensland Coast Bioregion (Queensland Herbarium, 2013) remains inadequate for some islands and should be updated. Few fauna surveys have been conducted except in association with specific projects (WIGW Fauna Survey report).

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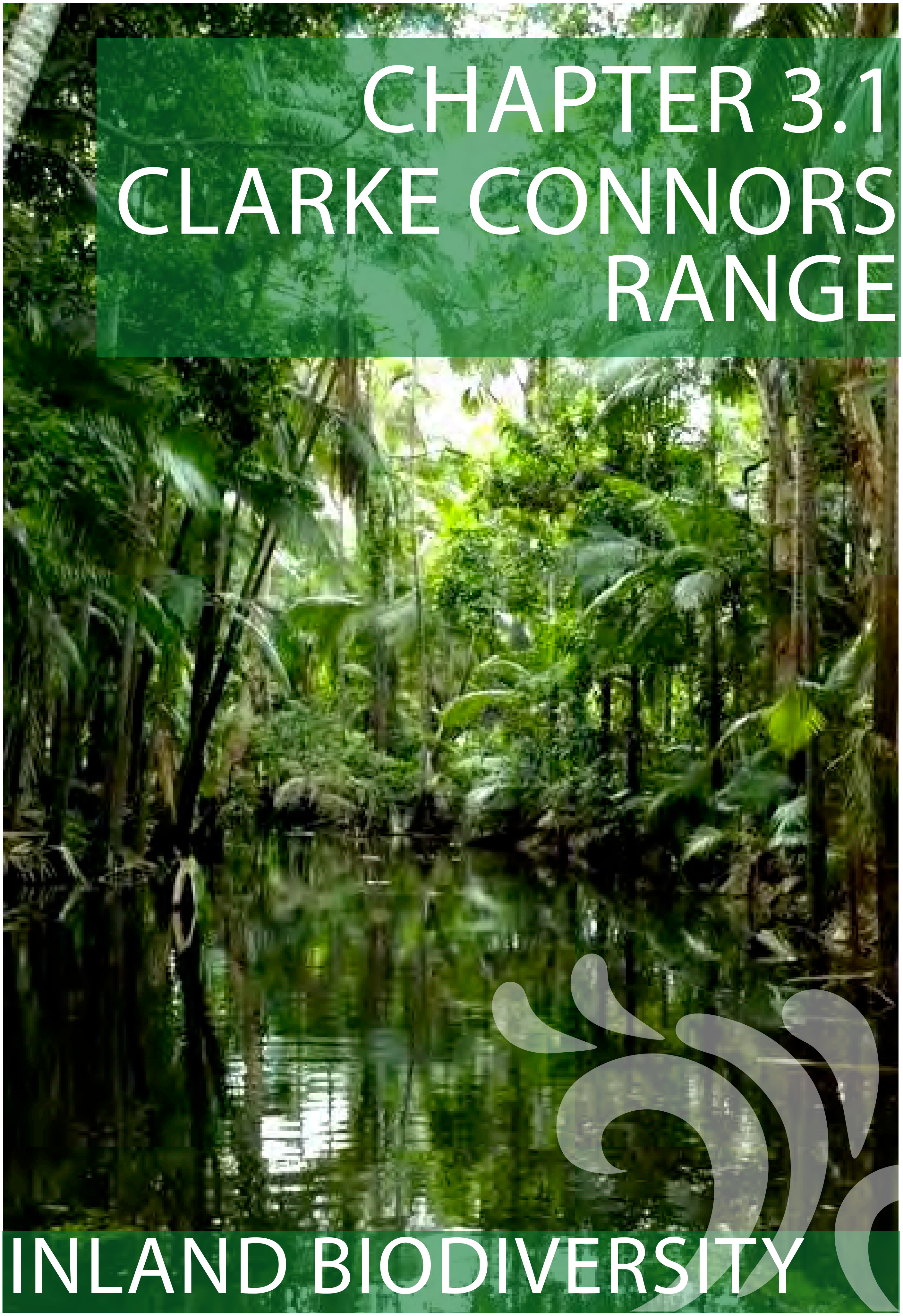
CHAPTER 3.1 CLARKE CONNORS RANGE



INLAND BIODIVERSITY

Clarke Connors Range

SUMMARY

The Clarke Connors Range extends 300km along the western boundary of the Mackay Whitsunday Region to a width of 50km, and reaches an altitude of 1267m on Mt Dalrymple near Eungella Township (Image 1). This area is listed on the Register of the National Estate by the Australian Heritage Commission Act (1975-1990), and is one of the largest wilderness areas in Queensland with outstanding natural values.

The range forms the Clarke Connors Range subregion of the Central Queensland Coast Bioregion, which lies adjacent to the Brigalow Belt Bioregion to the west, north and south, and the Sarina to Proserpine Lowlands subregion of the Central Queensland Coast to the east. In this respect it is an area of highly significant environmental gradients, and a wildlife corridor of State significance. The range forms the watershed that feeds the three major Rivers in the region (Proserpine, O'Connell and Pioneer), in addition to holding headwaters of the Burdekin and Fitzroy Rivers.

Much of the biophysical diversity of the range can be attributed to its geological makeup and climatic variability. Average annual rainfall varies from about 1600 mm per annum decreasing to about 1200 mm in the south and to 1000 mm to the west. Granodiorite and similar rocks form much of the range and thus most of the soils present are relatively low in fertility. However, areas of phosphorous rich basalt result in fertile soils associated with the Crediton farming area, just south of Eungella. Intrusive andesite forms stunning landscape features in the uplands of Homevale National Park notably; Diamond Cliffs, the Marling Spikes and Sydney Heads. Granitic geology of the Mt Beatrice and Mt Catherine mountain pair results in rugged, rocky outcropping while smaller areas of sedimentary rocks (Carmilla Beds) form rocky and scree slopes along areas at the eastern slope of the range.

The dominant land use of the range is beef cattle grazing and nature conservation. A substantial part of the range lies within protected areas or State Forests. Notably these include Eungella and Homevale National Parks, Andromache Conservation Park, Proserpine, Cathu, Gamma, Crediton, Mia Mia, Epsom, Kelvin, Connors, Koumala and West Hill State Forests and/or Forest Reserves. In addition, a number of smaller areas of freehold land have been gazetted as Nature Refuges via voluntary conservation agreements.

Historically some smaller areas contributed to native hardwood, although over the past decade that practice has declined. However, recent changes to Governance in Queensland indicate that some areas such as Crediton State Forest will again be made available to logging. Pine plantation forestry has principally occurred in Cathu State Forest, however that has largely been removed as storm damage rendered the timber unproductive. Other land uses have included dairying, limited horticulture, hobby farming, and ecotourism, however these are largely static or in decline. Four dams; Peter Faust, Eungella, Teemburra and Kinchant lie within or closely adjacent to the range.

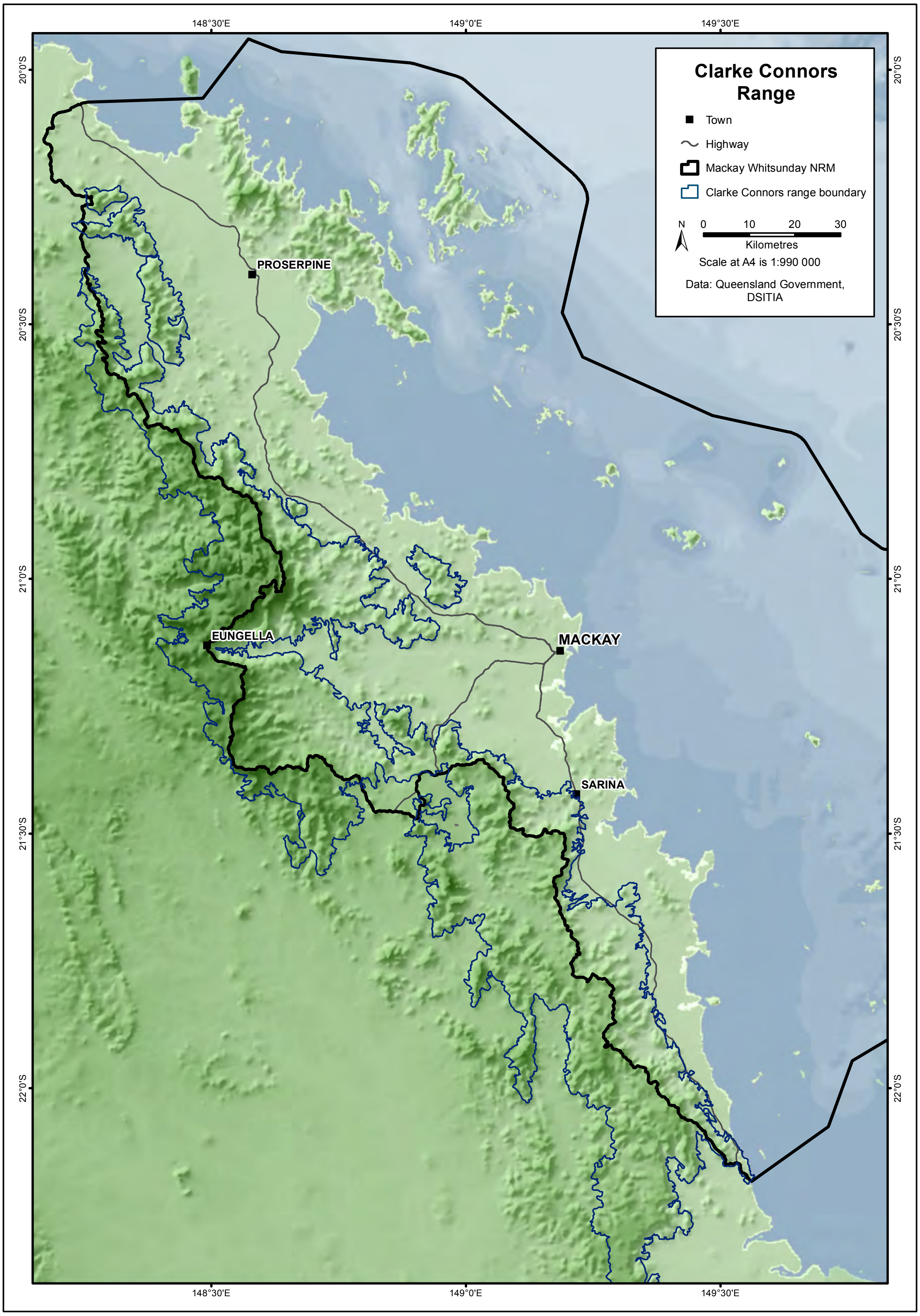


Figure 1 Geography of the Clarke Connors Range

VALUES AND SERVICES

Tourism

In 2012, the Mackay region hosted over 745,000 domestic visitors of which 165,000 were on holiday (Tourism and Events Queensland 2012a). Of the 43,000 international visitors to Mackay region, 26,000 were on holiday (Tourism and Events Queensland 2012b). Compared to previous statistics, these data suggest that holiday tourism is declining within the region, although business travel remains strong. Nevertheless, previous surveys (Anon, 2003) found that a very large proportion of visitors were attracted to the region's natural values, including those of key Clarke Connors Range visitor nodes (Image 2). Although detailed financial analysis of the value of ecotourism on the range is unknown, data highlight a strong but declining economic importance to the region.

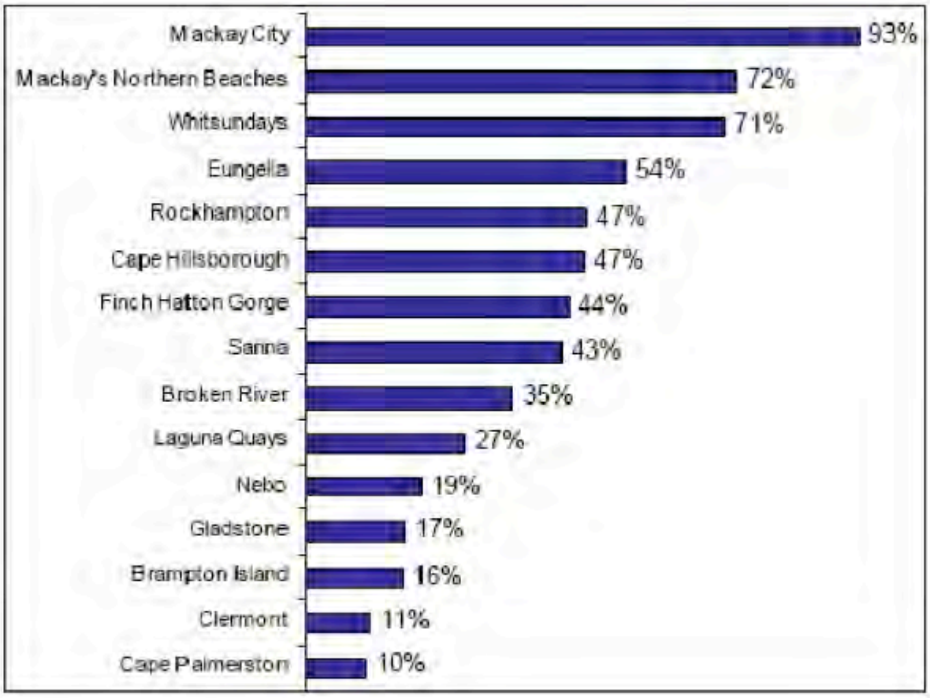


Figure 2 Major tourist destinations in the Mackay Region (reproduced from Anon, 2003).

Of the visitors to the Mackay region in 2002/03, many had particular interests in natural history. 27% of all Mackay region visitors went platypus watching, and 11% went bird watching (e.g. appproximately 189,000 and 77,000 visitors respectively).

Agriculture and Forestry

The majority of the Clarke Connors Range is State owned land which is leased for beef cattle grazing based on native pastures, although some areas have been sown with legumes to improve productivity (Bishop 2007). Improved pasture, namely buffel grass (Cenchrus ciliaris), is focused in the west of the Ranges. Native pasture grazing systems have the advantages of potentially maintaining ecosystem diversity, and have low maintenance requirements however, they are not able to sustain heavy grazing pressure and are prone to invasion by weedy grasses and broad-leaved weeds if over-grazed (Bishop, 2007).

Plantations of both native hoop pine (Araucaria cunninghamiana) and of exotic Caribbean pine (Pinus caribaea) are present in Cathu and Mia Mia State Forests although the commercial value of these is low compared to other plantation areas held by Forest Plantations Queensland. Native hardwood logging from the range is no longer a major industry in the region, however this may again grow under current governance arrangements for State owned

Fire plays an important role throughout most of the rangelands. Together with control of animal stocking rates, it is the major tool available for land management in the rangelands and can meet a range of land management objectives. It can help maximise biodiversity, protect fire sensitive habitats and culturally significant sites, manage woody weeds, and increase pastoral productivity.

"Strategic burning and wet season spelling in eucalypt land types can help manage woody regrowth and maintain native pasture seed banks… A fire (post early storms) every 2 to 4 years will encourage regeneration of black spear grass and will reduce woody weed thickening. It will also maintain the grass-legume balance". Bishop, 2007; 9-10.

Biodiversity Values

""(The) Clarke Range is the only (area in the) region with wet sclerophyll forest, and it has the largest area of rainforest as well and the largest suite of endemic animals. A concentration of endemic rainforest plants occurs towards the coast, on the Whitsunday Islands and adjacent coast, with species such as Gossia pubiflora and Brachychiton compactus growing in small patches of dry rainforest. Orographic rain from the east probably ensured their survival during the peak of aridity in the last glacial maximum, hence their coastal location". Low, 2011; 122.

The Clarke Connors Range has outstanding biodiversity values, being an area of overlap between tropical and subtropical influences, in addition to being a centre of endemism. The range supports three species of endemic frogs including; the endangered (assumed extinct locally) northern gastric brooder (Rheobatrachus vitellinus); Eungella day frog, Taudactylus eungellensis; and the rare tinker frog (Taudactylus liemi). It also provides important habitat for the vulnerable tusked frog (Adelotus brevis) and the rare whirring treefrog (Litoria revelata). One species of endemic and charismatic leaf-tailed gecko occurs on the range (Phyllurus nepthys), in addition to a recently discovered skink Saproscincus eungellensis (Sadlier et al. 2005) which is only known from high altitude (>700m) rainforest areas. A further two species of skinks are found only in central coastal Queensland rainforests; Eulamprus amplus and Eulamprus luteilateralis.

The mammal fauna of the Clarke Connors Range is rich and includes the threatened southern subspecies of the yellow bellied glider (Petaurus australis australis) and the northern sub species (Petaurus australis unnamed subsp), which is listed as vulnerable under the EPBC and National Capital Authority (NCA). It has not been confirmed whether the identity of the yellow-bellied glider at Eungella/Crediton is the 'vulnerable' northern or common southern sub species, or maybe another sub species.

The Range also supports a distinct sub-species of the swamp rat (Rattus lutreolus), as it is not commonly represented within central Queensland (Ball & Benison in prep, 2007). The common rock rat (Zyzomys argurus) has also been found on the range, almost 300km south of its previously recorded range (Dinwoodie, unpub data).

Recently, genetic screening of a dasyurid marsupial has identified a new species named the buff-footed antechinus (A. mysticus) (Baker, 2012). Furthermore, what was thought to be Antechinus flavipes within the Clarke Connors Range is actually either a combination of the new species and A. flavipes or solely the newly described species (A. mysticus).

The Clarke Connors Range supports what appears to be a large population of the nationally endangered northern quoll or native cat (Dasyurus hallucatus) a species which has suffered widespread decline elsewhere (DEW, 2005), especially recently across the top end of the species range (Northern Territory and Western Australia) as the cane toad expands into these areas.

24 regional ecosystems are represented on the Clarke Connors Range including open woodlands on alluvial plain, tall wet sclerophyll open forests, grasslands, rainforests and vine thickets, shrub land and heath land. This ecosystem level diversity is noted within Table 7.1. The range is notable in that relatively little vegetation clearing has taken place and large areas of most regional ecosystems remain structurally intact. These ecosystems provide habitat for a large suite (>40) of rare and/or threatened plants, many with highly restricted distributions. These include rainforest inhabitants but also importantly, a range of species which are more often found along ecotone (transitional) areas between different habitats, which illustrates the importance of these areas. A full review of rare, threatened and endemic fauna and flora occurring on the Clarke Connors Range can be found in Kitchener (1999).

Climate and Connectivity

The Clarke Connors Range has a climate which differs from the balance of the region, being both cooler and receiving greater rainfall (Images 3 and 4). The most reliable climate change scenarios (50th percentile) suggest that both temperature and rainfall change will be similar across the region although finer scale modelling implies that coastal and mountainous areas will differ somewhat.

The range could be viewed as a climate change refugia (Low, 2011), as it is likely to continue to be relatively wetter and cooler than elsewhere in the Mackay Whitsunday regions, and the broader central Queensland coast region. This is particularly important as this broader region is separated from the Wet Tropics and southeast Queensland rainforests by dry tropical belts; which will not offer refuge to central eastern Queensland's more wet adapted ecosystems, fauna and flora. In this respect, the Clarke Connors Range could be expected to provide an island of critical habitat within an increasingly hot and arid coastal zone. Whether this refugia is adequate to avoid species extinction in the longer term is unknown.

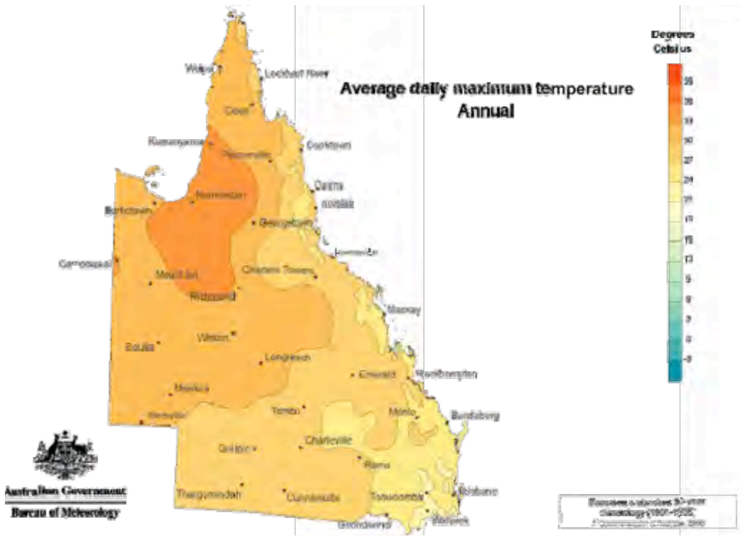


Figure 3 Average daily temperatures

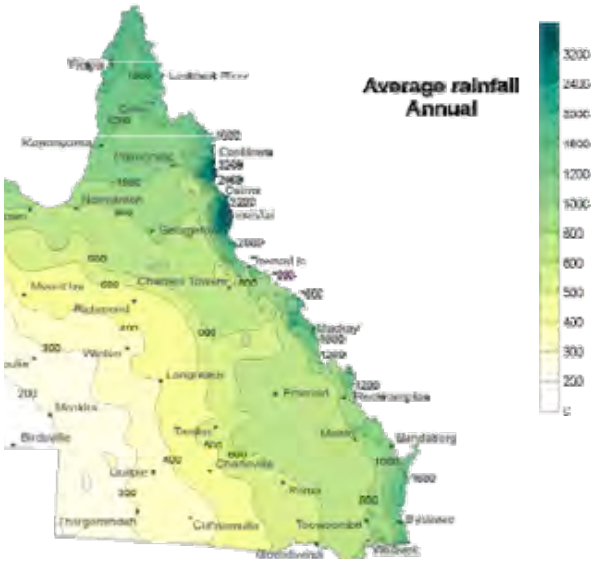


Figure 4 Average annual rainfall

Genetic comparisons among populations of the rainforest inhabiting leaf-tail gecko Phyllurus ossa suggest that rainforests in the region contracted during the Pleistocene period (~ 10,000+ years ago), isolating some populations, but has expanded again during subsequent warming periods (Stuart Fox et al., 2001). Former connectivity between for example the Conway & Dryander Ranges and the Mt Ossa rainforests is confirmed by presence of P. Ossa at these locations. However, other areas in the range support different species suggesting that previous climate change isolated these areas for some time e.g. P. Isis occurs on Pioneer Peaks, P. nepthys on the Clarke Connors Range, and P. championae only occurs in drier areas on the south of the Clarke Connors Range. These observations are significant in demonstrating that within available habitat this rainforest genus not only survived during climate change, but may have demonstrated a capacity to adapt and speciate.

Distribution patterns of other fauna on the range offer further insights to connectivity between northern and south eastern Queensland rainforests. Several bird species are present within south eastern rainforest, the wet tropics and Clarke Connors Range rainforests e.g. powerful owl and regent bowerbird, suggesting that these rainforests were once connected. However, the Clarke Connors Range rainforests have been isolated for sufficient time for at least one bird to have speciated. The Eungella honeyeater (Bolemoreus hindwoodi), listed as 'near threatened', was first described as a distinct species in 1983 and is endemic to the range area (Longmore and Boles, 1983). Rainforest birds have varying capacities to move between the three major rainforested areas in Queensland i.e. across dry tropical Burdekin and St Lawrence areas (Joseph et al., 1993). The Clarke Connors Range also supports at least 120 other birds including populations of the vulnerable glossy black-cockatoo (Calyptorhynchus lathami), and rufous owl (Ninox rufa queenslandica). These species are not restricted to the range; instead this area forms an important core refuge, and movement corridor.

As with other fauna, the distribution of invertebrates on the Clarke Connors Range largely reflects historical rainforest biogeography. For example, the range area (along with the Whitsunday Ranges) is an overlap zone between the wet tropics and south east Queensland rainforests, and a level of endemism has developed (Stanisic, 1994). Permanent invertebrate and plant survey sites were established by Griffith University in early 2013, which will be part of a larger elevational study throughout Australia. These sites are at various elevations (400 – 1200 m above sea level) within Eungella National Park and will serve as baseline data and to monitor future impacts of climate change.

PRESSURES AND THREATS

Inappropriate fire, weeds and overgrazing are the most significant threats to ecosystem health and are often closely related. Feral animals, primarily feral pigs degrade some habitats, particularly moist rainforested gullies and palm swamps. Tree damage caused by tropical cyclone Ului in March 2010 has contributed to weed invasion, higher fire risk due to accumulated fuel loads and subsequent degradation of habitat with some trees aged several hundred years old still recovering. Dieback is evident in stands of flooded gums, which may be susceptible to root rot fungi (Phytophthora spp.) due to the stress caused by the cyclone and also as a result of changes to hydrology.

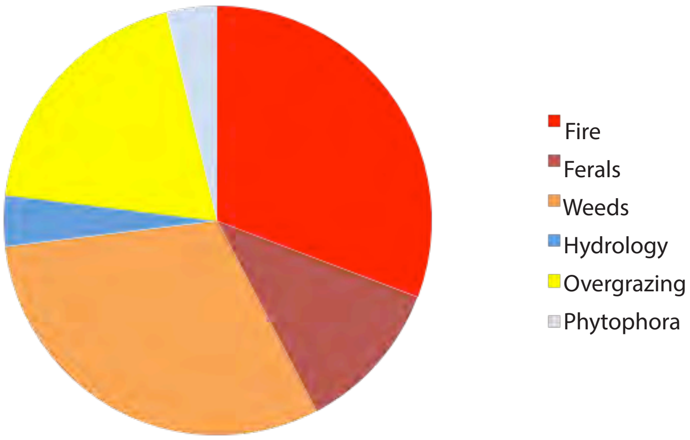


Figure 5 Relative significance of major threats to the 24 regional ecosystems supported by the ranges

Fire

Fire sensitive communities within the Clarke Connors Range include rainforests, vine thickets, vine forests, and some riparian communities. These communities do not require fire for regeneration as it may irreversibly alter the species composition and structure of the community. Introducing buffer zones around fire sensitive communities is advised to ensure that the margins of the community are not scorched, which can lead to a reduction in fire sensitive communities and invasion by exotic plants.

Too frequent fire in fire adapted communities leads to simplification of the community by reducing the floristic and structural diversity of the ground and mid strata. However, fire that is too infrequent can lead to loss of fire dependent species as mature individuals senesce while the next generation of individuals are either not produced or are unable to establish. Many fire adapted species will tolerate a range of fire intensities whereas others have quite specific fire intensity requirements. A fire regime that fails to take these requirements into account can alter the relative abundance of different species in a community, and has the potential to lead to local extinctions.

Allowing litter and fallen logs to accumulate over large areas in fire tolerant forests and grasslands provides essential habitat for ground dwelling fauna. Also key is ensuring variation in the structural complexity of the mid strata between forested patches and within each vegetation community to allow for a diversity of habitats. Mature trees, particularly those with hollows, are also critical habitat for many species. The role of fire in creating and maintaining tree hollows is complex and varies with vegetation community and climatic zone. In general, however, fire that is too frequent, intense and widespread causes the destruction of old trees that contain hollows. It takes many years (100 years or more for many eucalypts) for these to be replaced.

Too frequent and/or extensive burning in the fire adapted communities, particularly when there is little soil moisture, removes litter (such as fallen leaves, branches and logs) from the ground faster than it can be replaced, inhibits the development of a complex midstratum, increases the risk of losing habitat trees and leads to an over representation of habitat in an early successional phase.

Ferals

Feral pigs are prevalent along the Range, however they do have marked seasonal movement patterns. Core habitat areas include wetter palm forests and swamps and riparian areas (Ball, unpublished data). Feral pigs compete for resources with native animals, directly predate on and compete with native animals, transmit disease and degrade habitats (Department Environment and Heritage, 2013) (see Figure 7.6).

Figure 6 Gut contents of a feral pig with large numbers of native frogs. Photo courtesy of Barry Nolan, Queensland Parks and Wildlife Service.

Weeds

The Range is prone to weed infestation notably from rat's tail grasses (Sporobolus spp.), thatch grass (Hyparrhenia rufa) and grader grass (Themeda quadrivalvis), lantana (Lantana camara), sickle pod (Senna obtusifolia) and other broadleaved weeds (DAFF, 2006).

Other weeds within the region include a large selection of the pyrophitic (fire loving) grasses, sometimes known as the high biomass grasses including Guinea, hamil, molasses, para, elephant, hymenachne, aleman, and Indian couch. While some of these grasses improve pasture, outside of these areas they can become weedy and increase fire intensity and spread displacing native vegetation and changing vegetation structure. Such grasses are promoted by fire but in rare cases fire can assist in their management (e.g. molasses and para grass). Pyrophytic grasses tend to occur as a result of disturbance and spread along firelines and utility easements.

