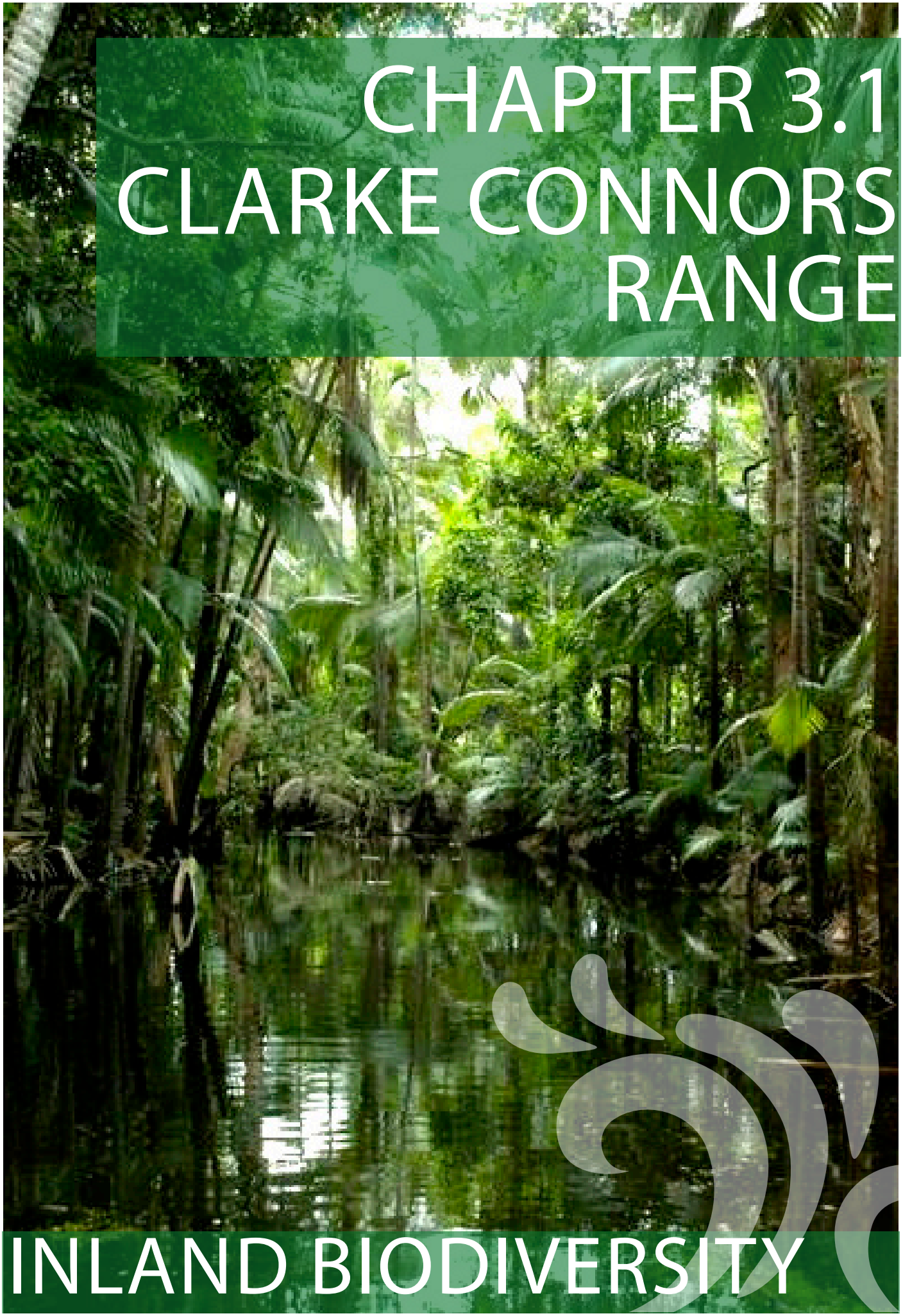

CHAPTER 3.1
CLARKE CONNORS RANGE

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.