There is potential for rag weed (Parthenium hysterophorus) becoming more prevalent as a result of transport of seeds from western areas, where this species is currently a major environmental and economic pest. Rag weed was identified in Crediton State Forest in 2010, thought to have been transported from Homevale National Park where it is known to be prevalent.

Water Quality

Water quality in Broken River is an important consideration given its habitat value to the platypus population. Algal blooms and high faecal coli forms continue to impact on the waterway health with declining water quality in the Broken River catchment threatening the tourism values of the area. E. coli contamination in Broken River has been at levels considered unsafe for swimming by the EPA for several years. These riparian areas are also inherently biodiverse and improved water quality will assist in maintaining those values. Paradoxically, platypus thrive in high nutrient waters with this poor water quality not appearing to negatively impact the local population so a management dilemma is presented, because to improve water quality risks potentially losing the platypus population and associated economic gains from tourism.

CONDITION AND TRENDS

Biodiversity

Few regional ecosystems within the range are considered endangered compared to other areas within the region. However, ongoing threats to habitat condition results in only 10 ecosystems being considered as being of no conservation concern at present (Image 7). In addition, 15 of the 24 ecosystems present have only low representation within protected areas.

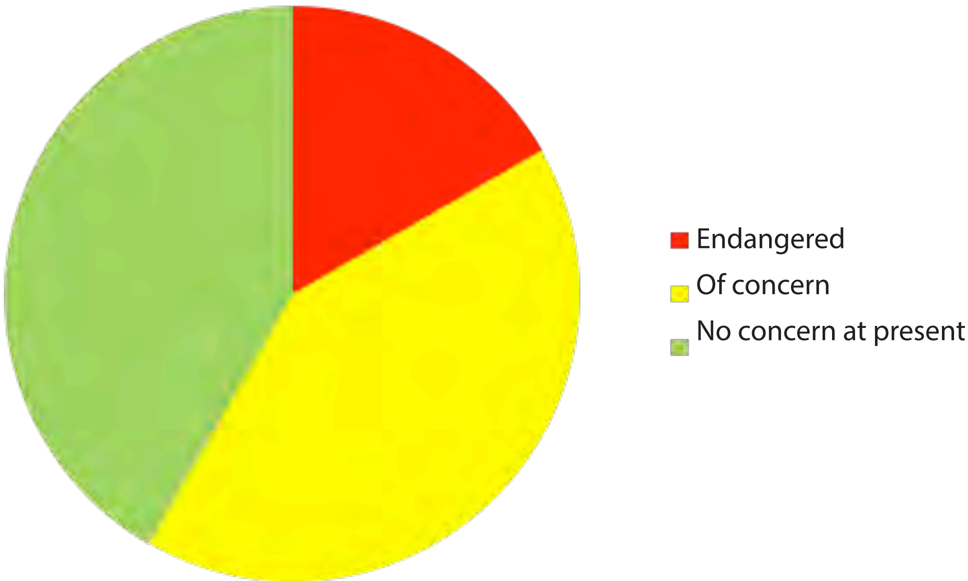


Figure 7 Conservation status of the range's regional ecosystems.

Fire

Fire is a key factor influencing the Central Queensland Coast bioregion, effecting both biodiversity and general resource condition. Effects of fire include the distribution and abundance of invasive plant species, vegetation thickening, pasture vigour and composition and the overall economic return of primary production. At the landscape scale fire can be both a valuable tool and a threatening process. The delineation between tool and threat is related to the purpose and strategy of using or not using fire in a particular landscape or land use.

Four important factors to consider when planning for fire management are:

1. Fire Frequency – how often should an area be burned;
2. Fire intensity – how hot does the fire need to be;
3. Season – what time of year will usually provide the desired conditions for a planned burn;
4. Burning mosaic – the percentage of ground cover remaining unburned after a fire.

Other important factors to consider are fuel loads, wind speed, humidity, fuel curing, slope and aspect. The guidelines are not intended to account for all circumstances. Seasonal, yearly and even daily conditions can vary dramatically. Draft guidelines and tools have also been developed that allow fire managers to estimate the carbon emissions likely to result from any given fire prescription and thus opportunities to minimize the green house gas emissions.

The use of fire as a management tool is usually guided by development of 'fire regimes' designed to protect property, control woody weeds such as lantana, invigorate pastures or produce green feed to assist in mustering cattle, protect fire sensitive habitats, manipulate habitats to maximise biodiversity, or for the specific management needs of a particular species (Bushfire Consortium, 2012).

Fire Management Guidelines for the Mackay Whitsunday region have been developed for 12 landscape types including those on the Clarke Connors Range (Bushfires Consortium, 2012), which represent best practice models for achieving conservation, production and wildfire mitigation objectives.

The State of the Region Report in 2007 identified large-scale wildfires during the previous 10 years (1999, 2001, 2004 and 2006). Investigation of the causal factors behind these large-scale wildfires identified a range of issues such as:

- The cane industry's move to green cane and trash blanket had reduced the opportunity to burn next to cane lands and increased the risk of fire events;
- Changing demographics in land use, with rural residential expansion occurring and a decline in cane farming. The diminishing profits in cane also saw an expansion in timber plantations and influx of people in mining industries who had no understanding of the role of fire in land management;
- El Nino weather years causing longer than usual dry periods and bad fire weather days; and
- Reduction of available people in the grazing industry due to the rapid expansion of the mining industry and greater incomes mining offered.

Since 2007 comprehensive fire scar mapping has been prepared annually for 250 land managers and 5 rural fire brigades within the catchment to assist in fire management planning, and to reduce critical threats to Environment Protection and Biodiversity Conservation Act (1999) listed flora and fauna including 1000 ha of Semi-evergreen Vine Thicket.

These data allow a review of fire regimes across a large geographical area and can guide investment to improved fire management in line with the guidelines. This process was commenced because of the observation that much of the fire that influenced the range prior to 2007 was inappropriate, included extensive wildfires in 1999, 2001, 2004 and 2006, and also highlighted that many areas of the range have gone long unburnt. This situation could possibly be made worse by a climate change resulting in higher temperatures and lower rainfall.

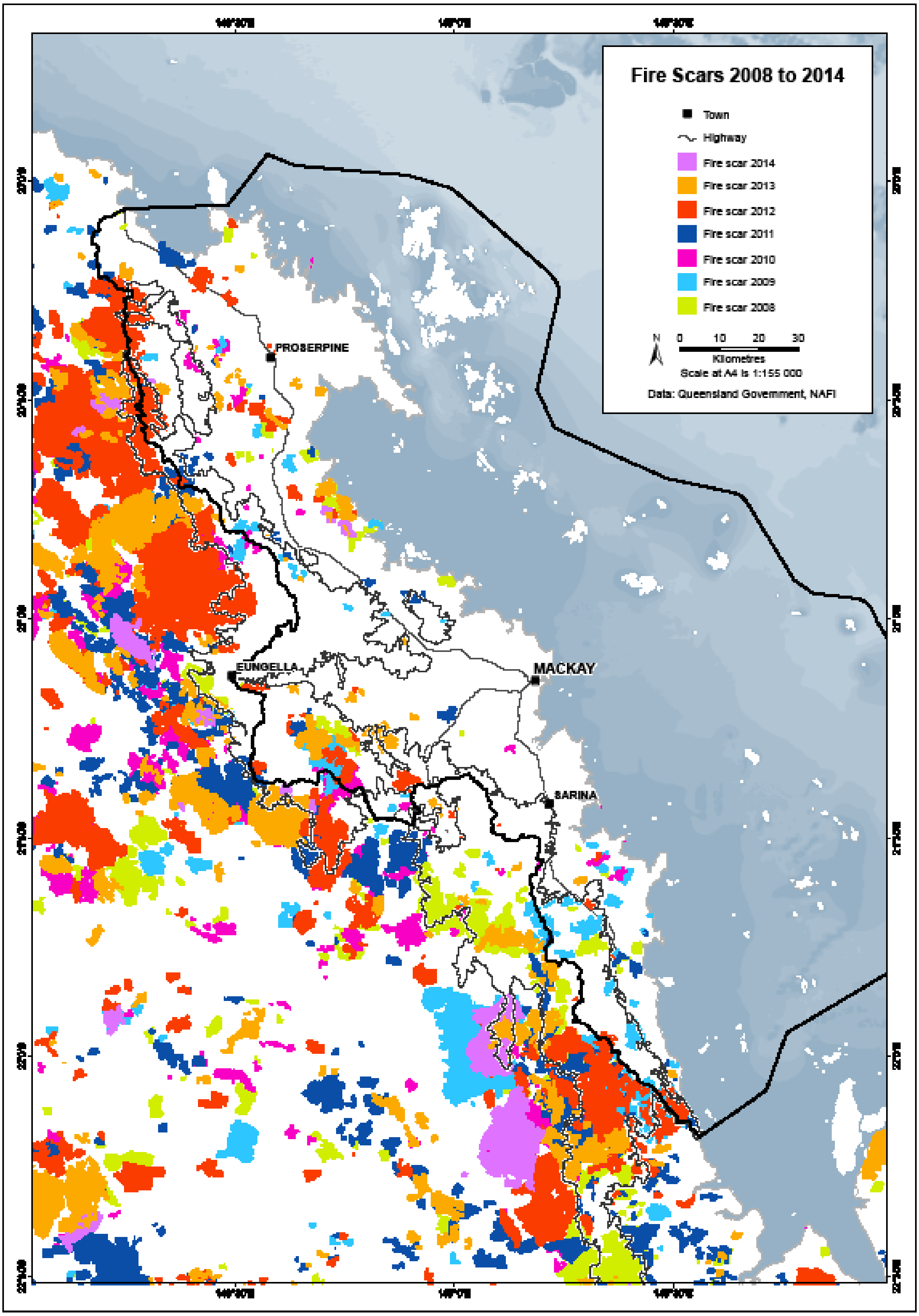


Figure 8 Fire scars in and around the region 2008-present

Land Management Practice

While existing land management practices continue to result in degradation of water quality in some areas, notably Broken River, significant progress has been made through investment programs in 2008 and 2009 to reduce pollution of the river.

The development of guidelines to manage specific issues such as lantana, rubber vine and threated species such as the northern quoll has also occurred since 2007 (Reef Catchments, 2009a, 2009b, 2009c, 2009d). Lantana is common and widespread throughout the catchment which is a significant economic pest causing considerable loss of pasture productivity, and has large impacts on biodiversity through habitat degradation (Tran et al 2008). Fire remains the only economic way in which to control lantana across such broad landscapes (ARMCANZ, 2000)

The management of weeds is not monitored however it is expected that the extent of weed distribution and movement patterns throughout the range persists, in particular for key problem species such as grader grass.

Likewise, the management of feral pigs along the range is not feasible to gauge. One of the most significant threats is the spread of disease such as chytridiomycosis, a fungal disease which infects and kills frogs including the endangered Eungella day frog; and phytophthora (Phytophthora cinnamomi), a root rot fungi which can cause dieback of all forest types. Both these diseases are known to be present on the range and further spread is of concern.

> The region contains other vertebrates that could decline from climate change, because they reach their northern limits on the Central Queensland Coast and have high water requirements, for example the vulnerable tusked frog (Adelotus brevis), rare whirring treefrog (Litoria revelata), the great barred-frog (Mixophyes fasciolatus) and the swamp rat (Rattus lutreolus). Two wallum fish, the ornate sunfish (Rhadinocentrus ornatus) and the vulnerable honey blue-eye (Pseudomugil mellis), are each represented by a small outlying population in a separate wetland around Shoalwater Bay, far distant the main populations found from Fraser Island southwards, suggesting fortuitous survival in response to past climate change and a high vulnerability to future change. All of these species can be expected to survive in South-east Queensland. Lowe (2011; 126)

GOVERNANCE

Much of the range is protected within National Parks or State Forests. National Parks are to be managed in accordance with the Nature Conservation Act 1992. The management principles provided by this act are to:

- Provide, to the greatest possible extent, for the permanent preservation of the area's natural condition and the protection of the area's cultural resources and values; and
- Present the area's cultural and natural resources and their values; and
- Ensure that the only use of the area is nature based and ecologically sustainable.

The foremost principle to be observed in the management of State forests is the permanent reservation of such areas for the purpose of producing timber and associated products in perpetuity and of protecting a watershed therein.

Management responsibility for National Parks and State Forests lies with the Queensland Parks and Wildlife Service. A small area of Cathu State Forest is under the control of Forest Plantation Queensland for purposes of managing exotic and hoop pine plantations.

An overarching plan for the management of National Parks and State Forests on the range has been prepared: Planning for the Future: A strategic plan for the protection and presentation of parks and forests in the Mackay Highlands. This plan generally recommends that most State Forest areas associated with the Eungella area be managed more for their conservation values and that conversion to National Park tenure is appropriate.

Most of the remaining land on the range is leased under the provisions of the Land Act for cattle grazing. Conditions of these leases include both general requirements for 'Duty of Care' and also specific management requirements such as pest plant and animal control.

INDICATORS

Future fire management activities as measured by remote sensing and on ground mapping, can be compared to the Clarke Connors Range fire management guidelines and a report carding process established. Further indicators, both relating to biodiversity and cattle production can be used in key, representative areas as direct measures of the results of changed fire regimes.

The presence and activity of feral pigs and other feral animals can be determined through a range of monitoring programs which incorporate social, economic and environmental factors.

The distribution and movement patterns of other pests such as weeds, and microbial pests such as (Phytophthora cinnamomi), and chytridiomycosis can be directly surveyed and mapped.

Water quality improvements can be directly measured using existing guidelines.

The establishment of replicable monitoring and support for research projects within the range will determine if biodiversity values have been maintained. This includes broad baseline monitoring such as recently established by Griffith University to monitor Climate Change responses; and species targeted projects, either threatened species or indicator species to indicate ecosystem function (e.g. northern quolls, yellow-bellied gliders, swamp rats, Eungella honeyeater, endemic frog species etc).

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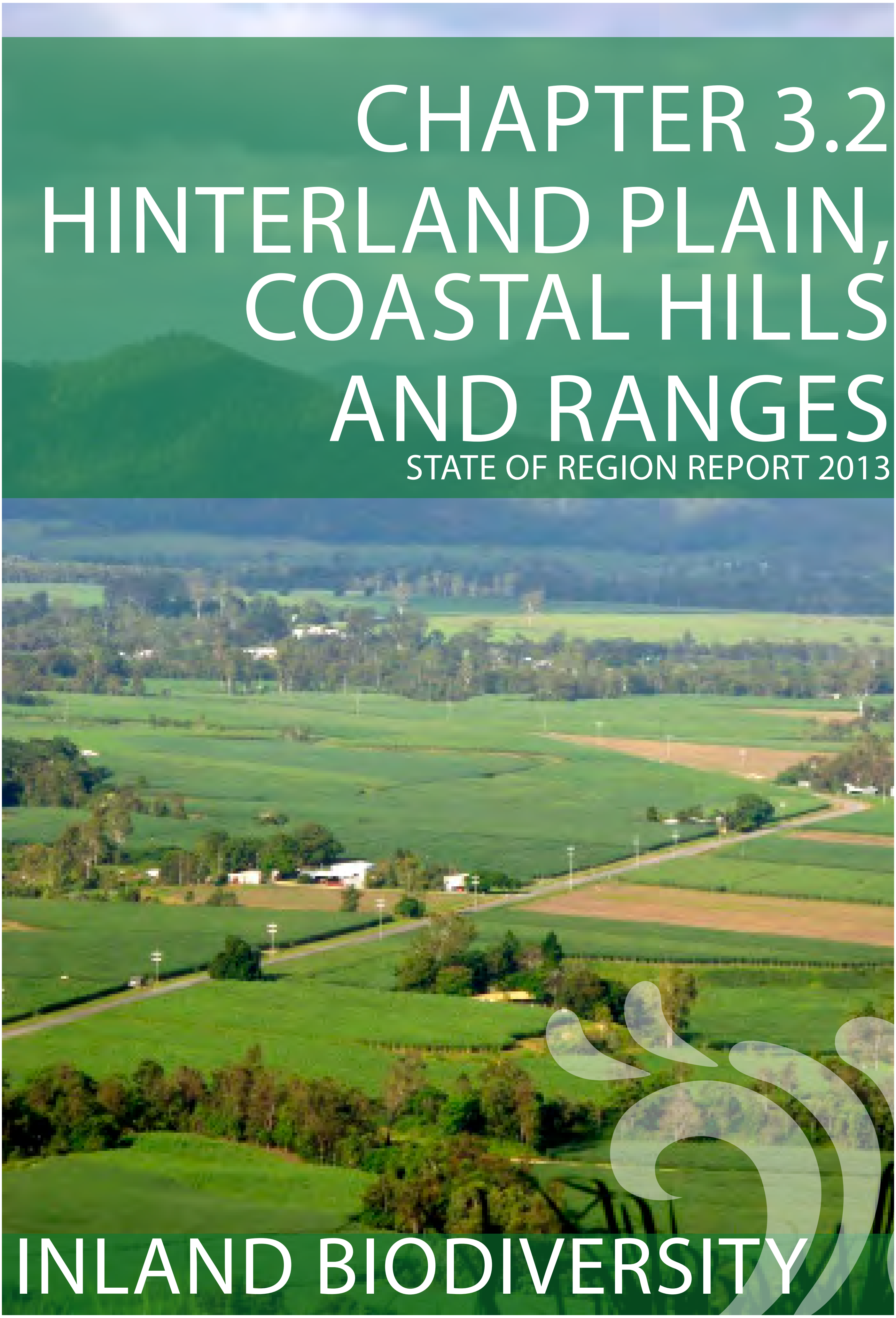
CHAPTER 3.2 HINTERLAND PLAIN, COASTAL HILLS AND RANGES

STATE OF REGION REPORT 2013



INLAND BIODIVERSITY

SUMMARY

Between the coastal zone and the Clark Connors Range lie extensive plains of alluvial flats, intruded in parts by coastal and near coastal hills and ranges. Most notable are Mt Funnel (largely within Cape Palmerston National Park), Ben Mohr, Mt Kinchant, Mt Martin, Mt Vince, Mt De Moleyns, and Mt Toby within the Pioneer Valley (most of which are National Parks or State Forests), Mt Blackwood, Mt Jukes, Mt Mandurana, Mt Adder (Pioneer Peaks National Park), Cape Hillsborough, Cape Gloucester, and the Tonga and Condor Ranges. The Whitsunday area is dominated by two coastal ranges; Conway and Dryander, whose rainforest clad massifs comprise several flat top ridges, formed on gently inclined late-stage rhyolite lavas (Willmott, 2006).

These features overlie the Debella, Proserpine-Sarina lowlands and Whitsunday subregions of the central Queensland coast bioregion (Image 1). The Debella sub-region consists mostly of sandy plains of limited productivity, and rainfall that is lower than the remainder of the region. This area is used almost exclusively for beef cattle grazing. Conway and Dryander Ranges, and associated alluvial flats form the Whitsunday sub-region. Most of this area is rugged and mountainous and receives high rainfall. Cannon Valley lies between the two ranges and is dominated by sugar cane production, and growing urban and rural residential development.

The much larger balance of the region overlies the Proserpine to Sarina coastal lowlands. This area receives high rainfall (declining in the south), is generally fertile, and is mostly developed for sugar cane production and beef cattle grazing.

The region's forest asset is a combination of existing remnant and regrowth native forests on both Crown-owned and privately-owned land, in addition to Crown and privately-owned planted forests that are helping to restore and increase the asset.

National parks, state forests and unallocated state land make up the majority of the region's Crown native forest. Crown-owned plantations consist of pine species and were established in the region between 60 to 30 years ago and also recent planted hardwood plantations. Privately-owned forest plantations have been a slowly growing part of the landscape for last 25 years.

"A major reason for seeking sustainable environmental solutions is to maintain the benefits that come to humans from nature and its components. The term "Ecosystem Services" has been coined to describe these benefits. Ecosystem services include provision of clean air and water, natural fertilisation and nutrient cycling in soils, mitigation of climate, pollination of plants including crops, control of pests, provision of genetic resources, production of goods like food, fuel and fibre, maintenance of cultural and social values, and others."

The Nature and Value of Australia's Ecosystem Services: A Framework for Sustainable Environmental Solutions, Cork & Shelton (2000; 151)

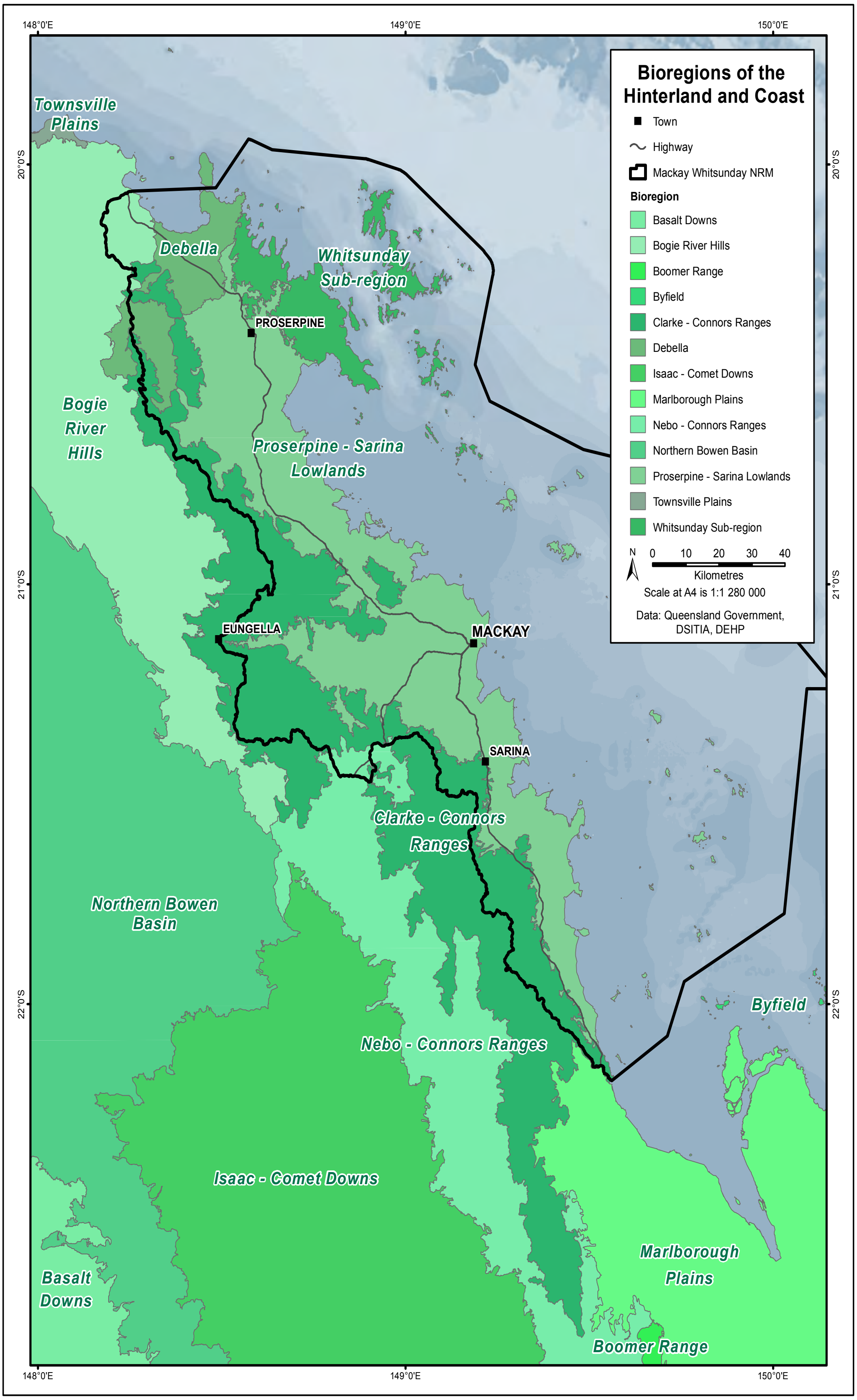


Figure 1 Central Queensland Sub-Region

VALUES AND SERVICES

Recreation and Tourism

Hinterland plains, coastal hills and ranges represent significant recreational and tourism opportunities with National Parks and other protected areas providing a range of experiences such as remote area bush walking, camping and mountain biking along the 'Whitsunday Great Walk', and shorter coastal walks within the Conway Range. The larger part of the 'Mackay Highlands Great Walk' commences in the region and finishes at Homevale National Park. Cape Hillsborough National Park provides easy access to natural areas for the region's communities, and is used as an outdoor classroom by many primary and secondary schools.

A private resort and council operated park are located in the middle Cape Hillsborough National providing easy access and accommodation within meters of the National Park. Cape Palmerston National Park, although only a short drive from Mackay and Sarina, provides a remote area experience for visitors in almost completely natural surroundings.

Biodiversity

The hinterland plain, coastal hills and ranges support outstanding biodiversity. The portion of the region that lies within the central Queensland coast bioregion contains 39 regional ecosystems (REDD, 2007). The summit of Mt Dryander is covered by 486ha of an endemic rainforest ecosystem and both the Conway and Dryander Ranges support large areas of other, highly diverse rainforest communities. These ranges are similar to the Clarke Connors Range in that they contain features of both the Wet Tropics and southeast Queensland rainforests.

Figure 2 The Proserpine rock wallaby is endemic to the Whitsunday ranges and a small area of the Clarke Range

The Dryander and Conway Ranges, along with Pioneer Peaks and other near coastal hills and mountains, support a suite of endemic species including leaf-tail geckoes (Phyllurus ossa ossa, P. isis, P. championae) and plants e.g. Whitsunday bottle tree (Brachychiton compactus), Mt Blackwood Holly (Graptophyllum illicifolium), Ornate-fruited Neisosperma (Neisosperma kilneri) and Actephila championiae (no common name) (Wildnet, 2007).

Recent research (Couper and Hoskin, 2013) revealed that Phyllurus ossa is represented in the region by three sub-species; P. ossa ossa occurring on hills and mountains near Mackay; P. ossa hobsoni which only occurs on Mt Dryander and the Conway Range; and P. ossa tamoya subsp. nov., which was only recently discovered on Whitsunday Island. This highlights the need for further research in understanding the natural assets of the region.

Also notable is the nationally endangered northern quoll (Dasyurus hallucatus), which is estimated to have large and stable populations within the hinterland and associated hills (Dinwoodie, unpublished data). Because quoll populations in other regions continue to decline, this area may be a stronghold for the species, which continues to persist alongside cane toads.

Other threatened species present in these areas include the Proserpine rock wallaby (Petrogale persephone), rufous owl (Ninox rufa), and coastal sheath-tail bat (Taphozous australis), although many others are present.

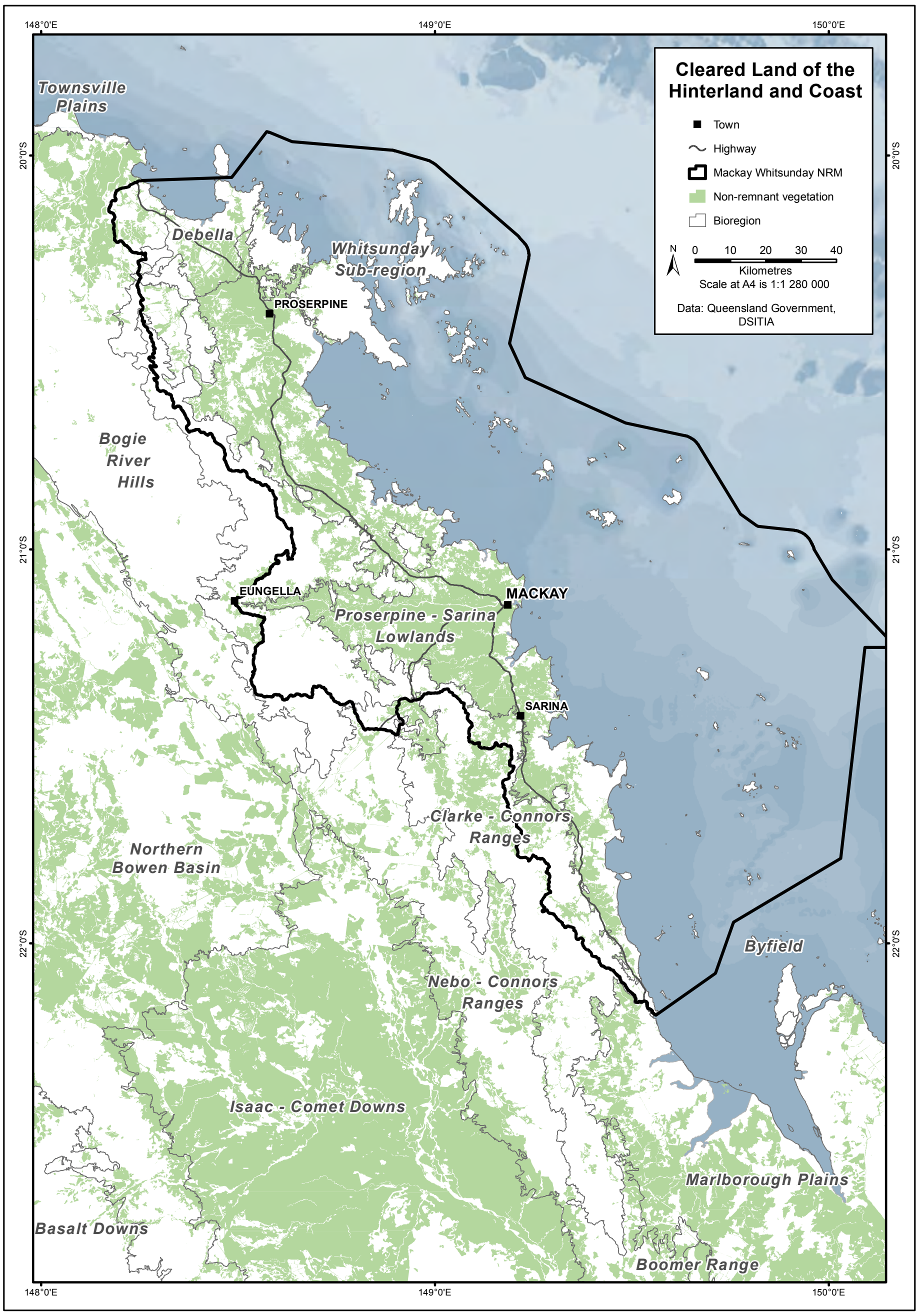


Figure 2 Non remnant vegetation in MWI region

Forests and Forestry

Native forests are naturally occurring vegetation communities or regional ecosystems containing some form of tree cover. Native forests have multiple values and form an important part of the region's biodiversity and production assets. They provide a range of commercial products such as timber and honey, and an array of ecosystem services that include clean air and water, and carbon sequestration.

Planted forests or plantations are defined as planted forest areas that include block plantings, shelterbelts, tree lines, and revegetation (e.g. riparian). Plantation forestry can deliver a range of other benefits to the region and is one of the best examples of productive land use that can achieve triple bottom line benefits – economic, environmental and social/cultural.

PRESSURES AND THREATS

Land Clearing

The most significant pressure to have acted upon the hinterland plain was land clearing associated with development of the sugar cane industry and to a lesser extent beef cattle grazing.

Although vegetation clearing restrictions have been in place for some time, the Vegetation Management Act has been revised including the ability of landholders to clear high value vegetation (including regional ecosystems considered 'endangered', 'of concern' or 'least concern' and regrowth that has not been cleared since 31 December 1989). Arguably there could be environmental benefits to the changes by simplifying and streamlining the process for landholders to reduce, for example, thickening of native vegetation.

Rural residential development and the push of urban expansion into hills, particularly at Airlie Beach and Shute Harbor continue to be a threat to habitats, with secondary impacts including predation on native species by domestic pets and invasive spread of garden plant species.

Invasive Species

The condition of remnant vegetation can decline as a result of invasion by exotic plants which modify habitats, displace native species, alter fuel characteristics and thus also alter prevailing fire regimes. This is a significant pressure to native and endangered species, the majority of which inhabit fire sensitive habitats and are threatened by inappropriate fire management. Key species include exotic grasses particularly Guinea grass (Megathyrsus maximus), grader grass (Themeda quadrivalvis) and thatch grass (Hyparrhenia rufa).

Herbaceous weeds such as sickle pod (Senna obtusifolia), Singapore daisy (Sphagneticola trilobata), and tobacco weed (Elephantopus mollis) can significantly modify ground layer vegetation. Shrubs such as lantana (Lantana camara), and some trees (e.g. penny leaf Dalbergia sisso and Java plum Syzigium cumini) also readily displace native species and are prolific in some areas of remnant vegetation.

> "Domestic and feral cats spread Toxoplasmosis gondii which has been known to cause blindness and death in these rock-wallabies. There are few data available on predation or the effects of toxoplasmosis on the mortality rate in Petrogale persephone populations. However, given the extensive areas of development adjacent to P. persephone habitat and the recorded incidents of death due to toxoplasmosis it is believed they form a serious threat."
>
> National recovery plan for the Proserpine rock-wallaby Petrogale persephone, DERM (2010, 10)

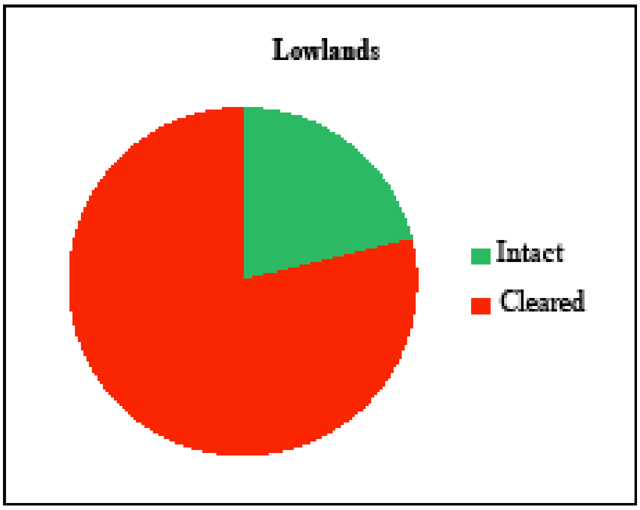
Feral pigs are prevalent across the hinterland plain, coastal hills and ranges and significantly impact biodiversity and agricultural assets. Wild dogs also inhabit most landscapes in this area and periodically have significant social, economic and environmental impacts. Although more rarely observed because of their cryptic habits, both feral cats and foxes are common across the region. Both species have a high impact, for example in predating directly on native species (Dickman, 1996).

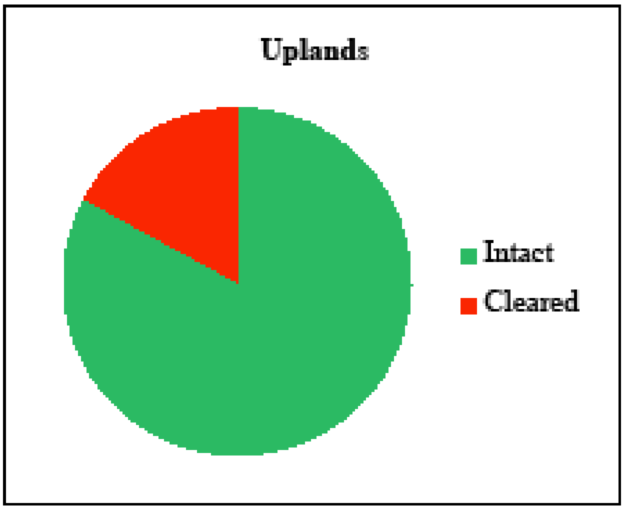
Feral cats also pose a threat to both through transmission of disease such as toxoplasmosis (DEW, 2007) and sarcosporidiosis, which can be transmitted to native animals, domestic livestock and humans. Dogs and foxes also contribute to disease in kangaroos and wallabies through the spread of hydatids, which is one of a number of threatening processes impacting the Proserpine rock-wallaby (DERM, 2010)

Current priorities for pest control, outlining priority species in different landscapes has been identified within the Regional Pest Management Plan (Mackay Regional Pest Management Group, 2011).

CONDITION AND TRENDS

Approximately 75% of the hinterland plain has been cleared of native vegetation compared to less than 25% of upland areas (Figure 3). 15% of vegetation that occurred on alluvial and sand plains is left remaining. Of the thirteen regional ecosystems that occur in these areas, 11 are endangered, and 12 have either no or little protection within conservation reserves (Table 1).





compared to uplands areas within the region.

The ecological impacts of remnant vegetation fragmentation are less clear as few region specific studies have been undertaken (Ball, 2007). However, Anon (2005) provides a comprehensive assessment of the region using broader concepts of landscape ecology including identification of key conservation areas, and of important corridors at different scales. This analysis demonstrates that most remaining linkages among remnant vegetation occurs in upland areas, although several riparian zones provide potentially important links through the ranges to the hinterland plain and coastal zone.

There are no comprehensive assessments of vegetation or habitat condition within the region. As a result, the impacts of exotic plants and of feral animals remains poorly understood. Significant advances have however been made in recording and analysing prevailing fire regimes and developing best practice guidelines. It is now possible to map at a regional scale the way in which fire management is being applied. This is important because fire is a major ecosystem driver, and will have a significant influence on the distribution and abundance of many weeds. However, lack of other data prevents a strategic region-wide approach to identifying important areas for investment.

Threatened species are more sensitive to the impacts of changed land-use, and therefore act as indicators of the condition of habitat, and for the health of other populations. It follows that if ecosystems (i.e. habitats) are managed to facilitate the recovery of these species, then other components of that ecosystem may also benefit.

Regional Ecosystem	Description	Biodiversity Status	Reservation Status
8.3.2	Broad leaved paperbark woodland often with emergent eucalypts and grassy/herbaceous ground layer, on seasonally inundated alluvial plains with impeded drainage	Endangered	Low
8.3.3	Weeping paperbark ± river oak open forest to woodland, fringing watercourses	Of Concern	Low
8.3.4	Freshwater wetlands with permanent water	Endangered	Low
8.3.5	Clarkson's bloodwood + swamp mahogany + polar gum woodland, or polar gum woodland on alluvial plains	Endangered	Low
8.3.6	Blue gum, pink bloodwood and swamp mahogany (or Moreton Bay ash dominant) open forest on alluvial levees and lower terraces	Endangered	Low
8.3.11	Broad leaved paperbark (dominated by an undescribed species) closed forest to woodland in broad drainage areas (wetlands)	Endangered	None
8.3.12	Grassland on alluvial and old marine plains	Endangered	None
8.3.13	Blue gum and/or Moreton Bay ash and/or paperbark open woodland to open forest on alluvial and old marine plains, often adjacent to estuarine areas	Endangered	Low
8.5.1	Clarkson's bloodwood open forest on Tertiary sand plains including small areas of shale. Includes low rises with pink bloodwood open forest, ± broad leaved paperbark ± rainforest species open forest	Endangered	None
8.5.2	Broad leaved paperbark ± bull oak, or Broad leaved paperbark woodland on Tertiary sand plains	Endangered	None
8.5.3	Ironbark ± ghost gum ± Clarkson's bloodwood, ± polar gum ± broad leaved paperbark woodland on broad low rises and gently sloping Tertiary sand plains	Endangered	Low
8.5.5	Queensland peppermint and/or Clarkson's bloodwood woodland ± *Eucalyptus* sp. (Jimboomba A. R. Bean 7772) usually with a lower tree layer of paperbarks on Tertiary sand plains	Endangered	None
8.5.6	Broad leaved paperbark and black oak woodland with Eucalyptus species, on Tertiary sand plains	Of Concern	High

Table 3.2.1 Biodiversity and reservation status of regional ecosystems on alluvial and sand plains

GOVERNANCE

Many of the coastal ranges and hills are protected within National Parks or State Forests. National Parks are to be managed in accordance with the Nature Conservation Act 1992, with management responsibility sitting with Queensland Parks and Wildlife Service. The management principles provided by this act are: A National Park is to be managed to:

- Provide, to the greatest possible extent, for the permanent preservation of the area's natural condition and the protection of the area's cultural resources and values; and
- Present the area's cultural and natural resources and their values; and
- Ensure that the only use of the area is nature-based and ecologically sustainable.

The key principle to be observed in the management of State forests is the permanent reservation of such areas for the purpose of producing timber and associated products in perpetuity and of protecting a watershed therein.

Prior to 2006 privately-owned forest plantations in the region have generally been established in association with State/Commonwealth Government sponsored programs – Forest Plot Scheme, CRRP, Tree Assistance Scheme, WAPIS & NHT. It is estimated that there are 500+ plantations in the region of between 0.25 Ha to 25 Ha in size, which equates to approximately 500 ha. Species types vary broadly from eucalypt or pine monoculture plantations through to mixed plantings of 20+ rainforest / cabinet species.

There are also provisions within the Nature Conservation Act for declaration of Nature Refuges over private land through negotiation of Conservation Agreements. Once gazetted, Nature Refuge status is binding on Successors in Title and therefore conserved in perpetuity.

Some land on the hinterland plain, coastal hills or ranges, is leased under the provisions of the Land Act for cattle grazing. Conditions of these leases include both general requirements for 'Duty of Care' and also specific management requirements.

The Vegetation Management Act (VMA) regulates broad scale tree clearing; apart from small scale requirements for management purposes e.g. for fire breaks or fence lines. From 1 July 2013, the VMA was amended to allow for the sustainable vegetation management activities to occur to support the development of high-value agriculture to assist in the growth of the agricultural industry and contribute to the government's goal of doubling Queensland's food production by 2040. Reef watercourse protections will continue to ensure that these ecosystems maintain the condition of the land and uphold the state's commitments under the Reef Water Quality Plan, with applications possibly required to offset the impact of activities through revegetation of other areas. The regulation of clearing of high-value regrowth vegetation will be removed towards the end of 2013 from freehold and Indigenous land. Such reforms provide landholders with the ability to undertake vegetation management activities such as fodder harvesting, encroachment, necessary environmental clearing and vegetation thinning without the need for government involvement or assessment.

This will be a key forum within which ongoing sustainability of natural resources will be negotiated. The same provisions do not apply in urban areas although endangered regional ecosystems are still protected. However, the 'endangered' status used by the VMA is calculated only by the extent of a regional ecosystem left remaining, not the condition of remaining examples. Thus a regional ecosystem which has a biodiversity planning status of 'endangered' may still be cleared in urban areas if its VMA status is only 'of concern'. In order to protect areas of high biodiversity value (e.g. threatened species habitat) Essential Habitat Mapping can be prepared and gazetted by provisions of the VMA. This mapping then regulates any further clearing of that habitat regardless of what regional ecosystem(s) is present or its conservation status.

Legislative power to enforce the control of pest plants and animals lies with Local Authorities, and with DNRW. All landholders have legal requirements to make efforts to control pests on their land.

INDICATORS

An indicator of ecosystem health may be the extent to which key conservation areas are protected within conservation reserves and Nature Refuges and the extent of remnant vegetation otherwise managed by landholders for its conservation value.

Active and evidential management of remnant vegetation for its nature conservation value by improved pest and fire management and opportunities to begin to further understand habitat condition, the affects of pests and fire, and management needs across the region.

In addition is the extent of endangered regional ecosystems, key corridors and/or threatened species habitat (i.e. key conservation areas) protected by either State sponsored conservation reserves and/or by Nature Refuges is increased significantly.

Further Essential Habitat mapping would have to be prepared for key threatened species (which are also key indicator species), known to persist adjacent to or in areas which may be subject to urban expansion, in order that key habitat areas are protected.

Such priority threatened species include northern quoll, coastal sheath-tail bat, and rufous owl.

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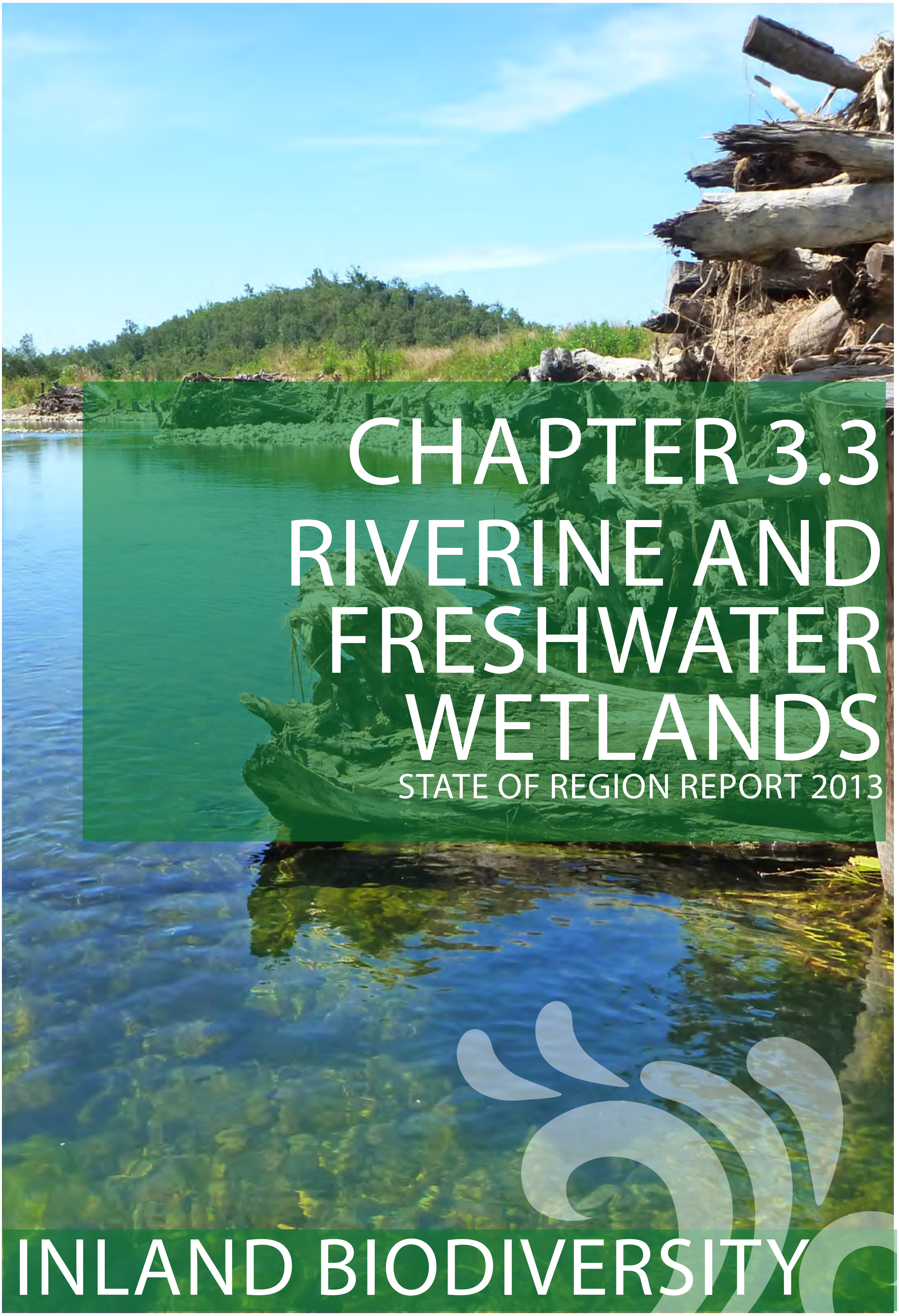

CHAPTER 3.3
RIVERINE AND FRESHWATER WETLANDS

STATE OF REGION REPORT 2013

INLAND BIODIVERSITY

Riverine and Freshwater Wetlands

REEF CATCHMENTS

SUMMARY

The major streams in the region are the Gregory, Proserpine, Andromache and O'Connell Rivers to the north, the Pioneer River and St Helens, Murray, Sandy, Alligator and Plane Creeks in the central area and Carmila Creek to the south. Of these, the major catchments are the Don, Proserpine, O'Connell, Pioneer and Plane Creek. These catchments are characterised by having their watershed in the higher altitude areas of the Clarke Connors Rang, draining the relatively narrow coastal passages to nearby coastal wetlands, estuaries and the Coral Sea. The western watershed of the Clarke Connors Range flows into both the Burdekin River to the north-west and the Fitzroy River to the south-west (Figure x).

Nationally important wetlands include Broad Sound, Edgecumbe Bay, Four Mile Beach, Great Barrier Reef Marine Park, Proserpine Goorganga Plain, Sand Bay, Sandringham Bay – Bakers Creek Aggregation, Sarina Inlet – Ince Bay Aggregation, and St Helens Bay area (figure x).

There are coastal freshwater wetlands which abut brackish and estuarine systems (for example, in the area around Rocky Dam Creek, Proserpine-Goorganga Plain) and also both small and large artificial impoundments.

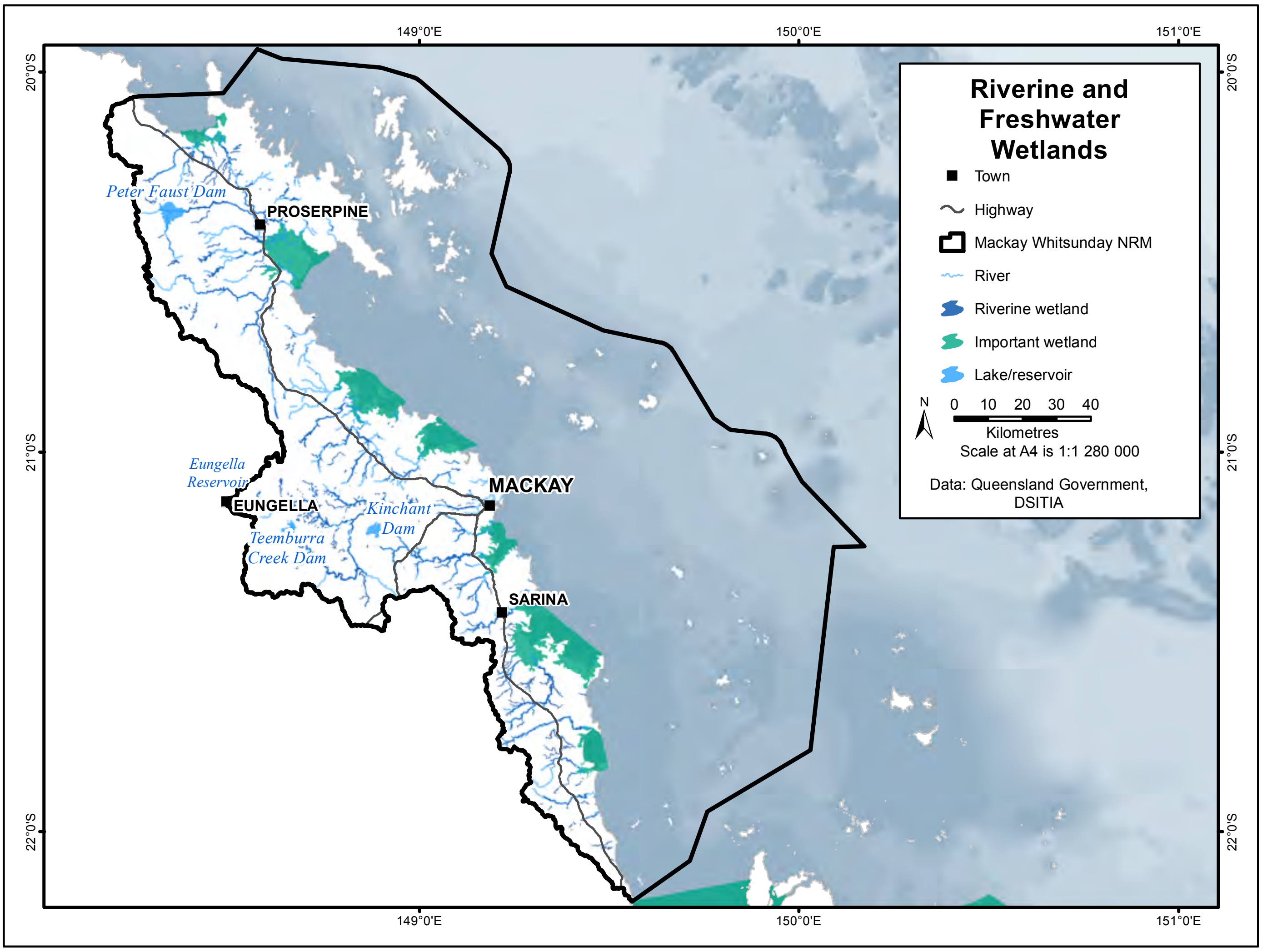

Figure 1 Riverine and freshwater wetlands of the region

Regional Ecosystem	Biodiversity Conservation Status	Extent Protected in Conservation Reserves
8.3.1: Semi-deciduous notophyll/mesophyll vine forest fringing	Endangered	Low
8.3.2: Broad leaved paperbark woodland often with emergent eucalypts and grassy/herbaceous ground layer, on seasonally inundated alluvial plains with impeded drainage	Endangered	Low
8.3.3: Weeping paperbark ± river oak open forest to woodland, fringing watercourses	Of Concern	Low
8.3.4: Freshwater wetlands with permanent water and aquatic vegetation	Endangered	Low

Table 1 Primary wetland regional ecosystems of the central Queensland coast bioregion.

VALUES AND SERVICES

The region's wetlands are dynamic ecosystems host to a diversity of water fowl and other birds, amphibians, reptiles and insects, for example the western part of Peter Faust Dam has an estimated 1500 nesting pairs of pied cormorants, over 200 pairs of black swans and more than 400 pairs of Australian pelicans.

Australia has over 300 species of freshwater fishes, of which around 45 are found in freshwater streams in the region, providing an important commercial and recreational fishing resource. Although commercial fishing occurs only in estuarine and marine waters in Queensland, commercially harvested fish species, such as barramundi, mangrove jack and striped mullet, depend on free access to good quality freshwater habitats to spend some portion of their life-cycle (Marsden et al 2006). Fish species such as jungle perch, barramundi, mangrove jack, sleepy cod, sooty grunter and eel tail catfish are staples of the recreational angler, with streams such as the Pioneer, St Helens Creek and O'Connell providing excellent riverine fisheries (Marsden et al 2006).

Wetlands provide important ecosystem services, such as regulation of the hydrological cycle through water storage and transport, and ground water recharge functions (Cork and Shelton, 2000; Graham et al., 2004). They also play a major role in sediment retention and nutrient cycling, by stabilising and filtering run off and maintaining water quality for the region. Wetlands are critical to the economy as the primary storage of water resources for both agricultural and industrial uses.

> ""High quality freshwater habitats also influence many species that do not directly enter freshwater. It is well recognised that freshwater inflows dramatically affect the productivity in estuarine and marine systems. Protection of freshwater catchments and habitats ensures that high quality water is delivered into marine systems, providing the greatest productivity benefits to these systems. In general, although no commercial fishing actually occurs in freshwater, the quality of freshwater habitats and fish communities is vital to the continuation of commercial fishing activities in the Mackay Whitsunday Region"
>
> Marsden et al., 2006; 10

Riparian vegetation provides erosion protection and improved water quality by enhancing infiltration (Eldridge and Freudenberger 2005; Lovett and Price, 2001; McIntyre et al, 2002, Wilson, 2002), in addition to the shade, cover and water temperature that regulates up to 90% of food sources (detritus and insects) habitat in the form of snags (logs, roots, branches and leaves), providing healthy fish habitat.

The identification of regional riverine and wetland values, including environmental, irrigation, stock watering, recreation, drinking water and cultural values, has been captured as part of water quality planning. National parks and protection areas are considered of highest ecological value, with Repulse Creek ranking highest.

Wetland ecosystems and the health of waterways are of great material and cultural importance to Indigenous people; many have profound cultural significance and values. Almost all wetland plant and animal species have some form of traditional use, particularly vegetation, crustaceans, fish, reptiles, mammals and waterbirds (particularly their eggs), or cultural significance (for example totemic significance). Historically, significant resources for traditional ownership clustered around areas of greatest biodiversity, such as along ecotones (transition areas between two or more ecological communities): wetlands were one of these transitional zones. Traditionally, Indigenous people valued wetlands for food, medicine, tools, materials for manufacturing and fibre, in addition to cultural activities, story places, and seasonal indicators.

PRESSURES AND THREATS

The main pressures in riverine and freshwater wetlands include draining, clearing and hydrology alteration as a result of urban and agricultural development. Associated threatening processes include barriers to fish migration, waterway modification and impact on flow, water quality degradation, riparian vegetation removal, sedimentation of waterways, and introduced flora and fauna (Drewry et al 2007). Waterway modifications to riparian vegetation, streambed conditions, and removal of snags create loss of habitat heterogeneity, increased water temperatures and lower dissolved oxygen, which has negative effects on fish populations and water weed infestations (Marsden et al 2006).

Maintenance of 'environmental flows' is essential to the condition of freshwater habitats, estuarine ecosystem processes and to allow movement of species that require freshwater and marine environments to complete their lifecycle. Major barriers to migration include dams, weirs, culverts, pipes, causeways, stock crossings and water weed infestations (Marsden et al 2006).

Potential exists for conflict over water allocation. Construction of damns and weirs regulates or prevents water flows notably during low flow events. Alternatively, some waterways such as those used for reticulation of water from Teemburra Dam, may receive flows of water destined for use in irrigation, during seasons when natural flows are normally minimal.

Decreases in water quality as a result of sedimentation, inorganic nutrients and pesticides pose a major threat to waterways and ecosystem health. Water quality issues within the region include sedimentation, inorganic nutrients and pesticides. Key water quality pollutants of concern include Dissolved Inorganic Nitrogen, Particulate Nitrogen, Filterable Reactive Phosphorus, Pariculate Phosphorus, Total Suspended Sediment and the herbicides ametryn, atrazine, diuron, hexazinone, tebuthiuron.

The main exotic fauna in the region's waterways are mosquitofish (Gambusia holbrooki), guppies (Poecilia reticulata), sword-tails (Xiphophorus hellerii) and red-claw crayfish. Emerging threats to the region's waterways are Mozambique tilapia (Oreochromis mossambicus) and Spotted tilapia (Tilapia mariae).

Feral pigs are the most significant pest animals of freshwater wetlands causing major damage through direct predation on native species, habitat degradation due to rooting and wallowing, and subsequent declines in water quality (DEW, 2013).

Aquatic weeds such as Water Hyacinth (Eichhornia crassipes), Salvinia (Salvinia spp.) and Water Lettuce (Pistiastratiotes) are present, in addition to introduced pasture species such as Hymenachne (Hymenachne amplexicaulis), Para Grass (Brachiaria mutica) and Guinea grass (Megathyrsus maximus), which can dramatically alter habitats structure and water flow. Other threatening species include highly invasive vines; Rubber Vine (Cryptostegia grandifolra R.Br.), Cat's Claw Creeper (Macfadenya unguis-cati), and Madeira Vine (Andredera cordifolia), which are capable of destroying riverine vegetation, pulling down the largest of trees, and reducing the ability of native vegetation to regenerate. Mimosa pigra is an extremely invasive pest species capable of completely replacing native vegetation with a very difficult to manage monoculture. An outlier of this weed is present at Peter Faust Dam and is currently subject to a critically important eradication program.

Blue green algae is a concern in a number of the catchment's dams and weirs, as are floating and emergent water weeds which are a recurring problem in a number of waterways, impacting greatly on water quality and ecosystem health. Ultimately, declining stream and land condition as a result of sediment and chemical run off and changes in upstream habitat, is impacting the condition of the Great Barrier Reef Marine Park.

CONDITION AND TRENDS

Water Quality

There has been significant investment made in determining the relative ecological value of freshwater catchments and the quality of their component waters. Faithful (2003) conducted a two year water quality data collection project in the Proserpine and O'Connell catchments, informing the beginning of a regional water quality database. This was in turn supported by numerous additional baseline assessments and studies such as Mitchell et al (2005), Drewry et al. (2007), Lewis et al. (2007) and Rohde et al. (2006, 2006b, 2008). Information is also available regarding ecological values for key coastal wetlands and some impoundments, such as Nationally Important Wetlands (EA, 2001). Spatial descriptions of all wetland areas are provided by the EPA (2006) and includes reference to their component regional ecosystem were applicable, and data relating to hydrological modification.

In 2005, a water quality monitoring and sampling project occurred that determined contaminants in fresh and marine waters in the region, while drawing some conclusions as to the source and potential mitigation of such discharges (Rohde et al 2006). Then in 2007, a Water Quality Improvement Plan (WQIP) was developed that described management interventions for rehabilitation of priority habitats and reduction of pollutants from diffuse and point sources (Drewry et al 2007). Proportioning the region into 33 catchment management areas, the WQIP was informed by water testing to define the condition and value of the area before outlining necessary interventions for rehabilitation of priority habitats and reduction of pollutant loads.

The WQIP presents the most comprehensive assessment of the catchment waterways, including fish community composition, water quality, flows, fishway barriers, in stream habitat and riparian vegetation condition and extent.

The freshwater condition of wetlands which occur in these catchments are variable; from near pristine in the headwaters and lowland reaches of the Impulse-Repulse Creek system, to highly modified lowland reaches of the Pioneer River. Because the region is comprised of 17% National Parks, reserves, remnant vegetation and other protected areas considered to be of High Ecological Value (HEV), water quality in these areas is considered very good. HEV areas are included in Repulse Creek, Finch Hatton Creek, St Helens Creek, Basin Creek and the Upper Andromache River. The Basin Creek and Repulse Creek catchments contain intact riparian vegetation from headwaters to the coast.

Of the 33 catchment management areas outlined in the WQIP, 7 are considered in low condition (Dewey et al, 2007). Such areas of low condition, for example Bakers Creek, correspond with large areas of intensive cropping (>30%) and have modified in-stream habitat and often poor riparian vegetation. Whereas Repulse Creek for example ranks as virtually pristine as its catchment lies within Conway National Park and State Forest, both of which are managed almost entirely for conservation. Waterways within landscapes predominantly used for beef cattle grazing tend to be in intermediate to good condition, for example Gillibin Creek.

However, in cases such as Plane Creek, aquatic ecosystem condition ranks poorly and yet has less than 30% intensive cropping. This is as a result of significant changes in flow regime and in-stream habitat through the construction of dams and weirs, in addition to urban and industrial runoff causing degradation in the condition of this stream beyond what could be expected by agriculture alone.

Myrtle Creek, Alligator Creek, Proserpine main channel, Sandy Creek and Bakers Creek commonly exceeded ambient water quality objective (WQOs), commonly with nutrients (DIN, FRP, PN, PP) and % dissolved organic saturation (Table 2). These percentages are generally low, although Particulate Phosphorus exceeded the WQO more often than for other nutrients.

Indicator	DIN	PN	FRP	PP	TSS
Current condition exceeding the ambient WQO (% of management areas)	27	6	21	36	6

Table 2 Percentage of management areas with nutrient and TSS current condition exceeding the ambient WQOs in the WQIP.

Fisheries Management

The actual stream management, for example 'river improvement' works and construction to rectify barriers appears to influence fisheries' values more than prevailing land use (Marsden et al, 2006). In-stream flood mitigation and erosion control works such as de-snagging and straightening of streams has also had considerable impact on the condition of a number of streams in the catchment.

Fish kills have been recorded in a number of streams across the catchment and are more prevalent in highly developed systems such as Reliance Creek, Goosepods, Alligator Creek, Sandy Creek, Bakers Creek and the Pioneer River.

Catchment	Stream condition	Fish habitat condition	Fish community condition
St Lawrence and Clairview	Low disturbance	Good	Good
Flaggy Rock	Good	Good	Good
Carmilla, West Hill and Marion	Moderate disturbance	Moderate	Moderate
Rocky Dam	Moderate disturbance	Moderate	Moderate
Plane Creek	Highly disturbed	Poor	Moderate
Sandy, Alligator and Bakers	Highly disturbed	Poor	Poor
Pioneer	Highly disturbed	Moderate	Moderate
Reliance and Constant	Moderate disturbance	Good	Good
Murray, St Helens, Blackrock and Alligator	Highly Disturbance	Moderate	Good
O'Connell	Moderate disturbance	Moderate	Good
Proserpine	Highly disturbed	Poor	Poor
Whitsunday	Low disturbance	Excellent	Excellent
Gregory	Moderate disturbance	Good	Good

Table 3 Waterways condition by catchment, fisheries perspective

Ecological Health

In the WQIP, an index of freshwater ecosystem condition was developed to assess the condition of waterways that went beyond water quality. The 'relative ecological condition of freshwater stream index' uses a combination of monitoring data and expert opinion to generate a score for fish community condition, water quality, changes in flow regime from pre-development condition, barriers to migration, in-stream habitat condition and changes in riparian vegetation from pre-development condition (Drewry et al. 2007).

Value rated	System rating (A=excellent, E=poor) Objective 2050	Condition 2007	Target 2014	Achieved 2014	Draft Target 2021	System repair actions	Draft Priority	Cost $ '000s
Fish community	A	C	B	B	A	Flow, Instream Habitat and Riparian Vegetation repair actions priority		
Event water quality	B	D	C	C	B	Crop & grazing priority actions		
Flow	B	D	C	C	B	Implementation of voluntary irrigation restrictions to maintain waterhole during low flow		100
Barriers to Migration	A	C	B	B	A	Monitoring & maintenance fishways & incorporate fish passage into new barriers		100
Instream Habitat	A	C	B	C	B	Restoration & stabilisation of 10 priority reaches		1,000
Riparian Vegetation	B	D	C	C	B	Active restoration & connectivity of priority reaches. Grazing management on riparian land		500
Estuary Modification	A	B	A	B	A	Active restoration & management to encourage recovery, natural habitat & channel stabilisation		300
Mangroves & Saltmarsh	B	D	C	D	C	Management to encourage recovery		100

Figure 2 System condition 2007-2014 for the O'Connell River Management Area

A review of ecosystem condition features throughout the 2014 progress reports, with 'ecosystem implementation highlights' detailed for each of the 33 sub-catchments. For example, the O'Connell River progress report notes that:

- Flow management has been improved through waterhole mapping that enables a better understanding of the volumes of water required to maintain critical fish habitat;
- Riparian management has been improved on 33 km of the O'Connell River by graziers who have erected riparian fencing and off stream watering points with Reef Rescue support;
- Barriers to migration have been removed through construction of fish passages structures on all major barriers;
- Instream habitat has been restored through the installation of a series of engineered log jams at a priority reach.

O'Connell River Management Area

Land Use	Management Practices	Key Pollutant	2007 % Adoption	2014 % Adoption Target	2014 % Adoption Achieved	Effort realised	% of target	Draft 2021 % Adoption Target	Cost $ '000s
Cane & Horticulture	Soil	PN PP				H	95		
	Nutrient	DIN FRP				H	90		
	Pesticide					H	75		
Grazing	Soil	PN PP				L	10		
Existing Urban Management	Nutrient	DIN FRP				?	?		
New Urban Development	Soil	PN PP				?	?		

D = old practice; C = common practice; B = Currently promoted practice; A = cutting-edge practice

Figure 3 O'Connell River Management area adoption rates and achievements according to land use

Other

The wetland area index has increased in 2011 and 2010 for the first time since the 1990's as a result of widespread flooding which has extended waterbird habitat and consequently the number of waterbirds in the area has increased (EPA, 2013).

GOVERNANCE

In 2010 the State Government released the Whitsunday Water Resource Plan, which is subordinate legislation under the Water Act and defines water resources while providing a framework to secure water supplies for existing users and supporting new opportunities (DNRM, 2010). The Whitsunday Resources Operation Plan was developed also to provide guidance on how water usage will be managed.

The State Government produced a report to accompany the Draft Water Resources Plan for the Proserpine and O'Connell Rivers, in addition to the Pioneer Valley Resource Operations Plan. The Queensland Government released a "Strategy for the Conservation and Management of Queensland Wetlands" (EPA 1999), and most recently a State Planning Policy that outlines how it will protect high ecological value wetlands in catchments adjacent to the Great Barrier Reef (Department of Environment and Resource Management 2011)

The River Improvements Trusts operate under the River Improvement Trust Act (1940) and Regulations (1998) to protect and improve the bed and banks of rivers, the repair and prevention of damage to the bed and banks of rivers and the prevention of flooding.

Local Government is responsible for ensuring developments install appropriate erosion and sediment control measures. Under sections 19 to 21 of the Environmental Protection (Water Policy) 2009, a local government with a population of more than 10,000 must develop a total water cycle management plan including collection, treatment, recycling and urban storm water.

Since 2007, the waterway barrier works legislation has been adapted to allow for not just impeding river flow, but for impeding fish migration. Previously building weirs and dams was captured as a barrier to river flow, and now culvets and road crossings are considered waterway barriers which triggers a requirement to consider fish passages.

Constructing or raising any barrier across a waterway (freshwater or tidal) requires a development approval under the Integrated Planning Act 1997 and the Fisheries Act 1994. Under this legalisation the application will be refused unless movement of fish across the waterway barrier is adequately provided for or an exemption is given due to no fish or habitat existing above the barrier. On large-scale infrastructure this may require a fishway that adequately provides for fish passage.

The Mackay Whitsunday Healthy Waterways program commenced in 2002 and represents all water quality and aquatic ecosystem health activities of Reef Catchments. Through 2009/10 the Healthy Waterways Alliance was launched, to provide coordinated management of aquatic resources across the Mackay Whitsunday Region with the aim that the region's waterways would meet environmental, economic and social needs of the region. Four expert advisory groups comprise the Alliance membership, providing expert advice for planning, monitoring and reporting on water quality and ecosystem management and restoration activities that align to regional programs and Reef Plan.

Healthy Waterways oversee the development and implementation of the WQIP, the Integrated Monitoring Program and the annual Healthy Waterways Forum.

The Reef Water Quality Protection Plan (Reef Plan) is a collaborative program of coordinated projects and partnerships designed to improve the quality of water in the Great Barrier Reef though improved land management in reef catchments.

The plan is a joint Australian and Queensland Government initiative that specifically focuses on non-point-source pollution. This is where irrigation or rainfall carries pollutants such as sediments, nutrients and pesticides into waterways and the reef lagoon.

Reef Plan sets ambitious but achievable targets for water quality and land management improvement, and identifies actions to improve the quality of water entering the reef. Initially established in 2003, the plan was updated in 2009. It details specific actions and deliverables to be completed by 2013 when Reef Plan will be reviewed.

INDICATORS

An 'ABCD' framework for the region was developed in 2007 to provide definition and scale of improvement from dated to innovative practices, creating a common reference point for water quality researchers, social scientists, economists, industry research and extension organisations, and land managers. The ABCD framework considers different standards of management practice, as opposed to resource condition, within industry for different water quality parameters, including soil management, nutrient management and chemical management).

Class	Short definition	Long definition
A	Practice likely to achieve long term resource condition goals if widely adopted	Cutting edge practices that require further validation
B	Practice likely to achieve medium term resource condition goals if widely adopted	Currently promoted BMPs that are industry and community endorsed
C	Practice unlikely to achieve acceptable resource condition goals if widely adopted – acceptable only in the short term	Common practices that may meet minimum industry and regulatory obligations
D	Practice likely to degrade resource condition if widely adopted	Practices that are superseded

Table 4 Management classes and definition for the ABCD framework.

The Paddock to Reef program is an innovative approach to integrating best available monitoring and modeling information on management practices, catchment indicators, catchment loads and the health of the reef, which includes outputs from WQIP.

The WQIP provides indicators water quality and ecosystem health for the 33 sub catchments, with water quality indicators available to define water quality and aquatic ecosystem condition. A combination of abiotic (physico-chemical) and biotic factors of water quality can be used to derive an index of relative ecological condition.

The process of establishing environmental values and water quality objectives is outlined by EPA (2005). 'Water quality guidelines' are measurable levels required to support and protect particular Environmental Values (EVs). Water quality guidelines are commonly state (Queensland Water Quality Guidelines) or national guidelines, such as ANZECC guidelines.

Water Quality Objectives (WQO) are set to protect the environmental values of waterways in the region under the WQIP. WQOs are based on the community's initial choices for EVs and the water quality guidelines (eg ANZECC 2000) to protect them (EPA 2005). A WQO may include social and economic factors, agreed by stakeholders or set locally (NAP 2007).

Current condition for many WQ parameters are based on sampling programs, for example, the median of a range of ambient condition sampling. Event-based condition and targets are also appropriate for catchments. WQ targets in the WQIP, for example, are estimated to be achievable given adoption of management actions and best management practices to improve water quality.

WQO indicator	WQO type	Description	Justification
DIN	Ambient, event, marine	Dissolved inorganic N. (Nitrate + nitrite + total ammonia).	Readily bioavailable
PN	Ambient, event, marine	Particulate N	Bioavailable in long-term
FRP	Ambient, event, marine	Filterable reactive P	Readily bioavailable
PP	Ambient, event, marine	Particulate P	Bioavailable in long-term
Turbidity	Ambient		Affects light penetration
TSS	Ambient, event, marine	Total suspended sediment	Indicator of eroded of sediment
DO%	Ambient	Dissolved oxygen percentage	Critical for aquatic organisms to survive. Low dissolved oxygen is the major cause of fresh water fish kills.
Ametryn, Atrazine, Diuron, Hexazinone, Tebuthiuron	Ambient, event, marine	Agricultural herbicide	Inhibits plant growth. Travels in water with sediment and in solution.
pH	Ambient	Indicator of how alkaline or acidic the water is.	Important to biological processes.
EC	Ambient	Electrical conductivity. A measure of electrical conductivity (dissolved solids usually salts).	Inhibits plant and animal growth.

Table 5 Water quality indicators used as WQOs in the WQIP

In the WQIP, selected water quality indicators were established through consultation with water quality experts as being most appropriate for the region to aid and monitor improvement of water quality to waterways and the GBR. Indicators include ambient, event-based and marine WQOs, and therefore values are different for specific situations. Event-based end of catchment WQO values are important because the majority of pollutants (e.g. sediment, nutrients, herbicides) are transported during storm events, rather than during ambient conditions. Event-based end of catchment WQO values are generally much greater than in ambient (low flow) conditions.

Based on the work completed in the WQIP it is possible to undertake ongoing water quality indicator monitoring and benchmarking which can track the regions ability to meet targeted water quality improvements in catchments and the region.

The Mackay Whitsunday index of relative ecological condition uses a combination of existing data and expert opinion to assess the relative ecological condition of freshwater and estuary waters across the region. These indicators were summed to give an overall score for ecosystem condition.

Indicator	Description	Data source
Freshwater and estuary fish community condition	Catch per unit effort and species diversity data to assess fish community condition based on an assessment by DPI&F, Mackay (Moore et al. 2008). 1 = poor, 5 = excellent.	Moore et al. (2007)
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 a 1 to 5 score by using the 20, 40, 60 and 80th percentiles of the ranked data. 1= worst 20%, 5=best 20%	Drewry et al. (2007)
Changes 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 (2007). 1 = Hydrology largely altered, major dams and diversions. A number of irrigation licences; 3 = Hydrology altered, minor dams or weirs present. Some irrigation licences; 5 =Hydrology largely unaltered, no major dams, diversion. Few to no irrigation licences.	NRW hydrographic staff (Platten 2007)
Barriers to migration	Barriers to fish migration were assessed by the DPI&F, Mackay (Marsden et al. 2006). 5 = no barriers, 1 = significant barriers.	Marsden et al. (2006)
In stream habitat condition	In-stream habitat condition was assessed by the DPI&F (Moore et al. 2008; Marsden et al. 2006). 5 =Streams with a wide diversity, high quality habitat and minimal disturbance; 1 = few habitat types and highly impacted habitat	Marsden pers comm.
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 2007) using data from regional ecosystem mapping (version 5 EPA 2005). Percent remnant riparian vegetation from pre-clear was ranked 1–5; 1= poor riparian vegetation condition.	Platten (2007)
Estuary modification	Estuary modification was assessed by Ozestuaries and reported as a 1–5 score (http://www.ozcoasts.org.au/), and incorporated into the aquatic ecosystem condition index	Platten (2007)

Table 6 Indicators of Mackay Whitsunday index of relative ecological condition of freshwater streams and estuaries.

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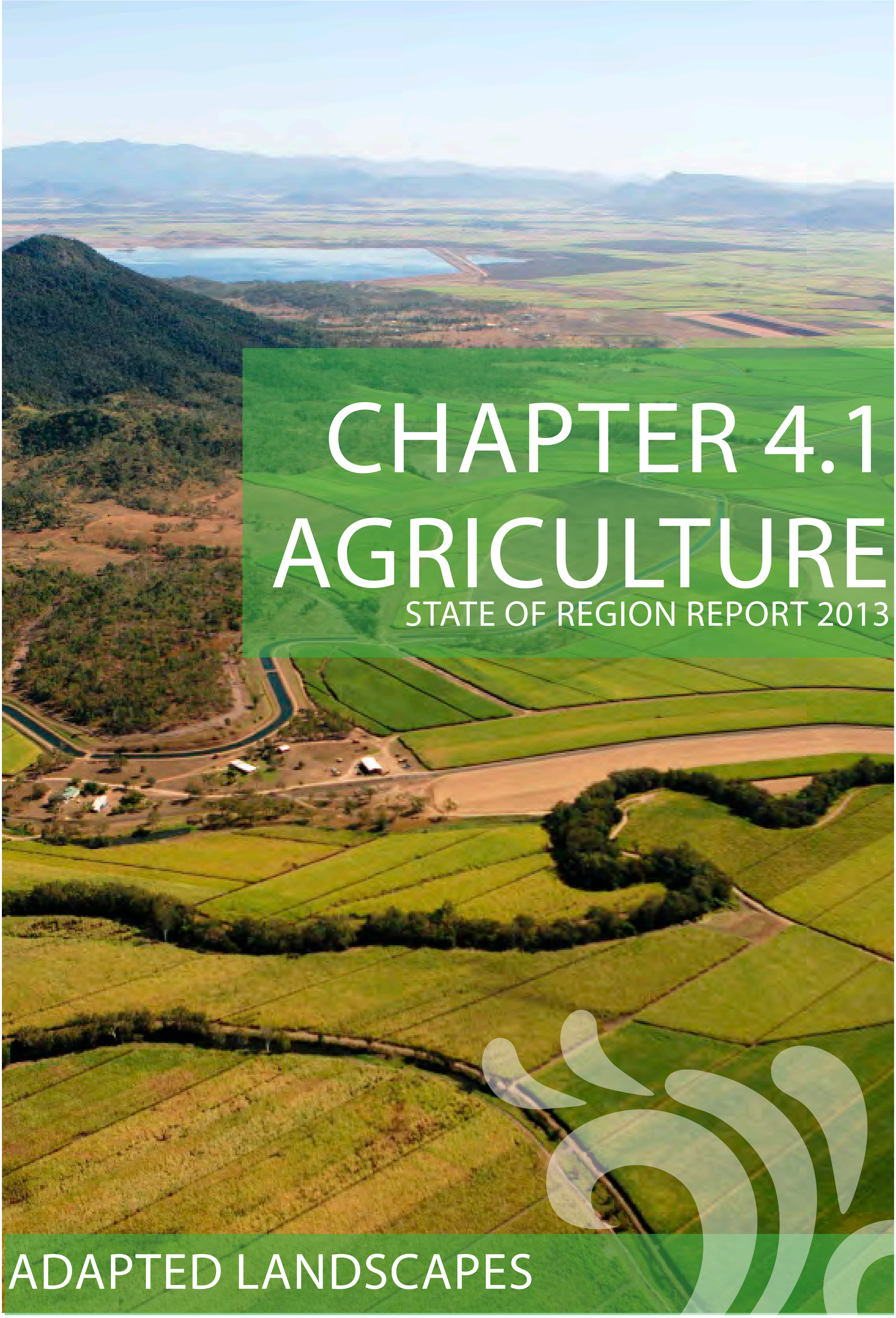
CHAPTER 4.1 AGRICULTURE

STATE OF REGION REPORT 2013



ADAPTED LANDSCAPES

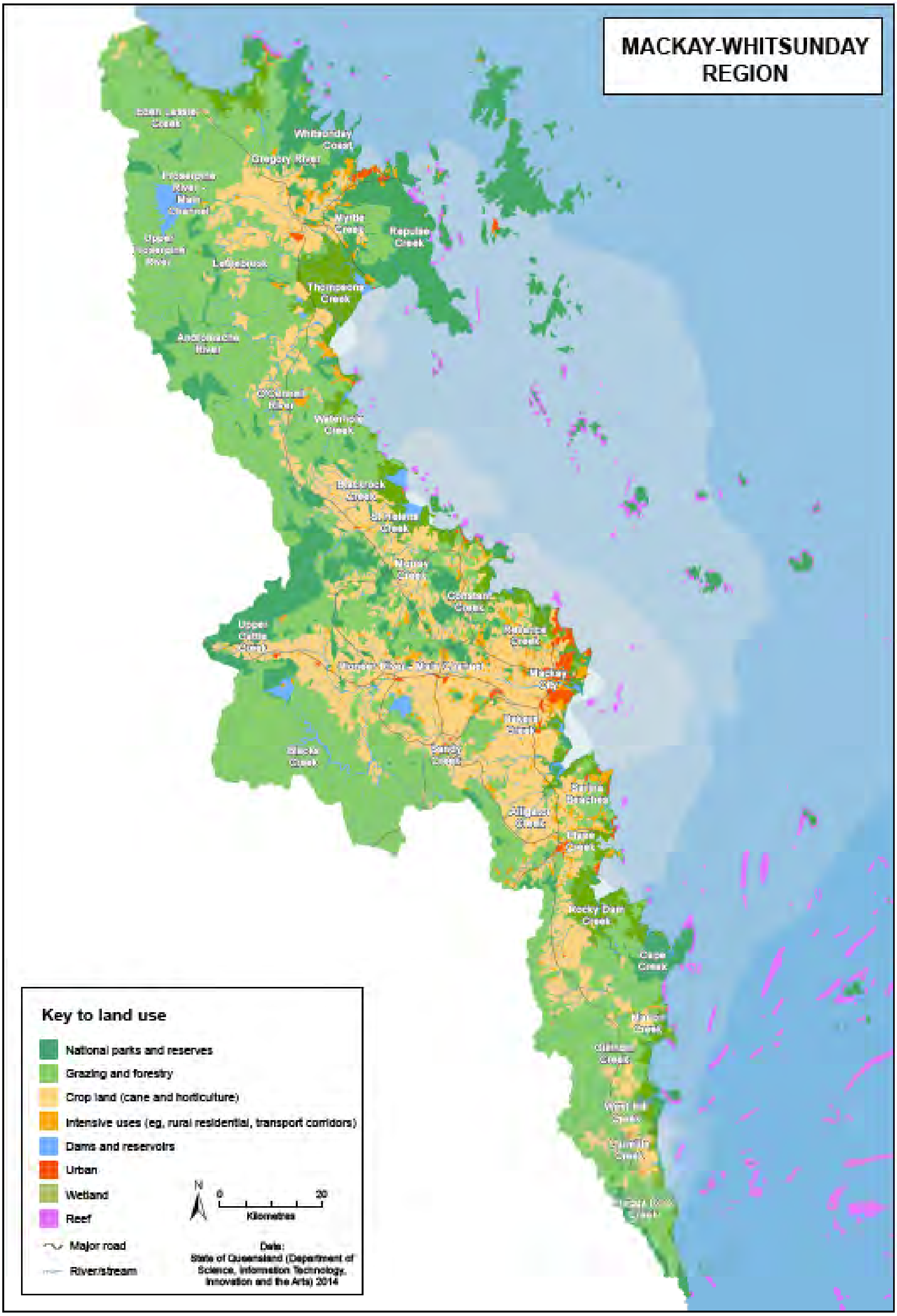


Figure 1 Land use in MWI 2013

N.B. Intensive Agriculture is defined as 1) 'Intensive horticulture' to 'intensive horticulture', 'shadehouses', 'Glasshouses' and 'Glasshouses (hydroponic)'; 2) 'Intensive animal production' to 'intensive animal production', 'Dairy sheds & yards', 'Poultry farms', 'Piggeries', 'Aquaculture', 'Other intensive animal husbandry' and 'Stockyards/ saleyards'.

Agriculture

REEF CATCHMENTS

"A farming or grazing system is said to be sustainable at the farm level if it 'satisfies the farm/grazing manager's needs over time while conserving the natural resource' (Gomez et al. 1996). Sustainable production systems include virtually all agriculture related land use enterprises in the landscape that rely on natural resources of land, vegetation, and water, and certainly includes cattle grazing, cropping, horticulture and agroforestry systems."

Pastures Mackay Whitsunday Region, Bishop (2007, 95)

SUMMARY

The regions agriculture and diverse scenic amenity define the character and image of the area, which is highly valued by both local residents and visitors.

Major intensive agriculture industries in the region are sugarcane, cattle farming and horticulture. The primary intensive agricultural land use is sugarcane which, while only making up about 18 per cent of the catchment area, constitutes land use close to 96 per cent of the intensive agriculture in the region. Grazing has the largest land use in region, accounting for 65 per cent of the region. It is estimated that more than 50 per cent of the regions beef cattle are run by approximately 10 per cent of enterprises and that 11 per cent of grazing is undertaken on improved pastures (Bishop 2007).

SUGARCANE

The Central Region Sugar Industry is located north and south of Mackay in North Queensland (Mackay Regional Advisory Group, 2005). Cane growing areas are situated on the coastal floodplains to the east of the dividing range from Flaggy Rock in Broadsound Shire through Sarina shire, Mirani shire, Mackay City and north to Bowen in Bowen shire. Cane growing is organised around two milling groups; Mackay Sugar Co-operative Association Limited (Mackay) and Wilmar International Limited (Proserpine and Plane Creek).

Each of these milling groups operates mills selling raw sugar to Queensland Sugar Limited which, in turn, is either exported through the Mackay Port or sold to the region's sugar refinery at Racecourse, owned by CSR Limited.

CATTLE GRAZING

The beef business is centred on breeding and sale of weaners, stores or cull cows, although an increase in fattening operations is occurring. A key influence of this change is the movement of many sugarcane growers toward the use of sown pastures on what was sugarcane production land. The distribution of beef enterprises is approximately 80 per cent coastal and 20 per cent hinterland.

Cattle grazing occurs mainly on improved pastures totalling an area of 74,000 hectares, while both natural or native pasture and agroforestry occupy around 427,000 hectares.

Meat processing is undertaken in the main at Thomas Borthwick & Sons (Borthwicks) abattoir in Bakers Creek south of Mackay, with 90 per cent of throughput exported and 10 per cent retained for domestic sales.

HORTICULTURE

Horticulture comprises 0.7 per cent of the NRM region and approximately 3.6 per cent of intensive agriculture land area. The Mackay Whitsunday council region supply in total more than 60 per cent of Queensland's horticulture products, the majority occurring within a 50 kilometre coastal strip in and around the townships from Bowen to

Molongle Creek, although the majority of this occurs outside the catchment boundary. Horticulture crops include mangoes, tomatoes, capsicum, green beans, pumpkin and sweet corn, and eggplant. Only a small proportion of horticultural produce from the region (5-10 per cent) is exported.

DAIRY

Dairy is confined in the main to three dairy operations within the Marani shire, which in 2012 generated 3 mega litres of milk (compared with 8.8 mega litres in 2001), before being sent to Rockhampton to be processed

AQUACULTURE

There are 38 approved aquaculture facilities in the region valued at approximately $8.6 million per annum. The aquaculture species cultured in this region include black tiger prawns (Penaeus monodon), barramundi (Lates calcarifier) and redclaw crayfish (Cherax quadricarinatus).

WATER RESOURCES

The groundwater and waterway systems of the region support the region's agricultural industries. Since European settlement, most of the regional watercourses have been subject to human development inputs including point-source discharges (e.g. sewage, industrial waste) and diffuse (non-point) sources resulting from land clearing and development, agricultural, urban stormwater and recreation activities.

In the region there exist several highly developed catchments with regulated flow, mainly as a result of cane farming. Management areas with high proportions (>40 per cent) of cane farming include Reliance Creek, Sandy Creek, Alligator Creek, Mackay City and Bakers Creek. Management areas with flow regulation include Pioneer River and Rock Dam Creek.

VALUES AND SERVICES

"Land suitable for agricultural production is a valuable, finite commodity that is to be managed to ensure its long-term protection for future generations. Use of land with both agricultural production values and biodiversity values should seek to achieve a balance between the protection of ecological processes and natural systems, economic development and the wellbeing of communities"

(DLGP 2012, 69).

The value of agricultural production in the Mackay, Whitsunday and Isaac council regions was $891 million in 2010–11, or 9.3 per cent of Queensland's total value of agricultural production (DAFF, 2013). All agricultural land-use types have seen significant market value increases for the period from 2001 to 2012, ranging from 36 to 456 per cent (DAFF, 2013).

SUGAR CANE

"Cane growing and sugar production underpins the economic stability of many coastal communities. It is the social fabric that has woven itself through the development of coastal townships up and down the coast."

Canegrowers, n.d.

Sugarcane is grown across 168,000 ha or 15 per cent of the Mackay, Whitsunday and Isaac institutional region (REDC, 2012), and represents 30 per cent of the sugarcane growing area in Queensland. Sugarcane grown in the region in 2011 was worth $240 million. In 2012 the highest land value was for the irrigated sugarcane land of the Mackay Regional Council at $18,000 per hectare, which is the highest price for that land type in Queensland.

The central region sugar industry has a value chain which commences with growing of the sugar cane plant and ends with processing of harvested cane into raw and refined sugars, molasses, electricity and ethanol. The value chain has linkages to other suppliers and is contained by the environment and supported by the Central region's economy.

Mackay Port hosts one of the world's largest bulk sugar terminals exporting raw and refined sugar totaling close to 2 million tonnes per year.

Mackay Sugar in 2012 completed the construction of a $120 million power plant at its Racecourse Mill. The power plant will have the capacity to generate one third of the Mackay region's electricity requirements from bagasse (sugar cane fibre waste), provide power and steam for the Racecourse Mill and Refinery, and allow for the export of 27MW electricity into the national grid.

CATTLE GRAZING

The use of sown pasture systems since the 1960s replaced native pastures that provided low weight gains at low stocking rates (Partridge, 1992). Areas of native pasture in the region occur mainly in the hilly range country where slope and shallow soils, forests and woodland vegetation rule out cropping options and conditions are not favourable for replacement pastures. Historically the three broad native pasture communities in the region are;

1. Pastures sparse or absent, includes two coastal communities (littoral or marine and heath) and closed forests (rain forest) are grouped together as they have limited usefulness for grazing production in the natural state due to low grass cover and or low productive value. An exception is some of the tidal flats where valuable seasonal grazing is obtained from some couch species. Prominent soil in the rainforest areas are friable earths and fertile loams, in littoral areas they soils are grey clay subsoils and heath areas infertile sandy earths dominate.

2. Blady grass (Imperata cylindrical) - includes a composite of sandy coastal lowlands and undulating low hills with open forest and woodland communities. The major trees are tea tree/paper bark (Melaleuca species), Eucalyptus and Corymbia species and swamp Mahogany species (Lophostemon). The characteristic grasses are Kangaroo grass (Themeda triandra), blady grass (Imperata cylindrical) and giant spear grass (Heteropgon triticeus). Soils area generally infertile and intensive use of these soils for sown/improved pasture activity is only possible in areas with deeper top soils.

3. Black spear grass (Heteropogon contortus) is the most extensive native pasture in the region and is found woodlands and open forests on undulating plains and low hills to higher range areas. Tree vegetation consist of mainly Eucalyptus species such as Iron Bark (E.creba/E. drepanophylla), Grey Gum (E. mollucana), Blue gum/Forest red gum (E. tereticornis), Mortern bay ash/Carbeen (Corymbia tessellaris).

In the past the most common grass planted was Kazungula setaria and Rodd's bay plicatulum, which made up more than 90% of the grass component of sown pastures. Over the past decade Rhodes grass and signal grass have been the most planted with Bisset creeping blue also becoming popular. Today the new stylos and four joint vetch legumes are better production options (Bishop, 2007).

There is little intensive grazing in the area in the form of feedlots, for example. However, there are nursery grounds in operation that provide weaner cattle for large cattle farms to the west of the NRM region, due to the regionally reliable feed available for weaning cows.

	Area harvested for milling (ha)		Percentage for region		Cane crushed (t)		Percentage for region		Commercial Cane Sugar		Sugar Produced (t)		Percentage for region	
	2006	2011	2006	2011	2006	2011	2006	2011	2006	2011	2006	2011	2006	2011
Northern	80,558	68,678	21.26	19.48	5,631,724	3,626,646	17.00	13.77	11.83	12.89	660,370	453,211	14.60	12.94
Herbert-Burdekin	127,321	132,033	33.60	37.44	12,921,548	12,471,413	39.01	47.37	14.06	13.54	1,853,542	1,671,450	40.97	47.72
Mackay Proserpine	116,026	105,796	30.62	30.00	9,745,779	6,697,741	29.42	25.44	13.47	13.35	1,347,357	894,014	29.78	25.52
South Queensland	55,061	46,139	14.53	13.08	4,824,881	3,533,503	14.57	13.42	13.59	13.47	662,389	483,992	14.64	13.82
Queensland	**378,966**	**352,646**	**100.00**	**100.00**	**33,123,932**	**26,329,304**	**100.00**	**100.00**	**13.44**	**13.31**	**4,523,658**	**3,502,667**	**100.00**	**100.00**

Table 1 Queensland sugar production statistics, 2012. Source: Australian Milling Council (2012a) N.B: The hectares noted does not include fallow and other farmland i.e. headland, farm sheds/houses included in the 168,000 ha cane area in previous section

Local NRM Body Boundaries	Estimated cattle numbers	No of producers	Estimated gross value $ M at the farm gate.	Grazing nature vegetation	Grazing modified	Area (ha)
Terrain	1,956,190	35	11	675,600	45,600	893,800
Burdekin Dry Tropics	851,518	510	245	11,196,400	261,400	13,036,500
Mackay Whitsunday	1,150,700	201	326	270,500	29,000	432,700
Fitzroy	1,956,190	2,756	555	9,003,200	1,224,200	12,914,400
Burnett Mary	863,025	910	245	2,479,100	158,500	4,018,800

Table 2 Meat cattle state as at 30th June 2006. Source: Agforce data (composite of DPI & F original data)

HORTICULTURE

Perennial horticulture occurs on 1,534 ha or 0.02 per cent of the Mackay, Whitsunday, Isaac institutional region, while annual horticulture occurs on 8,580 ha or 0.1 per cent of the region. The overall gross value of horticultural crops in the Mackay, Whitsunday Isaac council region for 2010-2011 was around $207.5 million (previously $250 million in 2006), with approximately 200 businesses farming around 1,100 ha of productive land, while employing at least 3000 staff during peak season.

However, this boundary includes the highly productive Bowen area north to Gumlu, which overlaps in part yet lies predominantly just outside of the Reef Catchments' area. It is however noteworthy that in 2011 the Bowen area grew 58 per cent of Queensland's capsicums, 41 per cent of the state's beans, 38 per cent of tomatoes, 28 per cent of sweet corn, 20 per cent of mangoes and 17 per cent of melons. Within the NRM area exists one of the biggest egg plant growers in Australia, at Eden Lassie Creek, and numerous small farmers whose produce is sold at local market and as a result is not captured by statistics.

Other perennial horticulture crops in the region include lychees (around Bowen, Proserpine, Mackay and Sarina), bananas (Bowen and north of Mackay), pineapples (Bowen, Sarina and Koumala), macadamias (Bowen and Eton), coffee (Proserpine) and limes (Bowen).

Horticulture produce from the region goes to the domestic fresh markets, with 75 per cent being transported by road (the Bruce Highway) to Brisbane, and 25 per cent to Townsville. Produce is mostly packed on-farm, but there are some packing facilities for vegetables in Gumlu and one in Mackay for bananas.

PRESSURES

LAND CONDITION DECLINE

Decrease in condition occurs as a result of management practices associated with monoculture production systems, excessive cultivation, long term high grazing pressure, increased/prolonged use of inorganic petrochemical crop supplements, more frequent wetting and drying cycles from irrigation, and infrequent use of break cropping.

The key natural resource management pressures linked to the land are the loss of nutrients, pesticides and sediments and export of these into water and waterways that feed into the Great Barrier Reef lagoon, mainly from both diffuse and point sources of pollution (Drewry et al, 2006). The use of inorganic fertilisers and petroleum based pesticides for sustained crop production is associated with loss of direct nutrients/pesticides or their derivatives in soluble forms. Such use is attributed to a lack of targeted application of such supplements, and a lack of awareness or resources to enable compliance with environmental best practice (Fletcher, J. 2013 pers.comms. 4 July 2013).

Intensively cropped and grazed land commonly has a higher percentage of nitrogen and phosphorus in a soluble form than under natural conditions (Mitchell et al 2005; Drewry et al. 2006). As the dominant land use, grazing also contributes about one third of the total regional load of particulate nutrients and sediment (Drewry et al. 2006).

Within the region the loss of sediment and soluble nutrients (e.g. nitrogen) from intensive agriculture production systems is nearing 459,000 tonnes of sediment per annum and 1,920 tonnes of dissolved inorganic nitrogen per annum and 1,510 tonnes of particulate nitrogen per annum (Drewry et al, 2006). While the impact of sediment and nutrient loss from land and its impact on aquatic ecosystem health is relatively well understood, little work has been undertaken in the region to evaluate the impact of soil loss and soluble nutrient loss on the long term impacts toward soil/land fertility and hence land condition sustainability (Hardy, 2004). One can assume however that loss of fertile topsoil and soluble nutrients would have a significant negative impact on soil/land condition and intensive agriculture production.

Further general information on water quality pollutants in this region is available elsewhere (e.g., Faithful 2003; Brodie 2004; Rohde et al. 2008; Australia and Queensland Government, 2012).

Furthermore, yield decline is not always specifically related to fertiliser use. Other factors impact the system including dentrification, soil pathogens, poor variety selection, pH level, and elevation. The focus on reduction in inputs to achieve reduced run-off requires further evaluation with a more holistic approach to multiple and interrelated influencing factors.

Sediment and nutrient quantities in soil are closely related to ground cover and erosion (Rayment and Neil, 1996). Not all the pasture forage grown is to be made available for grazing. Some of the pasture dry matter needs to be retained for soil conservation to achieve more than a 70% ground cover and improved recovery of pastures during spelling or rotation (Weston, 1988).

> "Key to land condition is also the prevalence of weeds which impact upon business viability and productivity. Weeds by definition are plants out of place. Weeds in pastures decrease diet quality and animal carrying capacity. Weeds also compete with pasture species for nutrients and moisture. Because most weeds are not grazed they grow faster and can quickly dominate pasture. Weeds can therefore be a cause and symptom of poor pasture and land management. Weeds are also rated by Mackay Whitsunday graziers as one of the major issues with regard to productivity, viability and maintaining sustainable land condition. A highly variable rainfall combined with fluctuating commodity prices places extra pressures on land use management systems. In the main grazing land managers see the implementation of correct stocking rates as critical issues in reducing weed competition on the land and hence competition with pasture species and even stock poisoning from toxic weed pests."
>
> Bishop, 2007;15

WATER ALLOCATION

Irrigated agriculture accounts for around 80 per cent of water use in the region. Most of this use is associated with sugarcane and horticulture in the Proserpine, Pioneer Valley and Sarina areas. The cost of developing water storage and supply infrastructure is high and many agricultural producers may struggle to afford water from the proposed sources. For example, the expansion of sugarcane west of Proserpine will be limited by access to an affordable irrigation water supply. Existing irrigation allocations are close to being fully committed, however cane growers may not use their full allocations as a result of the increased costs (pumping, equipment maintenance, wages etc.) in applying irrigation.

CLIMATE

Australia already has one of the most variable climates in the world, and Mackay, Whitsunday and Isaac region is one of the most climatically variable in Australia. Even without the threat of a changing climate the region faces challenges to continue the production of agricultural goods. While experienced in flood and drought adaptation efforts, the increased frequency of such events will emerge as one of the key challenges to the future of farming in the region.

Because each region will respond differently to variations in climate, the same can be anticipated of the impact at local mill areas, with the success of crops differing greatly inter-regionally between farms.

> "When the sky falls, and cyclones hit, finding the positive side of life can be an industry challenge. When agricultural industries are exposed to the extreme vagaries of climate, productivity is impacted – and recovery is rarely achievable in a single season, particularly in an industry reliant on ratoon crops with new planting only occurring every four to five years. Consequently, there is a need to look more closely at a range of indicators, and recognise the value and investment in industry risk management. In our 2011 Review we estimated that approximately six million tonnes of cane had been left unharvested in the 2010 season as a result of the never-before-seen rainfall during that year's crushing season. This estimate proved correct with 6.18 million tonnes of stand-over cane being harvested and crushed during the 2011 season. This is a record amount of two year old cane for the Queensland industry to process and created significant challenges to both harvesting and processing. When handling large amounts of stand-over cane, mills' crushing rates needed to be reduced by up to 25 per cent, to ensure that raw sugar of an acceptable quality continues to be produced. On the upside, industry stakeholders always learn from such experience, and will have an enhanced capacity to adapt response strategies, should wet conditions that prevailed across 2010 — 2012 affect the industry again."
>
> Australian Sugar Milling Council (2012, 7)

LAND COMPETITION

The following are considered key threats to agricultural production in the region:

- Sugarcane production areas in coastal areas have been impacted by infiltration of seawater into freshwater aquifers and by urban and industrial expansion around Mackay. Urban expansion also affects infrastructure supporting agricultural production;
- There is resistance to plantation forestry from some local governments and some sectors of the sugarcane industry due to perceived competition for land;
- Mining operations in the Bowen Basin and related infrastructure are currently expanding into high-productivity grazing land northwest and southeast of Dysart and along the Isaac River, and this will affect production levels and have flow-on impacts to supply chains. These soils are also suited to cropping, so it also threatens future expansion of cropping in the affected areas;
- The significant expansion of mining infrastructure (including rail and road corridors across high-productivity grazing and cropping areas) reduces production and affects agricultural operations, access to stock routes and stream/water flows.

Land exists that could be developed for agriculture, subject to the provision of a secure water supply (DERM, 2013), however the likelihood of this new land being opened up to account for agricultural land lost is unknown.

Regional water supply infrastructure does not have the capacity to meet present demands. The short-term strategy is to improve the efficiency of existing irrigation systems and to facilitate small-scale infrastructure works (e.g.farm dams).

> "Good quality agricultural land is a valuable asset to be recognised and protected. Alienation and loss of this resource through fragmentation, urban development, mining or other high impact development will not be supported, unless there is an overriding need in the public interest for the proposed use, and there are no alternative locations available"
>
> MIW Regional Plan, Department of Local Government and Planning (2012, 69).

COMPETITION FOR QUALIFIED STAFF AND LOSS OF KNOWLEDGE

Grudnoff (2012) states that much of the decline in agriculture and other parts of the economy (tourism, manufacturing, construction) can be attributed as a consequence of the mining boom due to the upward pressure on the exchange rate which in turn reduces the competitiveness of other Australian industries.

> Since the beginning of the mining boom Australia's rural sector has lost $43.5 billion in export income. This includes $14.9 billion in 2010-2011 alone. These losses have occurred because the mining boom has forced the Australian dollar to historic highs… Within the rural sector the beef and veal industry has also been adversely impacted with exporting income being cut by $2 billion in 2010-2011 and $6.2 billion over the boom. The sugar industry lost $566 million in 2010-2011 and $1.8 billion over the boom… The growth in the mining sector has come at a cost to other sectors of the economy, especially the rural sector – and these costs are substantial.
>
> The mining boom has not been managed well. It has been allowed to expand with little consideration for the collateral damage it causes to other sectors of the economy. The rural sector is one part of the economy that has been badly affected", Still beating around the bush: The continuing impacts of the mining boom on rural exports,
>
> Grundoff (2012, 1).

Agriculture has also experienced continued loss of knowledge and skills on farms due to generational changes in interest with fewer young people undertaking studies in agricultural fields and returning to the farm with this knowledge. Key to this is the low productivity and high input required for farming, which can be unattractive to young people commencing their career.

CONDITIONS AND TRENDS

"The Australian economy, like all modern economies, is diverse and ever changing. In 1951 agriculture accounted for just over 30 per cent of Australia's GDP—much bigger than mining has ever been—but today agriculture represents just 2.6 per cent of GDP. Sixty years ago it would have been inconceivable to imagine agriculture shrinking to less than a tenth of its size as a share of the economy. By the same token, nobody would have predicted that the telecommunications sector would become so large; the mobile phone industry employed virtually nobody in the 1980s. But change is a signature feature of a healthy economy, and these things did indeed take place."

Mining the Truth, Richardson and Denniss (2011, 1)

AGRICULTURE IN THE REGION

The value of agricultural production in the Mackay, Whitsunday and Isaac council regions has increased slightly from 8.5 per cent of Queensland's production value in 2006, to 9.3 per cent in 2010 (DAFF, 2013). However, agriculture in Queensland has experienced steady decline since the boom in late 1990s, early 2000s. The Queensland Government's Agricultural Land Audit (2013) focuses on reversing this decline and doubling the value of agricultural production in the state by 2040 as one of the four pillars of the Queensland economy (tourism, agriculture, resources and construction).

INDUSTRY	VALUE $M	STATUS AT 2013
	2005-2006	
Sugar cane	380	Decline due to multiple factors including weather events, world sugar prices and high Australian Dollar driven by global commodities market
Horticulture and other crops	250	Decline despite an expected growth due to land managers looking at on farm income diversification from sugarcane
Livestock grazing	24.4	Slight increase in production following on from fair seasonal condition and commodity prices. Large numbers of investors/retirees are also entering the commodity with small blocks.
Livestock dairy	3.3	Significant decline in the number of dairies with the likelihood of more losses of dairy enterprises from the region (Fisher 2006).
Aquaculture	1.7	Sustained increase in production over the past few years
Timber and forests	0.5	Strong growth in private plantations and interest in native forest harvesting amongst the grazing sector.

Table 3 Overview of industry gross value and current status

Efforts have been made to identify potential productive agricultural land according to infrastructure capacity. Improvements to transport infrastructure including the Bruce Highway upgrade will enable faster and more efficient transport of agricultural produce and inputs. Infrastructure development as a result of mining growth in surrounding areas are viewed by the Queensland Government as opportunities to improve agricultural commodities transport also.

The Queensland Agricultural Strategy (DERM, 2013) outlines four key pathways to grow the sector; by securing and increasing resources availability, driving productivity growth across the supply chain, securing and increasing market access, and minimising the costs of production.

NUTRIENTS, SEDIMENTS AND PESTICIDES

Loss of key nutrients via rivers has increased from 2-5 times for nitrogen and 4-10 times for Phosphorous over the last 150 years representing the impact of long term intensive agricultural use (Moss et al, 1993).

However, agricultural industries have made significant advances in improving management practices, evidenced by an estimated decrease in fertiliser use by some 15 per cent across the state over the past 5 years. Nitrogen and Phosphorus fertiliser usage rates in sugar cane industry have dropped by 53kg/ha and 15kg/ha respectively in the past 10 years.

2011 - 2012

• Suspendant sediment load reduced by approximately	28,328 t/yr
• Particulate Nitrogent load reduced by approximately	98 t/yr
• Particulate Phosphorus load reduced by approximately	91 t/yr
• Dissolved Inorganic Nitrogen load reduced by approximately	86 t/yr
• Filterable Reactive Phosphorus load reduced by approximately	28 t/yr
• Total Pesticides load reduced by approximately	331 kg/yr

2008 - 2012

• Suspendant sediment load reduced by approximately	189,380 t/yr
• Particulate Nitrogent load reduced by approximately	399 t/yr
• Particulate Phosphorus load reduced by approximately	222 t/yr
• Dissolved Inorganic Nitrogen load reduced by approximately	240 t/yr
• Filterable Reactive Phosphorus load reduced by approximately	50 t/yr
• Total Pesticides load reduced by approximately	1618 kg/yr

Figure 2 Reef Rescue total Estimated Load Reductions from Current Water Quality Grants New Impact Area, Mackay Whitsunday Isaac (NRM Regions) in 2011-2012 and 2008-2012

Over 40 per cent of sugar cane growers in the region use legume crops on fallow ground and 8 per cent of the sugar cane areas use GPS control traffic technology. Little information on fertiliser usage rates and adoption of new farming technology (e.g. GPS) is known within the horticulture and beef industries within the region.

Mill mud, a nutrient rich by-product of the milling process, was previously blanket spread on the field in an ad hoc manner at a nominal rate of 150 tonnes per hectare (t/ha). With the commission of new spreaders that allow for precision application directly onto rows, mill mud is now applied at a reduced rate of 50t/ha effectively tripling the land one manager can service with their mud allocation.

In October 2003 the Queensland and Australian governments signed the Reef Water Quality Protection Plan (Reef Plan) that aimed to halt and reverse the decline of water quality on the Great Barrier Reef. Since Reef Plan (2003) an updated Reef Water quality Protection plan has been endorsed (Queensland Government, 2009) with a number of implementation and monitoring programs established including Reef Rescue, Reef Regulations and the Paddock to Reef programs, which provide on-ground initiatives necessary to achieve the targets.

As a result of the Reef Plan (2009) and Reef Rescue, since 2008 cane and horticulture farmers have improved management of soil, nutrients and herbicides on more than 75 per cent of the intensive cropping land in the catchment and graziers have improved pasture management on more than 1,000 hectares of pasture. This includes cane farmers purchasing equipment, such as GPS guidance and inter-row spray shields and implementing new farming practices (break cropping, mill mud application, zonal tillage, control traffic via GPS) to reduce inputs such as fuel and/or chemicals while maintaining productivity and ensuring future economic profitability and environmental sustainability.

For cattle farmers this includes stocktake training, land-type fencing, establishing pasture monitoring sites, soil testing, riparian fencing, off-stream watering points and industry/partnership projects. The collective investment in these activities since 2008 has been $88,085,029 from industries (service providers and landholders) and $32,480,973 from grants in the Mackay, Whitsunday and Isaac catchments.

REEF CATCHMENTS

According to the Reef Water Quality Projection Plan Report Card (Australia and Queensland Government, 2012), the overall marine condition in the Mackay, Whitsunday, Isaac catchments in 2009–2010 was moderate and that progress toward Reef Plan targets was encouraging, although inshore water quality and coral reefs remained moderate and seagrass meadows remained poor. The report found that:

- 60 per cent of sugarcane growers, 44 per cent of horticulture producers and 15 per cent of graziers have adopted improved land management practices;
- The greatest proportional catchment load reduction was the pesticide load with an estimated 376kg (18 per cent) less;
- Flow management has been improved through waterhole mapping that enables a better understanding of the volumes of water required to maintain critical fish habitat;
- Riparian management has been improved on 33 km of the O'Connell River by graziers who have erected riparian fencing and off stream watering points;
- Barriers to migration have been removed through the construction of fish passage structures on all major barriers and in stream habitat has been restored through the installation of a series of engineered log jams at priority areas.

Progress and status

Targets		Region	Catchments: O'Connell	Pioneer	Plane	Proserpine
% adoption improved practices	Grazing	17				
	Horticulture	41				
	Sugarcane	17				
% loss	Wetlands	0.01	0	0.27	0.01	0
	Riparian	0.50	0.92	0.08	0.49	0.51
% groundcover		98	99	98	96	98
% load reduction	Nitrogen	4				
	Phosphorus	1				
	Sediment	3				
	Pesticides	18				
Overall marine condition						
Water quality						
Seagrass						
Corals						

Very good · Good · Moderate · Poor · Very poor

Figure 3 Progress report for MWI from Reef Water Quality Protection Plan Report Card 2013

Agriculture

REEF CATCHMENTS

"Agriculture has become more diverse and increasingly export-oriented since the 1980s, and now includes some non-traditional commodities and processed products. There are several niche processing facilities for products such as gourmet dairy products, sauces, dried fruit and vegetables, and frozen vegetables.

There are growing market-specific opportunities—for example, grass-fed 'branded' beef and sheep. There are also opportunities for organic produce. In the western regions, organic beef is cost-effective and reliable because drier conditions reduce the risk of pests and diseases" DAFF, 2013; 8.

The current condition of grazing lands in the Mackay Whitsunday Region has not been monitored in any detail since a survey carried out in 1979 (Anderson et al, 1983). Sown pasture development reached a peak in 1974-75 of around 5,000 ha/annum, which corresponded with an increase in beef cattle numbers; from 80,000 in 1967 to 200,000 in 1980 and over 300,000 cattle and calves being sold in 2001. This is compared to 29,000 cattle grazing sown pastures in 2006.

GOVERNANCE

All agricultural enterprises in the region are supported/influenced by a number of state and federal government Acts and operational policies and guidelines including:

- Sugar Industry Act 1999: The principal objective of which is to facilitate an internationally competitive, export oriented sugar industry based on sustainable production the benefits those in the industry and the wider community. Key amendments to the Sugar Act were made in 2004 resulting from the sugar industry reform act 2004.
- Land Protection (Pest and stock Route Management) Act 2002: This Act declares invasive species and requirements for landholders to control them.
- Integrated planning Act 1999: A whole of government approach to identifying the risks of impacts from agriculture and to develop a planned framework for agricultural industries. General development of the environment is assessed against a code (Integrated development Assessment scheme – IDAS) under the Act to protect biodiversity, prevent land degradation and ensure development is sustainable.
- Environmental Protection Act 1994: This Act specifies a general environmental duty whereby a person must not carry out an activity that causes or is likely to cause environmental harm unless the person takes all reasonable and practical measures to prevent or minimise the harm. Several polices provide more detail for achieving the objectives of the Environmental Protection Act 1994, i.e. The Environmental (Water) Policy 1997 which includes guidelines, indicators and monitoring procedures for management of issues such as storm water and acid sulphate soils.
- Great Barrier Reef Marine Park Act 1975: This includes management of perceived risk of damage to the Great Barrier Reef from runoff and sediment discharge from farms.
- Great Barrier Reef Protection Amendment Act 2009
- Chemical Usage (Ag and Vet) Control Act 1988 and Regulation 1999: These outline farm use of chemicals such as; use of chemicals as per label instructions; Require a permit for off label use; Must specify hazard areas for spray drift and permit and license needs; Require material safety data sheets (MSDS) for all chemical used.
- Vegetation Management Act 1999: Regulates native vegetation on freehold land by: Providing a state policy and code accessing clearing applications; regional vegetation management plans; declaration of areas of high conservation value or areas subject to degradation.

In addition, agricultural industries have guidelines for best management practice focusing on a wide range of farming practices and inputs, which are updated regularly and endorsed by industry. All the programs in place operate within an agricultural natural resource management framework called "Farm Management Systems" or FMS (e.g. Growcom, 2006). The FMS approach is designed to support agricultural enterprises by having better planning, risk assessment, management actions, monitoring and review of farm operations. The system therefore supports growers to;

- Better plan their farm management processes;
- Assess their individual management performance and effectiveness of management practices;
- Identify opportunities for improvements or efficiencies;
- Demonstrate management practices and outcomes to external stakeholders.

INDICATORS

Key indicators of land condition that can be evaluated over time fit into two broad categories of measurement:

- Directly definable land condition parameters which can be easily measured;
- Practice changes associated with known land condition improvements.

The requirement for these broad categories is reflective of the fact that changes/improvements in land condition may not be measureable for a significant period of time despite the positive changes in land management being undertaken. Remembering that it may take some time for the biological processes associated with land condition to reach an optimum balance.

Key symptoms of declining land/soil condition as a result of poor land management include:

- Increase in pest competition (e.g. weeds, insects);
- Decrease in organic carbon based levels in soil;
- Decreased in water holding capacity and water infiltration rates;
- Increased wind and water induced erosion;
- Increased rates of fertiliser to maintain production standards; and
- Decrease in agricultural production.

All intensive agricultural industries have in place natural resource management frameworks via the Farm Management Systems (FMS) program. The FMS program seeks to support farm operations in improved planning, risk assessment, management actions, monitoring and review of farm operations. The key focus areas of operations for improved land management in intensive agriculture industries are:

- Improvements in soil structure (biological and physical);
- Improvements in nutrient management;
- Improvements in water use management; and
- Improvements in the use of pesticides.

To assess the effectiveness of improved land management practices and land condition, targets set need to benchmark land manager adoption rates and land condition (physical, nutrient and biological), to assist producers and communities to understand the improved practices are improving land condition. Setting key adoption targets is a collaborative process and the scale of monitoring important as it enables land managers and agriculture commodity groups to evaluate improvements in shorter time frames than monitoring at a catchment scale. Reference farms or trial sites provide indicators of success, while qualitative social data will best capture trending community attitudes that might influence adoption.

A well accepted agricultural best practice framework is the ABCD, which outlines a suite of practices that are 'Aspirational', 'Best Practice', 'Current' or 'Dated' related to nutrient, pesticide, soil and water management at the farm scale. A benchmark study was undertaken to relate water quality in 2007 to the percentage of industry that were adhere to the defined principals of either A, B, C or D for each of the management areas. This allowed the effort needed (i.e. moving from Dated to Best Practice for nutrient management), to be quantified for each area to achieve the water quality targets

The Water Quality Improvement Plan for the region (Drewry et al, 2007 currently being updated) measures water quality in a number of locations, which can be used to target management actions to improve water quality and ecosystem health. For example, at Carmila Creek (figure 4) ambient water quality was generally good in this catchment in 2007 with a low level of management action required to keep water quality in good condition.

Myrtle Creek (figure 5) in contrast is substantially more developed than Carmila Creek, with 31 per cent sugarcane production in this management area. Nutrients such as DIN, dissolved and particulate phosphorus were above water quality objectives in 2007, and therefore management was recommended to improving water quality such as increasing the level of adoption of best management practices.

Key Pollutant	Ambient Freshwater Quality Values			
	Objective 2050	Current Condition 2007	Target 2014	Action
Dissolved Inorganic Nitrogen µg/L	CC	8	CC	L H
Particulate Nitrogen µg/L	CC	78	CC	L H
Dissolved Inorganic Phosphorus µg/L	CC	5	CC	L H
Particulate Phosphorus µg/L	CC	10	CC	L H
Total Suspended Sediment mg/L	CC	3	CC	L H
Ametryn µg/L	CC	<LOD	CC	L H
Atrazine µg/L	CC	<LOD	CC	L H
Diuron µg/L	CC	<LOD	CC	L H
Hexazinone µg/L	CC	0.01	CC	L H
Tebuthiuron µg/L	CC	<LOD	CC	L H
Dissolved Oxygen % saturation	40-120	12-89	40-120	L H
pH	CC	7.3-7.8	CC	L H
Electrical Conductivity µS/cm	CC	279	CC	L H

CC = Current condition; **LOD** is Limit of detection which is 0.01 ug/L for all herbicides

Figure 4 Ambient Water Quality Carmilla Creek

Key Pollutant	Ambient Freshwater Quality Values			
	Objective 2050	Current Condition 2007	Target 2014	Action
Dissolved Inorganic Nitrogen µg/L	30	154	77	L H
Particulate Nitrogen µg/L	CC	112	CC	L H
Dissolved Inorganic Phosphorus µg/L	25	34	25	L H
Particulate Phosphorus µg/L	20	41	20	L H
Total Suspended Sediment mg/L	5	7	5	L H
Ametryn µg/L	CC	0.04	CC	L H
Atrazine µg/L	CC	0.11	CC	L H
Diuron µg/L	CC	0.11	CC	L H
Hexazinone µg/L	CC	0.08	CC	L H
Tebuthiuron µg/L	CC	<LOD	CC	L H
Dissolved Oxygen % saturation	85-120	12-56	85-120	L H
pH	CC	7.2-7.3	CC	L H
Electrical Conductivity µS/cm	CC	654	CC	L H

CC = Current condition; **LOD** is Limit of detection which is 0.01 ug/L for all herbicides

Figure 5 Ambient Water Quality Mrytle Creek

Under continuous heavy grazing any surviving desirable pasture plants will have a small root system and be slow to restart growing with the resulting bare ground left vulnerable to erosion and chemical and nurtient runoff (Aisthorpe and Paton, 2004; Schulke, 2003). The Grazing Land Management Program provides participants the tools and skills to monitor and manage land condition via adult action learning, including grazing pressure with variable rainfall, grass/tree balance, pastures and weeds and fire. The Stocktake Workshop provides a tool for balancing pasture supply with forage demand while still maintaining good land condition.

Monitoring currently occurs as part of the Australian Government's Reef Rescue initiative. The Reef Plan (2009) aims to improve the quality of water entering the reef and maintain its health and resilience. Positive changes have been observed in the catchments across the Great Barrier Reef region, and there has been good progress by land managers towards Reef Plan targets. As a result of this change, the estimated average annual pollutant loads entering the reef have reduced as outlined in table 4. Ongoing on ground activities and monitoring as part of Reef Rescue will continue to indicate the condition and trends of improved land management practices and the resulting impact on water quality in the Great Barrier Reef lagoon (Brodie et al., 2013).

POLLUTANT	UNIT	OBJECTIVE	CURRENT CONDITION	TARGET 2013	ACHIEVED	REDUCTION	PERCENTAGE OF TARGET
Dissolved Inorganic Nitrogen	Tonnes/year	1310	2100	1550	1666	435	69% of target due to cane nutrients
Particulate Nitrogen	Tonnes/year	1210	1770	1410	1568	202	56%of target due to combined cane and grazing soil
Filterable Reactive Phosphorus	Tonnes/year	130	350	250	271	79	69% of target due to cane nutrients
Particulate Phosphorus	Tonnes/year	280	650	500	566	84	56% of target due to combined cane and grazing soil
Total Suspended Sediment	Tonnes/year	520000	528000	520000	523520	4480	56% of target due to combined cane and grazing soil
Ametryn	Kg/year	120	160	120	134	26	65% of target due to cane pesticide
Altrazine	Kg/year	1210	1620	120	645	975	65% of target due to cane pesticide
Diuron	Kg/year	2870	4680	3510	3920	761	65% of target due to cane pesticide
Hexazinone	Kg/year	890	1190	890	995	195	65% of target due to cane pesticide

Table 4 Exert from forthcoming Water Quality Improvement Plan Review (2014). Includes only voluntary adoption programs such as Reef Rescue and supporting industry programs.T

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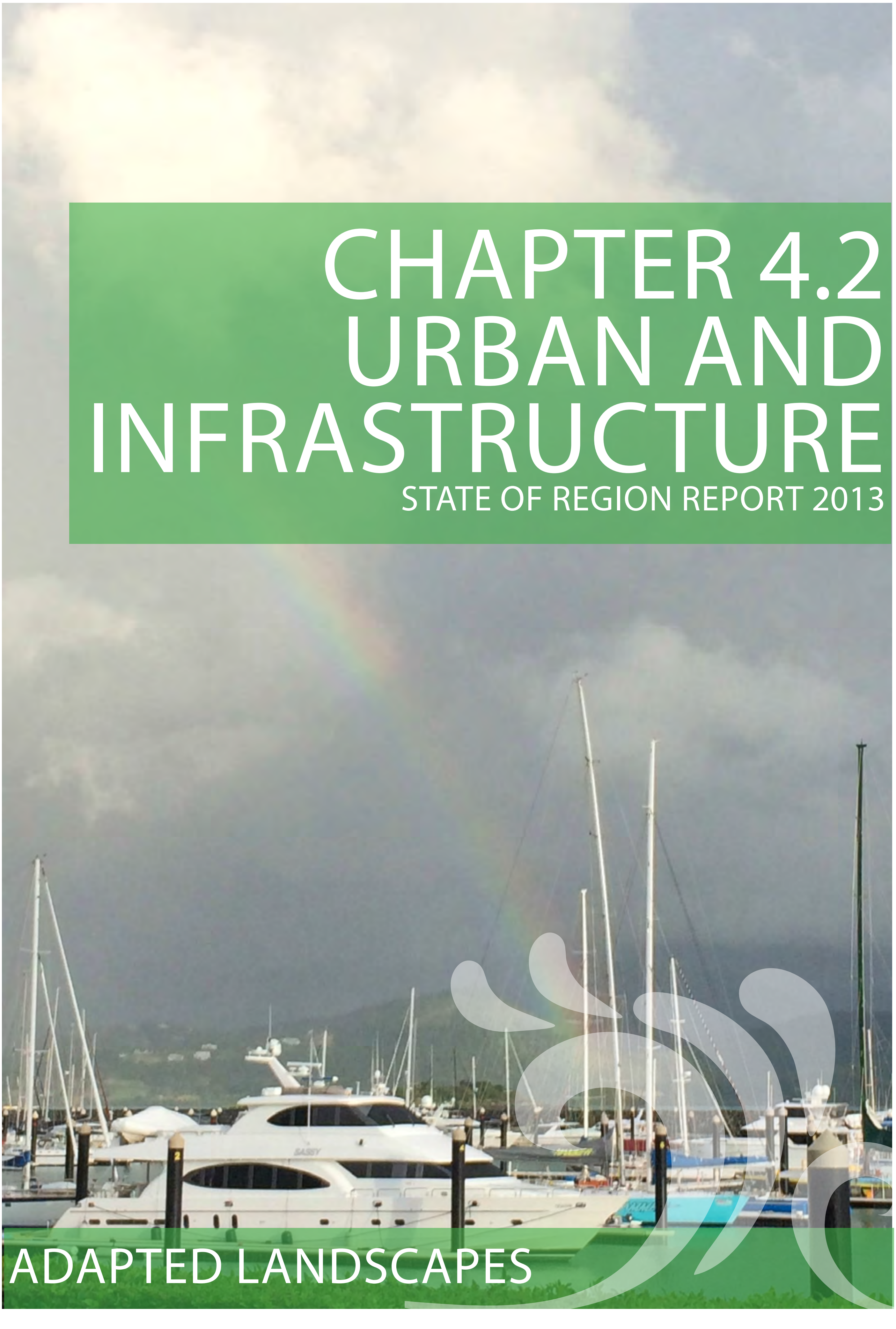


CHAPTER 4.2 URBAN AND INFRASTRUCTURE

STATE OF REGION REPORT 2013

ADAPTED LANDSCAPES

STATE OF REGION REPORT

Urban and Infrastructure

REEF CATCHMENTS

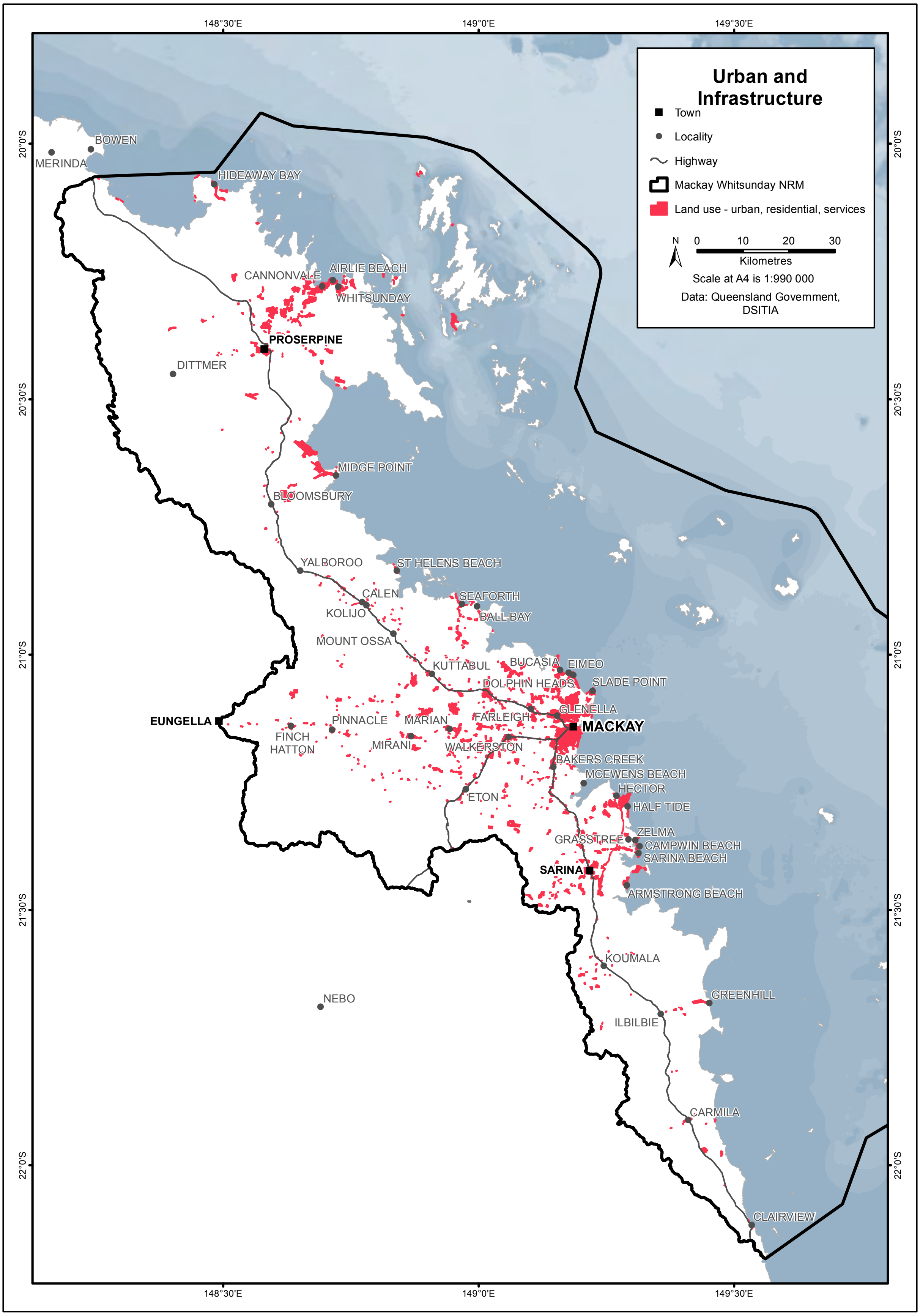


Figure 1 Urban, industrial, services and other built areas

Urban and Infrastructure

REEF CATCHMENTS

SUMMARY

Mackay, Whitsunday and Isaac region has experienced significant economic, urban and population growth in the last 30 years. The settlement pattern consists of several well-dispersed regional communities, with the majority of growth in coastal communities and Mackay City, the main urban population centre (Queensland Government, 2012). Other important centres are Bowen, Proserpine, Cannonvale and Sarina, which provide services to surrounding rural communities populations. Airlie Beach maintains its role as the centre for tourism.

As at 30 June 2012, the resident population of Mackay, Whitsunday and Isaac catchment region was 139,320 persons, comprising 52 per cent males and 48 percent females with the majority of people are aged between 35 and 54 years. 80 per cent of people were born in Australia and Indigenous people represent 4.2% of the total population. Nearly 60 per cent of the total population, or 78,200 people, live in Mackay City, where the majority of future growth is expected to be hosted.

Mackay Harbour imports petroleum and sugar and exports sugar and grain, while Hay Point 25 km south of Mackay is the largest coal terminal in the world, exporting nearly 90 million tonnes of coal per annum via 900 bulk shipping carriers.

Other vital infrastructure networks include the Bruce Highway, which runs the length of the region, and a series of railway networks comprising a main multiple use track running often in parallel with the Bruce Highway, railways to the north and south that connect coalfields with ports, and the intricate railway networks that service the cane industry.

There are no official estimates of Gross Regional Product (GRP) for the Mackay, Whitsunday and Isaac catchment region therefore estimates of GRP are based on administrative boundaries such as local government areas.

Gross Regional Product for the region is estimated at around $6.8 billion per annum. The economy of the region is still heavily influenced by the mining sector through the provision of inputs (labour, transport, support services such as construction), despite the location of such mines being in the Central Queensland Coalfields, outside of the region. Primary industries and tourism are also major contributors to GRP.

Educational attainment regionally reflects the needs of the dominant industries in the region, which are trade-based and have generally lower percentages of year 12 qualifications, tertiary qualifications and higher levels of certificate qualifications.

Level	Region	Queensland
Year 10	22.8%	18.8%
Year 12	29.0%	36.8%
Certificate	19.6%	15.9%
Undergraduate	5.8%	9.3%
Postgraduate	0.8%	2.2%

Table 1 Education attainment in region compared with State average

Industry	Value added ($ million)	% of regional value added
Agriculture, forestry & fishing	306	4.5%
Mining	927	13.7%
Manufacturing	517	7.6%
Electricity, gas, water & waste services	122	1.8%
Construction	679	10.0%
Wholesale trade	595	8.8%
Retail Trade	438	6.5%
Accommodation and Food Services	287	4.2%
Transport, Postal and Warehousing	620	9.2%
Information Media & telecommunications	72	1.1%
Financial & insurance services	297	4.4%
Rental, hiring and real estate services	225	3.3%
Professional, scientific & technical services	344	5.1%
Administrative & support services	133	2.0%
Public administration & safety	244	3.6%
Education & training	274	4.0%
Healthcare & social assistance	397	5.9%
Arts & recreation services	15	0.2%
Other services	207	3.1%
Non classifiable industry	71	1.0%
Total Industry Value Added	**6,770**	**100.0%**

Table 2 Value add of industries in Mackay, Whitsunday and Isaac

VALUES AND SERVICES

As at June 2012, 70 per cent of the Australian population resided in major cities, compared with just 2.3 per cent living in regional Australia (Australian Government, 2012). Regional centres are highly valued human environments, ideally providing residents with a useful, attractive, safe, environmentally sustainable, economically successful and socially equitable place to live, instilling a sense of place and cultural identity.

The MIW Region has one of the fastest growing economies in Queensland, attributed by Regional Development Australia (2013) to increased activity in resource mining in the Bowen Basin and Galilee Basin and the resulting activity in supporting industries, such as construction and infrastructure.

EMPLOYMENT

The dominant industries in the area are construction (10.3 per cent) driven by resource sector and population growth, retail trade (10.2 per cent) driven by population and tourism growth, mining (10 per cent) with rapid growth in recent years which is now slowing, and primary industries (3.9 per cent).

The structure of industry employment regionally differs significantly from the State in some areas. Based on percentage of workforce:

- Primary industries are almost 1.5 times as important as in the State
- Mining is almost four times as important as in the State
- Manufacturing is similar levels to the State (indicating many mining inputs are imported)
- Many white collar sectors are only half as important (media, telecommunications, insurance, finance, public administration, arts and recreational services)
- Most other sectors relatively similar.

	Region		QLD	
2011	Persons	%	Persons	%
Agriculture, forestry and fishing	2,755	3.91%	55,416	2.7%
Mining	7,059	10.0%	52,955	2.6%
Manufacturing	6,188	8.8%	171,669	8.4%
Electricity, gas, water and waste services	593	0.8%	24,828	1.2%
Construction	7,249	10.3%	183,780	9.0%
Wholesale trade	2,904	4.1%	74,288	3.6%
Retail trade	7,204	10.2%	217,610	10.7%
Accommodation and food services	5,525	7.8%	141,855	7.0%
Transport, postal and warehousing	4,936	7.0%	107,072	5.3%
Information media and telecommunications	415	0.6%	25,358	1.2%
Financial and insurance services	955	1.4%	54,153	2.7%
Rental, hiring and real estate services	1,329	1.9%	37,007	1.8%
Professional, scientific and technical services	3,113	4.4%	132,754	6.5%
Administrative and support services	1,927	2.7%	65,015	3.2%
Public administration and safety	2,788	4.0%	136,818	6.7%
Education and training	3,907	5.5%	160,921	7.9%
Health care and social assistance	5,877	8.3%	242,559	11.9%
Arts and recreation services	409	0.6%	28,444	1.4%
Other services	3,593	5.1%	78,713	3.9%
Inadequately described/Not stated	1,762	2.5%	48,060	2.4%
Total	**70,488**	100.0%	**2,039,275**	100.0%

Table 3 Employment by Industry 2011

The mining industry has a greater proportion of higher wages than any other industry, with 58 per cent of mining employees earning more than $2,000 per week, compared with 5.3 per cent in agriculture and 1.8 per cent in accommodation services.

	$1-$299	$300-$599	$600-$799	$800-$999	$1,000-$1,249	$1,250-$1,499	$1,500-$1,999	$2000+
Primary industries	9.5%	25.2%	20.6%	14.6%	12.6%	6.9%	5.4%	5.3%
Mining	0.5%	1.6%	2.1%	2.8%	5.5%	7.6%	21.5%	58.3%
Accommodation & food services	21%	31.5%	20.2%	12.8%	7.3%	3.1%	2.4%	1.8%

Table 4 Wages per week according to key sectors. Source: ABS, 2011.

The development of infrastructure associated with mines has the potential to be valuable to other industries, in particular agriculture, by increasing access to markets. Improvements to transport infrastructure including the Bruce Highway upgrade will enable faster and more efficient transport of agricultural produce and inputs.

Recent and planned infrastructure projects provide for current growth pressures, for example the new Marian water treatment plant which will service the townships of Marian and Mirani with a more reliable potable water supply. Mackay Council determine that there is sufficient raw water availability to meet the regions needs, with developments since 2007 included below.

	Capacity	Service areas	Comments
Water Asset			
Nebo Road WTP upgrade	74 ML/day	Mackay	Significant upgrade to existing plant
South Mackay Trunk Main and Mackay to Sarina Pipeline	100L/s to Sarina	Sarina	Security of supply to Sarina township
Upgrade to Dumbleton Road Raw Water Intake	65 ML/day	Mackay	Significant upgrade to pumping capacity
Various water main upgrades and extensions across the region ($30m)		All	Condition and capacity upgrade
Sewer Assets			
Mackay South STP upgrade	100,000 EPs	Mackay	Significant upgrade which included the Water Recycling Scheme
Mackay North STP upgrade	25,000 EP	Northern Beaches	Significant upgrade
Numerous upgrades to existing sewerage pump stations and new pump stations totalling $43million	various	Various across the networks	Works are combination of new, refurbishment and upgrades
Developments in progress			
Marian WTP	4 ML/ day treatment capacity	Mirani and Marian townships	Future infrastructure currently in tender phase for completion 2014

Table 5 Current and future upgrades in Mackay Region.

REEF CATCHMENTS

PRESSURES AND THREATS

Urban activities can degrade the regions natural ecosystem and environmental values. Critical issues in urban and infrastructure development include;

- Competition between land use predominantly urban/industrial development in competition with agricultural use of available land;
- Land degradation caused by poorly planned development works, for example erosion, inappropriate land clearing and land fill;
- Loss of ecologically sensitive habitats which provide critical ecosystem services such as wetlands and riparian vegetation;
- Exposure of Acid Sulphate Soils;
- Changes in land use practices that influence significant changes to drainage patterns and distribution.

LAND COMPETITION

Urban development issues are predominantly focused on overall land use planning operations and the ability to preserve good quality agricultural or other productive land and key habitat areas, including the downstream marine environment. The planning process should be robust enough to provide for urban expansion, tourism, industrial development and recreational needs while still upholding the environmental values that the community wishes to maintain.

The increasing regional population threatens to reduce good quality agricultural land from agricultural uses. With an estimate of only 3 per cent of Queensland land area suited to agriculture operations there is a need to protect food production and economic viability for the region and the state.

However, in the short term Mackay region retains enough residential, commercial and industrial land to accommodate future growth and, with clear boundaries for urban areas, avoid encroachment on agricultural areas.

> "The Mackay cane supply region has reduced by approximately 10,000 ha over the past 10 years. These losses are widely distributed across the region and are due to a number of causal factors. With the region's growing population, driven by the coal mining boom, housing developments remain one of the primary influences to cane land loss. A large portion of the land has simply gone out of cane and remains underutilised due to farmers being unable to maintain the farm for various reasons. The inability to retain skilled workers to assist with farming the properties and our aging grower population also continue to play a part in the decline of cane land" Mackay Sugar (2012; 21).

LAND DEGRADATION

Urban and industrial development have been identified as a major contributors of sediment and other pollutants to the region's waterways and this is a significant concern for the region given the current amount of construction activity.

Legislative based controls to reduce the potential for soil erosion on urban and industrial development sites exists with local governments. In 2012, for example, Mackay Regional Council introduced an Erosion and Sediment Control Compliance Program (ESCCP), targeting projects in the construction phase of development with typical fines of $2000 issued where sediment loss and erosion is evidenced.

While regulated in terms of minimising impact, the review of development in the coastal zone has potential to be undertaken in favour of the developer, a process that threatens key animal and plant ecosystem and species diversity. The net effect has seen the development of coastal environments with minimal planning associated with conservation or restoration of important habitat to maintain species diversity and land condition.

WATER SUPPLY AND QUALITY

The city of Mackay is supplied potable water by the Pioneer River and the majority of rural schemes within the region are either wholly or partially reliant on groundwater for their water supply. The townships of Marian and Mirani will benefit from a river water supply as a result of the Marian Water Treatment Plant, which will be built in 2014.

Salinity, reduced flows and over-allocation of groundwater resources have become regional issues, particularly along the coast (Drewry et al., 2007). Management strategies are required to ensure that the use of underground water resources is within sustainable limits and that underground water quality is not degraded.

Within the Pioneer Valley, the current extraction regime has resulted in extensive and ongoing saltwater intrusion and reduced water levels and reliability of supply in some areas. In the Proserpine area similar issues, impacts and threats such as saltwater intrusion, excessive use and groundwater-dependent ecosystems are relevant, but have not manifested to the same degree. This has been a result of the provision of an alternate surface water supply from Peter Faust Dam, which has since 1991 significantly relieved the pressure on the demand from the groundwater system. However, in areas not supplied from the surface water scheme, some of these management concerns still exist to varying degrees.

The ecological condition of the rivers and streams in the region are influenced by a range of factors, including urban land use, riparian zone management, direct modifications to river and stream channels, level of water resource infrastructure development within the rivers and streams, and the level of water infrastructure developed to take water from the rivers and streams. Environmental flows are crucial to the maintenance of healthy riverine habitats and systems and in maintaining stream geomorphology and ecology. Changes in flow regimes have potentially wide-ranging ramifications.

Urban development is a major diffuse source of nutrients, sediments and pesticides entering watercourses. This can be attributed to a lack of stormwater management, erosion and sediment control measures for land development and construction and a high percentage of directly connected impervious surfaces (Drewry et al., 2007)

Point sources of pollution locally are significant, especially from major urban centres such as Mackay city and Cannonvale/Airlie Beach (Drewry et al., 2007). There are other pollutants associated with urban areas, transport corridors, waste disposal areas and sewage treatment plants. These include organic compounds, hydrocarbons and heavy metals (Rohde et al. 2006).

Urban and Infrastructure

Urban waste management issues are focused on overall planning and management processes established to deal with waste products generated from urban populations and their activities. Potential sources of pressure include:

- Sewage collection and treatment and associated risk strategies in relation to meeting population growth, systems failures and natural disaster issues such as flooding and its impact on sewage treatment facilities;
- Treatment and disposal of solid waste amid a growing population;
- Storm water runoff including not only polluted water but also non polluted water and its impact at the interface of storm water outlets and tidal estuarine areas;
- Air quality, particularly pollution of air from industrial process and transport.

Adoption rates for urban development management practices outlined in the WQIP (Drewry et al., 2007) have been deemed poor, with movement through the ABCD framework for green and brownfield management and accompanying implementation activities considered unsuccessful in many cases.

"Urban management comprises two phases: new development ('Greenfields') and existing urban management ('Brownfields'). The major diffuse pollutants during new development are sediments and particulate nutrients. The major diffuse pollutants from existing urban areas are sediments, nutrients and heavy metals. In addition to the impact on water quality, urban development can have an ecologically significant impact on in-stream habitat. Urbanisation increases impervious surfaces which increases the number of surface runoff events, resulting in regular disturbance of in-stream ecosystems and ecosystem degradation"

Drewry, et al., 2011; 1

CAPACITY TO GROW

As the population continues to growth, the pressures on water and waste facilities increase. Challenges of supplying potable water to a growing population include aging infrastructure and the removal of State Government subsidies, which has added pressure to upgrade and replace infrastructure and continues to have major influence on Council's capital program. Servicing growth areas into the future will require significant capital investment, while escalating costs associated with key inputs into the provision of water and wastewater services such as Sunwater raw water price and electricity price is placing upward pressure on the cost to provide services to the community.

6 per cent of energy substations in the region are nearing constraint, with 12 per cent already constrained (REDC, 2012). Energy supply has been noted as a major challenge for the region, and a long term energy supply strategy is required in order to better plan for growth.

Investment in infrastructure has been strong since 2007 however the region is still suffering from an infrastructure lag, a regional challenge in keeping up with the population growth. Infrastructure lags also have a significant effect on industry growth in the short term, particularly in the areas of energy and water which are essential for new investment. Rising costs to bring infrastructure to market is a major concern, as the opportunity cost of investment not coming to market in the short term has a long term economic effect, particularly on employment.

STATE OF REGION REPORT

Urban and Infrastructure

CAPACITY TO GROW

There are currently 32 operating coal mines in the Mackay, Whitsunday, Isaac council regions with 35 new projects (including new mines and expansions of existing mines) planned for the future.

The Dudgeon Point Coal Terminals development project proposes the development of two new coal export terminals and associated infrastructure at Hay Point with a combined capacity of up to 180 million tonnes per annum. This $10-12 billion investment will feature six rail loops and train unloading facilities, a rail connection to Goonyella rail system, offshore wharf facilities for up to eight ship berths, and expansion of tug facilities to accommodate up to 10 extra tug and service berths. The project will also require dredging of approximately 13-15 million m3 to create berth pockets and a departure apron for ships.

The primary environmental concerns for port development are that ecosystems in port areas form a critical connection between land and sea with vulnerable habitats and species in these and adjacent areas, including dredging and ship anchorage sites. The Hay Point zoning which incorporates Dudgeon Point includes 45 percent of shorebird feeding sites. Community concern includes the potential for increased noise in suburban areas and particulate dust increase in the surrounding area (Mackay Conservation Group, 2013).

Further to the environmental impacts of mining development, rapid growth in a single industry can also create offsetting economic and social consequences. Referred to as 'Dutch Disease', this rapid growth in one industry can drive up the cost of labour and production and increase costs for all industries by drawing on the same labour pool, transport infrastructure, and other inputs. Additional and related problems include labour competition, shortages in housing and labour markets, bottlenecks in the provision of infrastructure, high housing and rental prices, and uneven distribution of socio-economic benefits (Rolfe et al, 2007; Richardson and Denniss, 2011).

Figure 2 Natural resource deposits and projected infrastructure development. Source Landtrak Corporation (n.d.)

Urban and Infrastructure

CONDITION AND TRENDS

"Between 2006 and 2011 population growth slowed to an average of 1.4% per annum, slightly below the State average of 1.8%. The Mackay-Isaac-Whitsunday region had previously been experiencing stronger population growth (3.1% per annum) between 2001 and 2006, exceeding the State average for this period. Over the long term, the region's population is projected to grow at a faster rate than the State average (1.8% compared to 1.7%)"

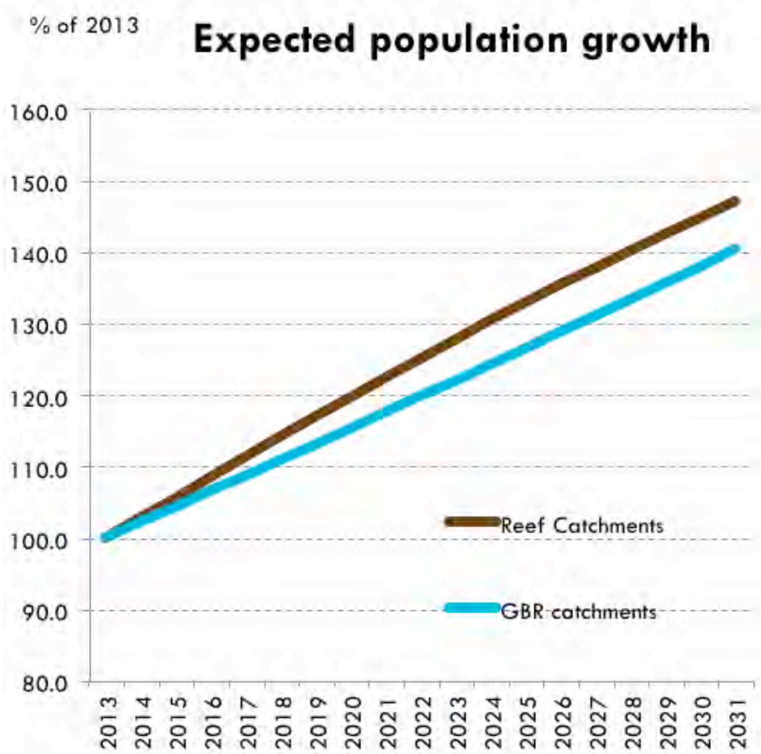
REDC Regional Report Card, 2012; 13

POPULATION GROWTH

The Mackay, Whitsunday and Isaac economic region was Queensland's fastest growing in 2010-2011, with an average annual growth of 13.7 per cent. On an individual basis Mackay ranked third at 8.5 per cent for production behind Brisbane (48.1 per cent) and the Gold Coast (9.4 per cent) (OESR, 2012b).

The Mackay, Whitsunday and Isaac catchment population is projected to grow by 47% by 2031, compared to a total Great Barrier Reef population growth of 40% over the same period (Figure 3).

Figure 3 Mackay, Whitsunday and Isaac catchment area projected population growth related to GBR wide catchment areas 2013-2031. Source: ABS, 2011.



Urban and Infrastructure

REEF CATCHMENTS

Council Area	Population	Increase Since Previous Year	Projected Population 2031	Additional Dwellings Forecast by 2031
Mackay	121,072	2.1%	187,400	43,300
Whitsunday	35,065	1.1%	55,500	10,200
Isaac	22,956	1.6%	37,000	5,800

Table 6 Dwelling and population forecast for Mackay, Whitsuday and Isaac Council Areas. Source: ABS, 2011.

"Broadhectare land refers to residential greenfield and brownfield land (greater than 2,500 mÇ) that is currently suitable for residential development. In December 2012, there were approximately 3,570 hectares of broadhectare land suitable for residential development in MWI. Based on the planning scheme intent, existing approvals, and an analysis of residential densities by location, this supply is expected to yield some 23,000 dwellings. This expected yield takes into account ownership and land fragmentation issues which often reduce the yield. In the year to December quarter 2012, MWI councils approved the development of 1,012 residential lots. This was a decrease of 49 per cent compared with the same period last year when 1,996 lots were approved", OESR 2012a; 3.

EMPLOYMENT

Regionally, the structure of employment has changed between 2006 and 2011 with the following points:

- Significant decline in relative importance of primary industries (down 2.8 percentage points to 3.9 per cent), which is a reduction of approximately 2,100 jobs
- Mining has declined in relative importance, despite the mining boom, partially due to mining FIFO, DIDO trends, and movements from construction to operational phases of mines
- Transport has increased in relative importance as more mines move to operational phase
- Manufacturing has increased slightly (while State-wide it has declined).

	Region (2006)	Region (2011)	% point change
Agriculture, forestry & fishing	6.7%	3.9%	-2.8%
Mining	11.7%	10.0%	-1.7%
Manufacturing	8.1%	8.8%	0.7%
Electricity, gas, water & waste services	0.8%	0.8%	0.0%
Construction	9.6%	10.3%	0.7%
Wholesale trade	3.9%	4.1%	0.3%
Retail trade	10.8%	10.2%	-0.6%
Accommodation & food services	8.3%	7.8%	-0.4%
Transport, postal & warehousing	6.0%	7.0%	1.0%
Information media & telecommunications	0.7%	0.6%	-0.1%
Financial & insurance services	1.5%	1.4%	-0.2%
Rental, hiring & real estate services	1.8%	1.9%	0.1%
Professional, scientific & technical services	3.7%	4.4%	0.7%
Administrative & support services	2.4%	2.7%	0.3%
Public administration & safety	3.7%	4.0%	0.2%
Education & training	5.9%	5.5%	-0.3%
Health care & social assistance	7.0%	8.3%	1.4%
Arts & recreation services	0.6%	0.6%	0.0%
Other services	4.1%	5.1%	1.0%
Inadequately described/Not stated	2.8%	2.5%	-0.3%
Total	100.0%	100.0%	0.0%

Table 7 Employment by Industry changes 2006-2011

Socio-economic Indicators for Areas (SEIFA) indicate that Mackay is relatively advantaged compared with the State, while Whitsunday is at a relative disadvantage. Mackay has higher income resources than the State, while Whitsunday is below the State. Both Mackay and Whitsunday are below the State in terms of education/ occupation, meaning residents have a relatively lower education and occupation status.

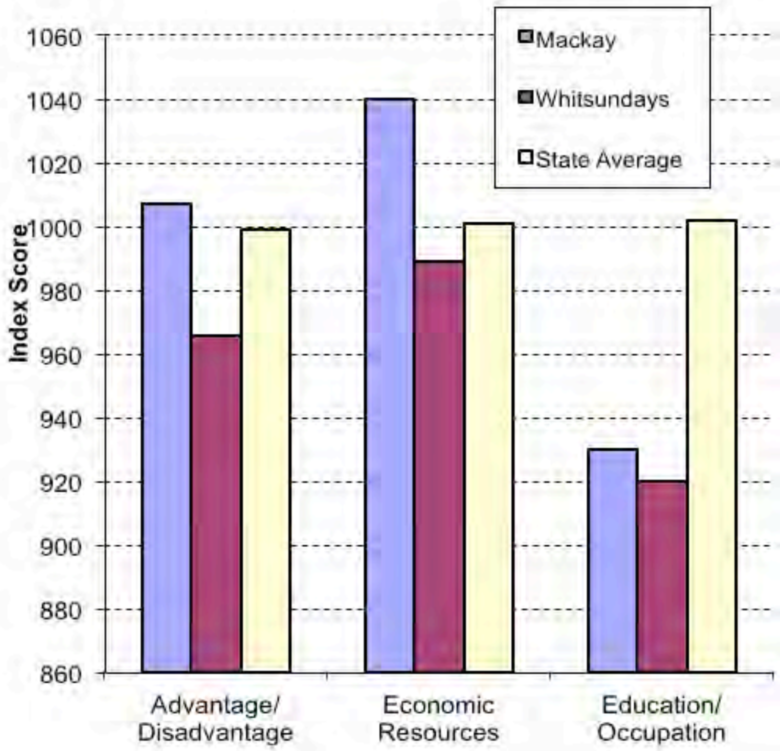


Figure 4 Relative advantage of Mackay and Whitsunday. Source: ABS, 2011

The region has seen a 21.9 per cent increase in the labour force since 2007, with a slight increase in unemployment of 0.9 per cent. Growth in the population is strongly correlated with consistent growth in employment across all sectors other than Agriculture, which decreased its workforce by 15.1 per cent. However, the GRP for Agriculture has increased by 22.7 per cent, indicating strong productivity gains in the sector (DLGP, 2012). The mining sector has experienced the largest increase in employment of 44.1 per cent.

The largest amount of investment was recorded in the Port sector, with more than $36.5 billion of new projects planned for the region. Mining investment remains strong with $32.5 billion planned over the next decade, complemented by $12 billion in rail projects. The strongest increase in investment is planned in the Whitsunday Regional Council area, driven by Port expansions at Abbot Point and new rail corridors from the Galilee Basin (REDC, 2012).

VISITATION

As occurred at a state level, domestic visitation to the region increased over the year. Mackay was the only region in the state to have recorded growth in holiday, visiting friends or relatives (VFR) and business markets. A key driver of the domestic growth was the recovery in business travel (which accounted for 45% of all domestic visitors to the region), and particularly from regional Queenslanders (REDC, 2012).

Urban and Infrastructure

In the year ended June 2011, there were a total of 1,298,000 visitors to the Mackay, Whitsunday and Isaac council regions, of which 233,000 were overseas travellers. The majority of visitors to the Whitsunday region were leisure travellers whilst the majority of visitors to the Mackay Tourism Region were Business travellers. In 2012 there were 1,124,000 passengers through Mackay Airport, of which 45 per cent were workers from the resource sector.

Due to growth in the resource sector, there is high demand for hotels, motels, serviced apartments and houses. Occupancy rates are particularly strong during the business week, with many accommodation providers in Mackay averaging in excess of 90 per cent Monday to Thursday and a yearly average of 69.8 per cent (REDC, 2013). Competition for land in the region is significant and is greatest between primary production and urban development and between all developed land uses and habitat preservation.

WATER RESOURCES

Allocation of sufficient water resources that meet community needs while maintaining environmental integrity is an ongoing challenge. This involves minimising offsite impacts of land and water use, managing natural habitat to conserve and enhance ecosystems, enhancing and maintaining water quality to maintain healthy ecosystems, and managing waterways and wetlands for the protection, enhancement and maintenance of aquatic ecosystems and the protection of public and private assets.

There are currently approximately 82,200 megalitres (ML) a year of groundwater allocated within the proposed Pioneer Valley Plan area and small volumes of groundwater accessed for domestic and pastoral purpose, which do not require licensing. Groundwater use for the majority of irrigation, industrial and municipal users of the Pioneer Valley amounted to approximately 52,395 ML during the 2002-2003 water year. The high levels of use have played a significant role in the current condition of the aquifer system.

The Whitsunday Water Resource Plan (Queensland Government, 2010) includes the Proserpine and O'Connell river catchments which flow into Repulse Bay. The water resource plan includes management of the Proserpine River Water Supply Scheme operated by Sun Water, as well as un-supplemented water and sub-artesian water. The supply scheme is supplied by water from the Peter Faust Dam on the Proserpine River.

In 1996 the Mackay Tourism and Development Bureau engaged consulting engineers to develop a regional resource strategy for the greater Mackay area. The result of the consultancy was a report titled Mackay Water Resources Strategy Volumes 1, 2 & 3 (Wagner, 1996). The report provides an overview of the water resources within the study area, the level of water infrastructure development and possible future water infrastructure development.

A comprehensive assessment of the region's water resources was outlined in a report "Overview of Water Resources and Related Issues – The Mackay Whitsunday Region" (DPI, 1993), which stated that the total groundwater yield for the region was estimated to be 164,200 ML per annum. It is further estimated that 86% of the supplies available have a water quality with less than 3,000 milligrams per litre total dissolved salts. Alluvium provides the bulk of groundwater supplies with approximately 110,900 Megalitres per annum available from this source.

Stream flow records are available from over 20 stream gauging stations throughout the region. The locations of the gauging stations are available online for stream catchments at Proserpine River, O'Connell River, Pioneer River and Plane River (Queensland Government, 2012). Water quality and water levels, from which volumes of water flows may be derived are monitored as part of the State wide ambient monitoring program.

Urban and Infrastructure

REEF CATCHMENTS

Groundwater Dependant Ecosystems are an issue requiring further in-depth investigation and analysis. The way in which these ecosystems are managed in the context of consumptive groundwater uses will become increasing important.

Achievements Water Quality Improvement Plan 2008-2013 (in publication)

- 5 stormwater modelling & management plans for 5 major urban catchment management areas;
- 16 site urban waterway health monitoring program;
- 3 Mackay Whitsunday Isaac regional councils received Reef Guardian Council accreditation;
- 2 sewerage treatment works funded for upgrades;
- 4 storm water solid waste traps installed with quantity and type monitoring program;
- New Urban ABCD Management Framework developed;
- "Best Practice Guidelines for Controlling Stormwater Pollution from Building Sites" published;
- Pilot Essential Services Commission development compliance program launched.

All The Water Quality Improvement Plan (Drewry et al., 2007) was reviewed in 2013-2014, with good progress modelled across several key areas, such as cane and grazing land management. The urban deliverables were however less successful. Of the 42 activities required to bring urban development in line with standards, while 17 commenced, 19 have not been completed and only 6 were noted as complete.

URBAN WASTE AND LANDFILL

Key urban waste management issues as outlined are predominantly linked to land clearing landfill, sewage collection, treatment and disposal and solid waste disposal. Current conditions indicate that substantial improvements have been made in the management of urban waste especially that linked to sewage collection and treatment. However some regional treatment facilities still require upgrades to new technology sewage treatment facilities, therefore declining water quality associated with sub standard sewage based treatment facilities is occurring.

Landfill issues as with most regional and metropolitan areas continues to be a challenge. Mackay Council operates a best practice landfill and transfer station model with front end recycling and waste diversion such as curbside recycling and resource recovery at all disposal facilities, while processing green waste into landscaping mulch. For the past decade, Council has prioritised the closing of poor performing landfills and replacing these with a regional facility that meets environmental standards, in addition to a progressive remediation program of the former landfills that will cost more than $40 million over the coming years.

Another regional focus of Councils is waste diversion activities and the recovery of construction and demolition waste (i.e. timber, concrete), which represents up to 30 per cent of the total waste stream. If a successful recovery service was introduced the current landfill would be reduced from approximately 114,000 tonnes per annum to 80,000 tonnes per annum. Construction may begin in 2014, subject to feasibility studies and development approvals.

Long term organic waste options at a local government level have undergone disruption as the Queensland Government withdrew the waste levy, the financial driver for successful organic waste collection and processing programs as evidenced in the southern states where levies make organic waste solutions viable.

Proposed expansion projects at Hay Point will add 110 million tonnes per annum (mtpa) of coal exports in a new coal port terminal, bringing the complex of coal ports (Hay Point 44 mtpa and Dalrymple Bay 85 mtpa) to 239 mtpa, making it the largest coal export port complex in the world, although the Hay Point proposal is currently on hold.

GOVERNANCE

Urban development assessment and approval processes are highly regulated with numerous pieces of legislation and State Planning Policy applied. However, the application and interpretation of the legislation and policy to individual development sites may vary depending on the site and the Local Government and State Government staff assessing the proposal.

Development and planning of urban growth is predominantly under the management of local government policy and planning which is facilitated by the Sustainable Planning Act 2009. In addition the Vegetation Management Act 1999 was amended in 2013 and provides a basis for land planning.

In 2013, the Queensland Government introduced a new approach to state planning policies with a single state planning policy (SPP) to replace the various state planning policies with. The SPP sets out policies about matters of state interest in relation to planning and development, and is a key framework of the government's broader commitment to planning reform. Land development in relation to coastal environments is a key issue within the region and the extent of the area is controlled by local government development requirements within the state government legislative requirements linked to development and vegetation management.

The primary source of surface water resource entitlements in the Mackay Whitsunday area is the water licensing and technical data stored in NRW's Water Entitlements Registration Database (WERD).

Two primary aquifers of importance occur in the Pioneer Valley and Proserpine Low lands. The importance of the groundwater resource in these two areas is underpinned by the designation under the Water Act 2000 (Water Regulation 2002), as Declared Subartesian Areas. For subartesian areas defined in the Water Regulation 2002, a water licence is required to take or interfere with subartesian water, other than for the purposes specified within Schedule 11 of the Water Regulation 2002. Works constructed or installed to take subartesian water in declared subartesian areas are assessable development under the Integrated Planning Act 1997, other than works constructed or installed solely for a purpose mentioned in Schedule 11 of the Water Regulation 2002. Outside of the Pioneer and Proserpine Declared Subartesian Areas regulation of groundwater does not occur. This is generally because the aquifers are of minor significance and discontinuous.

The Water Resource Planning process is the primary tool for sustainable water management, which:

- allows transparent sharing of water to protect environmental and human interests
- makes sure water users' allocations are secure for the life of the Water Resource Plan
- ensures that new al locations will be issued only if they can be sustained without undue environmental harm
- establishes a basis for water allocations in nominated areas to be permanently traded (transferred to another site or use), subject to important safeguards
- protects the health of rivers and underground water reserves.

Urban and Infrastructure

Many of the decisions potentially impacting upon natural resource condition can be managed by having a more coordinated approach to;

- Land use planning – Including the use of model scheme provisions, standard conditions of consent and benchmarking operational practices to known best management practice;
- Urban population education and skills development associated with;
  - Natural resource use ie. Water
  - Use of pesticides and the cumulative effect of pesticide use and subsequent runoff from high level intensive use of pesticides on small land areas.

INDICATORS

In valuing a sustainable urban environment at a time of growth, the Urban Development Institute of Australia (UDIA) developed a system of 'EnviroDevelopment' indicators so developers are able to promote environmental outcomes of projects, which can be used as a benchmark of a sustainable urban values (EnviroDevelopment, 2011). The six signs of sustainability are as follows:

Water	Improved water use through water efficiency mechanisms and/or source substitution such as rainwater and stormwater harvesting;
Energy	Reduced production of greenhouse gases and reduced use of fossil fuels. This is achieved through greater efficiencies in energy useage and use of renewable and non-polluting energy sources such as solar power;
Ecosystems	Protected and enhanced health and sustainability of natural systems and the encouragement of native biodiversity and rehabilitation of degraded sites;
Community	Vibrant, cohesive, sustainable communities with good community design the provision of community facilities and networks; safe, accessible housing and options for reduced use of private motor vehicles;
Materials	Environmentally responsible material usage including reuse of materials, recycled materials and consideration of the life cycle environmental costs of materials;
Waste	Comprehensive waste management procedures and practices to reduce the amount of waste to landfill.

A need has been identified for a guiding document or system which summaries what is meant by implementing best practise urban development, or ecologically sustainable development, such as this example from UDIA's EnviroDevelopment Technical standards. The development of a quick look up guideline for development assessment staff and developers may ensure the right information is gathered from studies to determine the best way to develop a site.

Such a tool has been developed as part of the Healthy Waterways Alliance and ABCD Urban Framework that is a model of best practice for development as follows (note that each council has individual planning schemes independent to this that may incorporate elements best practice for implementation but not every item).

REEF CATCHMENTS

DEVELOPMENT AND ASSESSMENT STAGE

Issues to be addressed at the development assessment phase of a development may lead to an improved knowledge of possible environmental impacts. Improved environmental outcomes can be grouped into themes.

Ecosystem

1. Stormwater
    i. Stormwater management plan submitted which complies with State Planning Policy 4/10
    ii. Studies conducted designed to implement Water Sensitive Urban Design
2. Vegetation management
    i. Comprehensive vegetation study including this identification of threatened species
    ii. Wildlife corridors identified and retained/ incorporated
    iii. Bushfire assessment
3. Fauna management
    i. Fauna study conducted to identify important fauna
4. Water quality
    i. Collection of baseline water quality data for site
5. Soil management
    i. Investigation of soils to inform ESCP
    ii. ESCP submitted for site

Waste Management

i. Concept plan for waste management storage and collection for the development
ii. Litter management plan for site

Development site suitability

i. Assessment conducted on site suitability including physical constraints
ii. Visual amenity assessment

Transport

i. Submission of a transport network plan showing vehicle and pedestrian connectivity

Materials sourcing plan

i. Plan on where materials will be sourced from to ensure materials are sourced from sustainably managed sources

Open space management

i. Contribute significantly more than statutory required

Landscaping

i. 90% of plant species are locally native
ii. No weed species

Energy assessment of site

i. Lighting
i. Water use efficiency planning
i. Grey water re-use
ii. Rainwater

CONSTRUCTION PHASE

The construction phase of the development has the greatest possible impact of the site and downstream ecosystems. It is at this stage of the development that impacts can be measured and mitigated.

Ecosystem

1. Stormwater
   i. Stormwater management plan implemented
   ii. Construction drainage plan implemented for site to separate clean and dirty water
2. Vegetation management
   i. Clearing completed in stages
   ii. Cut down vegetation mulched on site for latter use
   iii. Vegetation retention maximised on site
   iv. Damage to trees is minimised by machinery
   v. Vegetation retained on building envelopes maximised
3. Fauna management
   i. Designated fauna spotter who will relocate fauna from development site
4. Water quality
   i. Collection of water samples during construction phase to determine compliance with agreed site water quality discharge guidelines
   ii. Collation of water quality sample data and reporting
5. Soil management
   i. Topsoil stockpile areas managed and fenced
   ii. Minimisation of exposed soil areas
   iii. exposed soil areas progressively stabilised
   iv. Erosion measures implemented
   v. Sediment interception measures implemented

Waste management

i. Collection for construction waste centralised and contained

ii. Litter management plan for site – construction phase implemented

Development timing and staging

i. Consideration of wet season

ii. Earthwork construction and development staging

SITE CLOSURE AND POST CONSTRUCTION

The rapid closure of a development site can minimise the risk of off-site impacts. It is tempting to developers to cut corners in the closure phase to save money. Equally, developers want to produce a good saleable product which they can maximise their profits.

Ecosystem

1. Stormwater
   i. All stormwater drainage paths vegetated
2. Vegetation management
   i. Landscaping completed
   ii. Protection measures in place to ensure retained vegetation stay
3. Fauna management
   i. Implementation of possum boxes?
4. Water quality
   i. Collection of baseline water quality data for site after construction to ensure compliance with agreed guidelines
5. Soil management
   i. All exposed soil now vegetated

Waste management

i. Waste management storage and collection for the development completed and functional
ii. Kerbside recycling and green waste recycling
iii. Litter management and interception devices installed

Transport

i. Public transport is close by and available

Open space

i. Landscaping and turfing

Reporting and evaluation

i. A final report is developed to evaluate the compliance of the development against the development approval and environmental outcomes originally sought

The key indicator to managing natural resource condition linked to urban growth is associated with population settlement plans and planning schemes developed by local councils. By managing population growth, plans can better predict the likely impacts on natural resource condition. In having a settlement program, planners have the ability to reduce the development of quality agricultural land into housing and industrial developments and also plan to manage population waste.

Model for Urban Stormwater Improvement Conceptualisation (MUSIC) software is the industry standard predictive modelling software throughout Australia, and is being used by Mackay Council to determine appropriate stormwater management measures. Developments that are considered high risk are to demonstrate the achievement of council's water quality.

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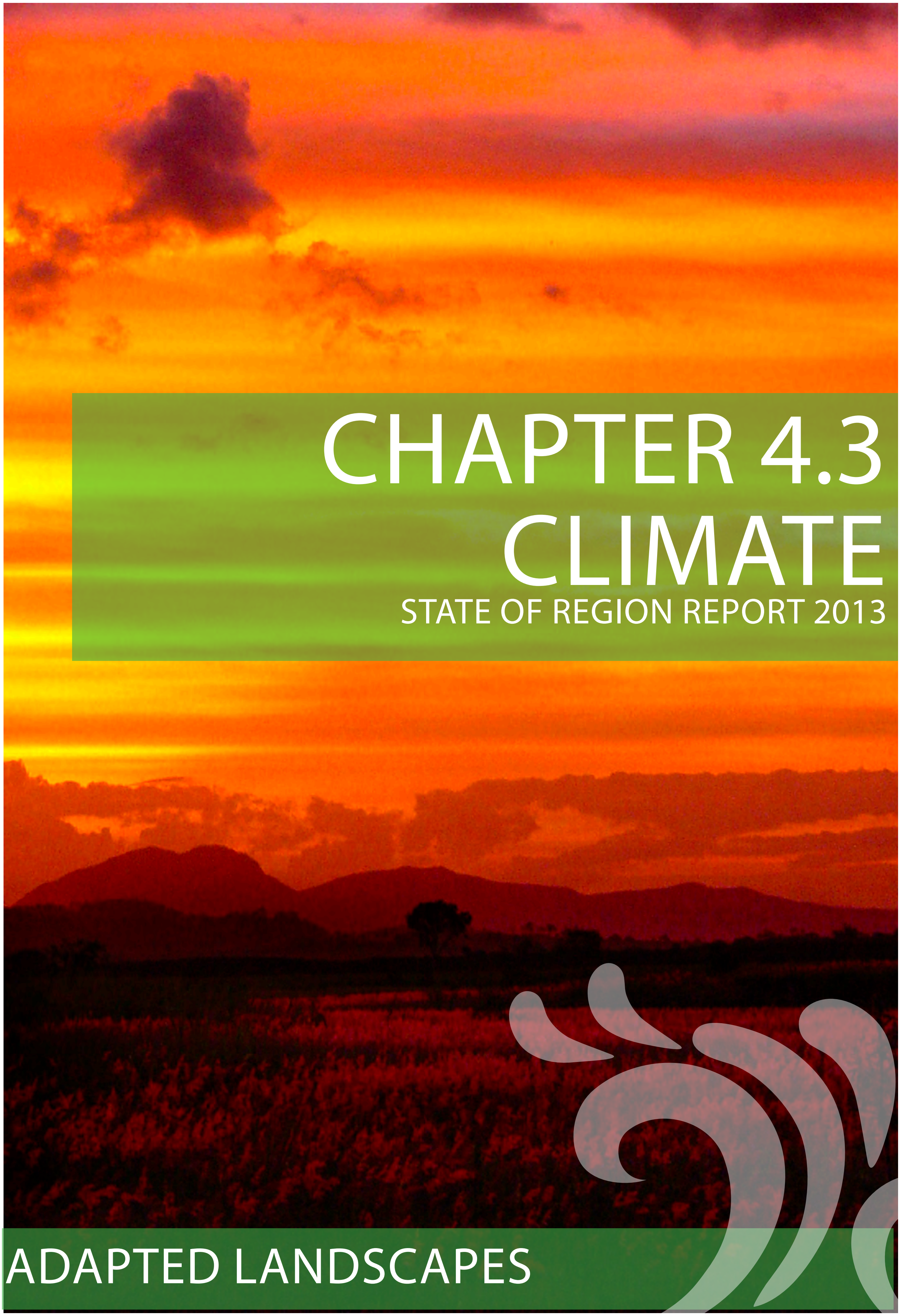


CHAPTER 4.3
CLIMATE
STATE OF REGION REPORT 2013

ADAPTED LANDSCAPES

SUMMARY

Australia is historically known as a continent with high natural climate variability. Climate change impacts are evident with increasing annual maximum and minimum temperatures, number of hot days and reduced rainfall in the southern, eastern and south western parts of the continent.

The Mackay Whitsunday Isaac (MWI) region has high natural climate variability and only short-term historical records, which makes it difficult to discern climate change. However, there is evidence that there has been an increase in annual maximum and minimum temperatures that is unlikely to reverse. A drying trend has occurred south of Cairns for the last 30 years, which includes decreasing rainfall in MWI region.

Climate change and climate variability is a highly topical, global issue that will take the concerted efforts of communities, industries and governments to decarbonise the economy and mitigate and adapt to the inevitable effects of a changing climate. Maintenance, expansion and preservation of the integrity of natural carbon stores will assist in mitigation as well as continue to provide other ecosystem services vital for sustaining communities.

VALUES AND SERVICES

The climate is influenced by global scale processes that are dominated by interactions between the ocean and atmosphere (IPCC 2007a). In the Australian and local context there are a number of atmospheric and oceanic phenomena operating on varying time scales that influence local and regional weather and longer term climatic patterns. These include the Southern Annular Mode (SAM), El Nino Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), the Madden Julian Oscillation (MJO) and the Indian Ocean Dipole (IOD). For further information on these phenomena refer to the Australian Bureau of Meteorology (http://www.bom.gov.au/watl/about-weather-and-climate/australian-climate-influences.shtml).

The current climate in the Mackay Whitsunday Isaac region influences the complexity and condition of natural assets and provides an envious lifestyle for the community that live here. The region has unique values that range from mountain ranges to coastal and marine communities that support climatically distinct and unique biodiversity values. It is also adjacent to the World Heritage listed Great Barrier Reef that is renowned internationally for its ecological importance and the beauty of its seascapes and landscapes (Johnson and Marshall, 2007).

The natural assets within the region have high biodiversity value and also provide natural stores for carbon in terrestrial vegetation, soils, wetlands and coastal and marine communities. Carbon stocks in different ecosystems have not been estimated on a national, state or regional scale to date; however global estimates of carbon stores in different ecosystems (in plants and soil) vary considerably. Tropical rainforests tend to have equal amounts of carbon stored in plants and soil; however wetlands and coastal and marine communities may store up to 10 times more carbon in sediments than in above-ground biomass (Pidgeon 2009). Furthermore, carbon stored in marine communities is stored over longer time scales than that in above-ground biomass as sediments will accrete vertically in response to rising sea levels (Mcleod et al. 2011).

Natural assets can also assist in the mitigation of damage from extreme weather events and can be more cost effective than using only structural approaches (Mangi et al. 2011, Queensland Government 2012a). Coastal and marine communities absorb the energy of storm-driven waves and wind and can reduce storm surge water levels by slowing the flow of water and reducing surface waves (McIvor et. al 2012). Mangrove communities therefore play a vital role in in protecting coastal natural and community assets.

In response to the cyclones and flooding in 2010/11 the Queensland Government initiated a synthesis of literature to review the role of natural ecosystems to mitigate the impacts of natural hazards (Queensland Government 2012a). General findings from this review are summarised below:

- Vegetation interventions can reduce flooding; however local studies are essential to understand the catchment context;
- There is a clear link between riparian vegetation, reduced flood velocity, changed downstream flood peak and increased upstream flooding. The increased localised flooding spreads the flood flow, removing systemic energy and reducing flood-velocity damage;
- There is clear evidence that coastal vegetation systems such as mangroves and saltmarsh can attenuate storm surges; however they need to be significantly broad to attenuate storm surge;
- Trees, especially younger but well established, strong and well-managed trees, can trap debris and reduce wind energy to limit cyclone damage.

PRESSURES

The Mackay, Whitsunday and Isaac local government areas have experienced large population growth, averaging 2.5% annual growth from 2007 to 2011 (Queensland Government 2012b). The majority of growth has been around Mackay (Queensland Government 2012c) as it is a major support centre for extractive industries. Increased population growth is directly related to higher energy usage, rising CO2 levels in the atmosphere and pressures on natural resources from increased human activity (Crutzen and Steffen 2003). Natural hazards such as bushfires, flooding and cyclones are a part of the environmental history for Australia and Queensland and will continue into the future. Not all natural hazards are disastrous, they only become disasters when they impact on vulnerable communities or environments.

An area of concern for this region is much of the urban population and ongoing development is sited in the floodplain and coastal zone, putting increasing pressure on coastal and marine natural assets, as well as altering the natural hydrology and drainage patterns. These areas are also likely to be the most affected by climate change (IPCC 2012). There are a number of strategies that can be implemented via statutory and land use planning processes to reduce the vulnerability and risk to communities (e.g. Palazzo and Steiner 2011) as well as improving energy efficiencies and impacts on the natural environment.

Over the relatively short span of 250 years, and for the first time in human history, we have changed and are continuing to change the composition of the atmosphere on a global scale.

Climate

The region supports productive agriculture including sugarcane, horticulture and extensive grazing. Shifts in the climate have potential consequences and/ or opportunities for productive agriculture through increased intensity of extreme weather events, biosecurity risks, increased solar radiation and higher CO2 levels. Direct greenhouse gas emissions from the agriculture, forestry and fishing sectors contributed 18.8% of the total national greenhouse gas emissions in 2009/2010 (Commonwealth of Australia 2012) with the largest quantity of net emissions attributed to Queensland. In 2009 agricultural emissions were 17% of Queensland total emissions with nearly 80% accounted for through enteric fermentation from cattle and sheep (Queensland Government 2011). There are potentially a large number of opportunities for these industries in carbon sequestration and emissions mitigation in the future; however, there are still large knowledge gaps in quantifying net sinks and sources for different agricultural commodities.

CONDITIONS AND TRENDS

"Over the relatively short span of 250 years, and for the first time in human history, we have changed and are continuing to change the composition of the atmosphere on a global scale. Levels of carbon dioxide, the most important greenhouse gas have increased by around 39% above pre-industrial levels, principally due to burning fossil fuels. This has led to a clearly defined trend of increasing average global temperatures, and there is growing evidence of consequent changes in the complex interlinked atmospheric, oceanic and terrestrial processes that shape climate at a global, continental and regional scale.

From 1970-2010, Australia's mean daily temperature rose in almost all parts of the country… The 13 year period from April 1997 to March 2010 was characterised by severe rainfall deficiencies that covered much of south-western and south Australia. For many places, the severity and duration of drought were unprecedented, with profound environmental, social and economic implications. Then in the 12 months from March 2010, large parts of the continent experienced above-average rainfall associated with an extremely strong La-Niña event. Most notably, eastern Australia received widespread record breaking rains, with associated loss of life and massive damage to agriculture, homes and infrastructure" Australia State of the Environment 2011; 16

Climate change is a global issue and is accepted by the majority of scientists to be caused primarily by human activity, primarily through burning of fossil fuel and land clearing. Increasing levels of greenhouse gases (carbon dioxide, methane and nitrous oxide) in the atmosphere is interfering with the Earth's energy balance. Global temperature increases are locked in at a minimum of 2oC even if emissions ceased immediately due to the lag time between atmosphere and ocean interactions and impacts on the global climate (IPCC 2007b).

The 2007 IPPC reports document direct observations in increases of global air and ocean temperatures, widespread melting of snow and ice and rising global average sea level (IPCC 2007b). The Great Barrier Reef ecosystem is considered highly vulnerable to climate change, as a result of increasing air and sea temperatures, ocean acidification, nutrient enrichment, altered light levels, more extreme weather events, changes to ocean circulation and sea level rise (Marshall and Johnson 2007). Johnson and Marshall (2007) also document the changes already evident in different ecosystems within the GBR.

GHG concentrations have continued to rise since the 2007 IPPC reports (Figure 1). There is an abundance of literature documenting additional impacts on global ecosystems and further loss of ice sheets since 2007. These reports will be synthesised as part of the IPCC's Fifth Assessment Report (AR5) due to be completed in 2013/2014.

Globally, there has also been a large increase over the last decade in the number of extreme weather events. Recent analyses of the increased incidence of extreme weather events indicate that there is strong evidence that heatwaves and precipitation extremes are strongly linked to human influence on the climate (Coumou and Rahmstorf 2012).

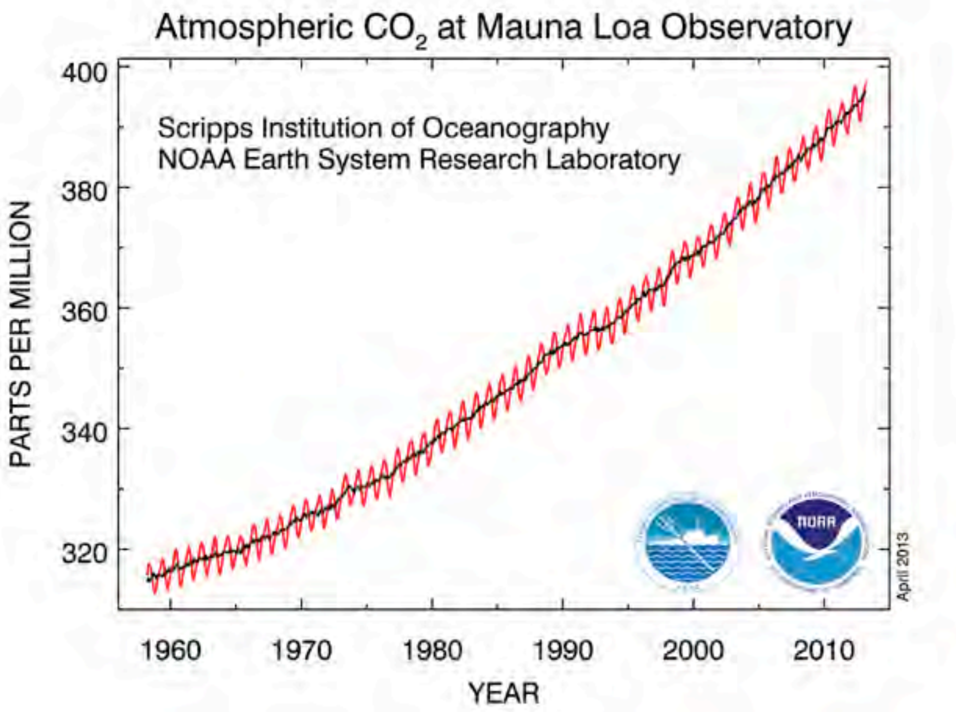
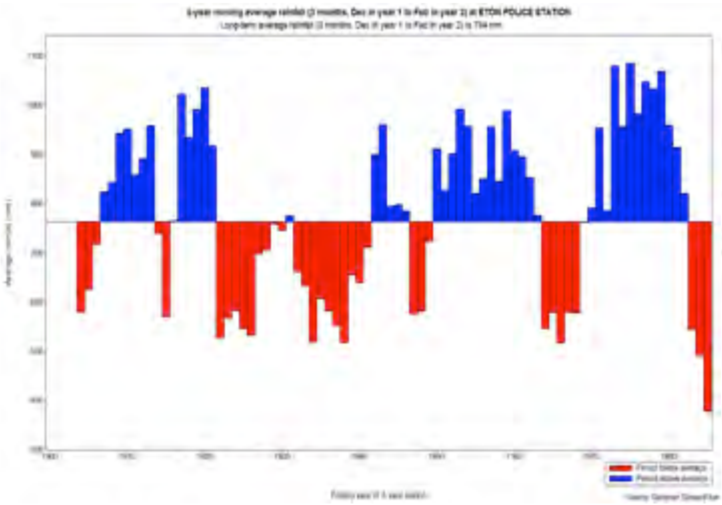


Figure 1: Monthly mean atmospheric CO2 measured at the Mauna Loa Observatory, Hawaii. Mauna Loa constitutes the longest record of direct measurement of CO2 in the atmosphere, Source: http://www.esrl.noaa.gov/gmd/ccgg/trends/mlo.html#mlo_growth, accessed 30 April 2013.

Internationally, Australia is recognised as a continent with high natural climate variability. Analysis of historical climate data for Queensland has shown that the Mackay Whitsunday Isaac region has much higher natural climate variability that makes it difficult to discern natural variability from climate change (Queensland Government 2009).

The high variability in annual and seasonal rainfall and distinct climatic zones within the Mackay Whitsunday Isaac region is demonstrated by rainfall data from selected weather stations (Figures 2 and 3).

(a)



(b)

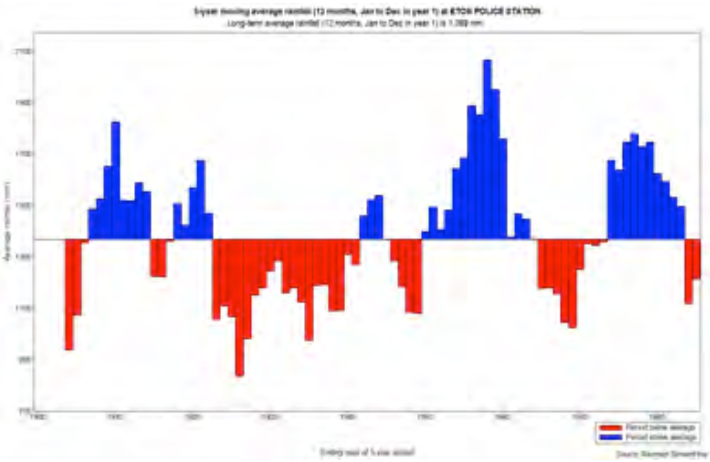
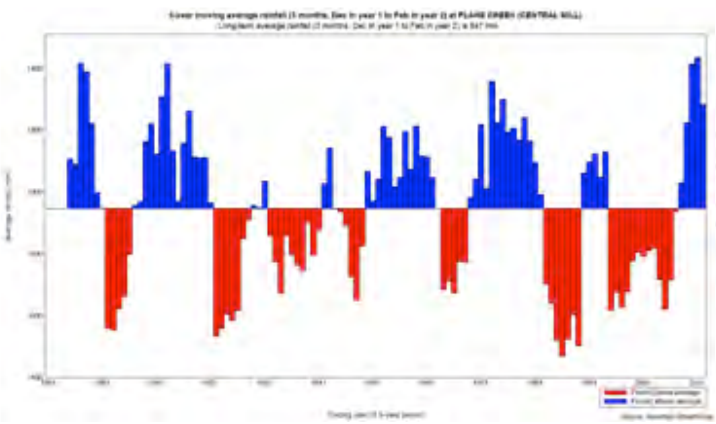


Figure 2: Five-year rolling average for historical rainfall from the Eton police station for a) December to February (summer) and b) total annual rainfall since 1900. Data source: Rainman

Eton is a drier part of the region with average annual rainfall of around 1380mm per annum. Historical records (since 1900) show the seasonal variability that has been experienced in summer months (Figure 2a) with distinctly dry summers (red areas) from the early 1920's to the early 1940's and wetter summers (blue areas) from the early 1950's to early 1960's and 1970's to early 1980's. Total annual rainfall has also been highly variable with distinctly drier periods (Figure 2b) from the early 1920's to the early 1940's.

(a)



(b)

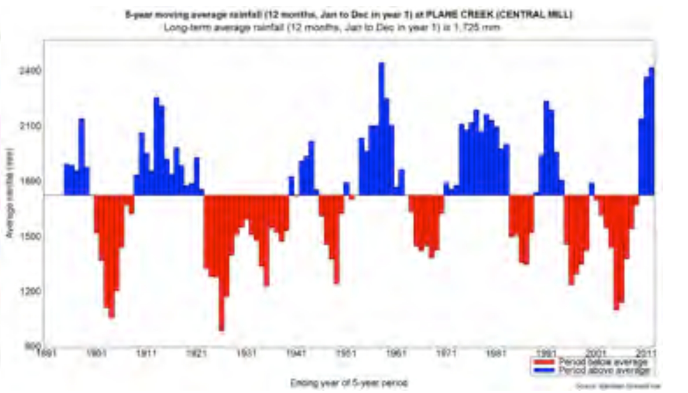


Figure 3: Five-year rolling average for historical rainfall from the Plane Creek Mill for a) December to February (summer) and b) total annual rainfall since the late 1890's. Data source: Rainman

Plane Creek (Sarina) has an average annual rainfall of around 1700 mm per annum and historical records also show high variability in summer months (Figure 3a) and in annual rainfall (Figure 3b). The periods where drier summers have been experienced and total annual rainfall lower than respective averages are consistent between the two climatic zones.

Climate

Changes to the current climate of the Mackay Whitsunday Isaac NRM region is inevitable as emissions from burning of fossil fuels and land clearing have not reduced at a global scale (see Figure 1). Despite the short-term nature of climate data in the Australian, state and local context there are some distinct trends that have arisen, particularly in the latter part of the 20th century. Reports prepared by the Queensland Climate Change Centre of Excellence (Queensland Government 2008, 2009) examined historical climate data and the projected impacts of climate change on the Whitsunday, Hinterland and Mackay region. Key findings are outlined below.

- Annual mean surface temperatures increased by around 1.1oC (from 1950-1970) which is significantly larger that the Australian annual average increase of 0.8oC and annual mean temperature increased 0.3oC over the period 1999-2009
- Maximum temperatures (annual average) increased by 0.9oC and minimum temperatures increased by 1.4oC from 1950-2007
- Projections indicate an increase in annual mean temperature of up to 4.2oC by 2070
- By 2070, Mackay may have 12 times the number of days over 35oC than is currently experienced
- Average annual rainfall fell nearly 14% (1999-2009) compared with the previous 30 years. This was, however, generally consistent with natural variability experienced over the last 110 years and does not take into account the high rainfall experienced in 2010-2011
- Climate models projected a range of rainfall changes from +17% to -35% by 2070
- Climate projections indicate annual potential evaporation could increase by 7-15% by 2070
- The 1-in-100-year storm tide event is projected to increase by 36 cm in Mackay and 31 cm at Airlie Beach if certain conditions eventuate. These conditions are a 30 cm sea-level rise, a 10 per cent increase in cyclone intensity and frequency, as well as a 130 km shift southwards in cyclone tracks.

Recent research funded by the Sugar Research Development Corporation has examined the projected impacts of climate change on the Australian sugar industry. Findings to date are contrary with previous projections, concluding that there is insufficient evidence for major shifts in rainfall patterns for the Mackay sugar industry (Everingham et. al 2013).

Increasing maximum and minimum temperatures trends are also evident from the five-year rolling averages for temperature anomalies (departure from the long-term average) from the Australian Climate Change Observations Reference Network Mackay site (Figure 4).

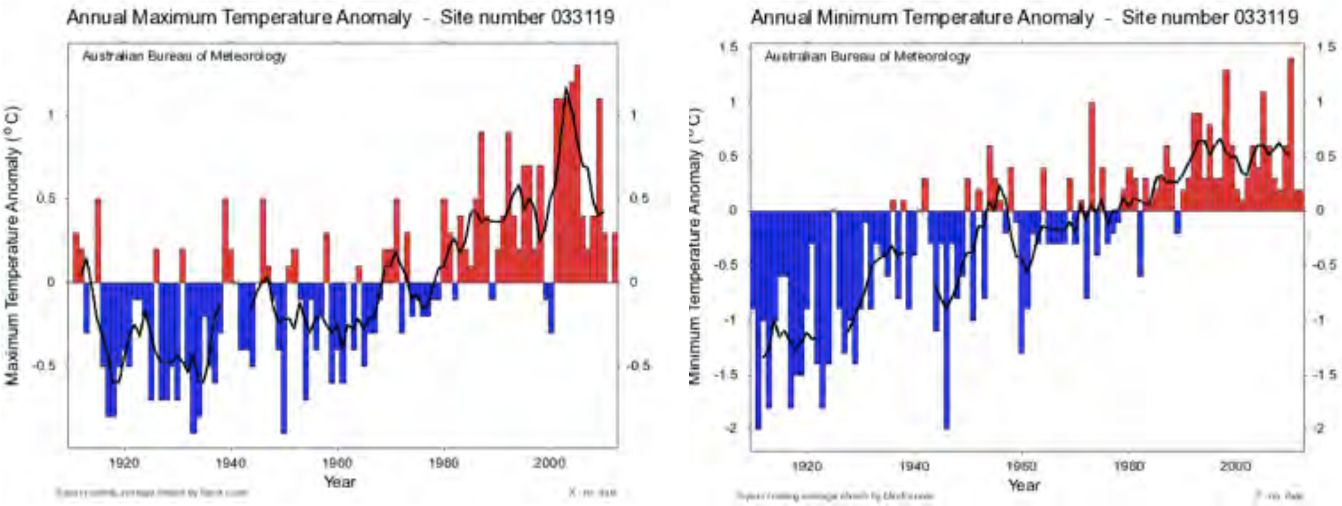


Figure 4: Historical maximum and minimum temperature anomalies from the Mackay Australian Climate Change Observations Reference Network (source: http://www.bom.gov.au/cgi-bin/climate/hqsites/ accessed 16 April 2013)

Updated climate change projections are currently being developed for the Mackay Whitsunday Isaac NRM Region and are expected to be available in mid-2013. A recent summary of climate change impacts on a national basis (CSIRO/ BOM 2012) state that:

- Global temperatures were the warmest on record in 2010
- Australia experienced record rainfalls and the coolest temperatures since 2001 due to a very strong La Niña event in 2010 and 2011
- Concentrations of long-lived greenhouse gases in the atmosphere reached a new high in 2011
- Australian temperatures are projected to increase in coming decades
- Rising CO2 emissions from the burning of fossil fuels has affected global temperature much more than natural climate variability during the past century.

GOVERNANCE

The United Nations Framework Convention on Climate Change is an international environmental treaty that came into force in 1994 with the ultimate objective of stabilising greenhouse gas concentrations in the atmosphere. Through the Convention the Kyoto Protocol was developed as a legally binding mechanism where countries ratifying the Protocol, committed to reducing their emissions by an average of 5% by 2012 against 1990 levels. Australia ratified the Kyoto Protocol in 2008. The Ad Hoc Working Group on the Durban Platform for Enhanced Action was established to develop a protocol as a follow-up to Kyoto by no later than 2015.

The Australian Government released the Clean Energy Plan on 10 July 2011 which outlines a number of mechanisms to assist in meeting agreed international targets and support Australian communities and businesses in transitioning to a low carbon economy. A long-term target of 80% reduced emissions from 2000 levels by 2050 has also been adopted by the Australian Government.

IThe Land Sector Package of the Clean Energy Plan has committed to action on the land to improve carbon sequestration and mitigation activities. These programs are:

- Biodiversity Fund. Support to plant, restore, manage and enhance biodiverse carbon stores
- Carbon Farming Futures. Support for research, extension and demonstration of new and innovative practices
- Regional NRM Planning. Funds to regional NRM Groups and supporting research institutions to assist in identifying in the landscape where adaptation and mitigation activities should be undertaken

The Carbon Farming Initiative (CFI) is a carbon offsets scheme that was passed by Parliament on 23 August 2011 and received royal assent on 15 September 2011. The CFI allows farmers and land managers to earn carbon credits by storing carbon or reducing greenhouse gas emissions on the land. To participate in the CFI there must be an approved offsets methodology; methodologies approved to date applicable to the MWI NRM region are; environmental plantings, reforestation and afforestation. These methodologies can be accessed through http://www.climatechange.gov.au/reducing-carbon/carbon-farming-initiative/methodologies/methodology-determinations

Key areas that will influence climate change adaptation and mitigation for the Mackay Whitsunday Isaac region include:

- Local government, state and federal government policy that recognises the role and maintenance of marine and terrestrial natural assets in storing carbon and mitigating the effects of extreme weather events
- Local and state planning policies recognise and limit development in potential risk areas
- Policies and strategies in place to relocate vulnerable and at risk infrastructure/ human settlements
- An increase in land area for vulnerable/ at risk ecosystems (e.g. saltmarsh, mangroves, coastal vegetation)
- An increase in CFI offset methodologies suited to the MWI region (e.g. reduced emissions from fertilisers)
- Community acceptance and commitment in their role to assist in climate change mitigation and adaptation

INDICATORS

Government policy reflects the need to protect natural marine and terrestrial ecosystems to maintain and increase carbon storage and reduce impacts from extreme weather events. The region’s community acknowledges and supports action at all levels to reduce the impacts of human activity, promotes and uses energy derived from renewable resources and the resilience of the natural landscape is improved.

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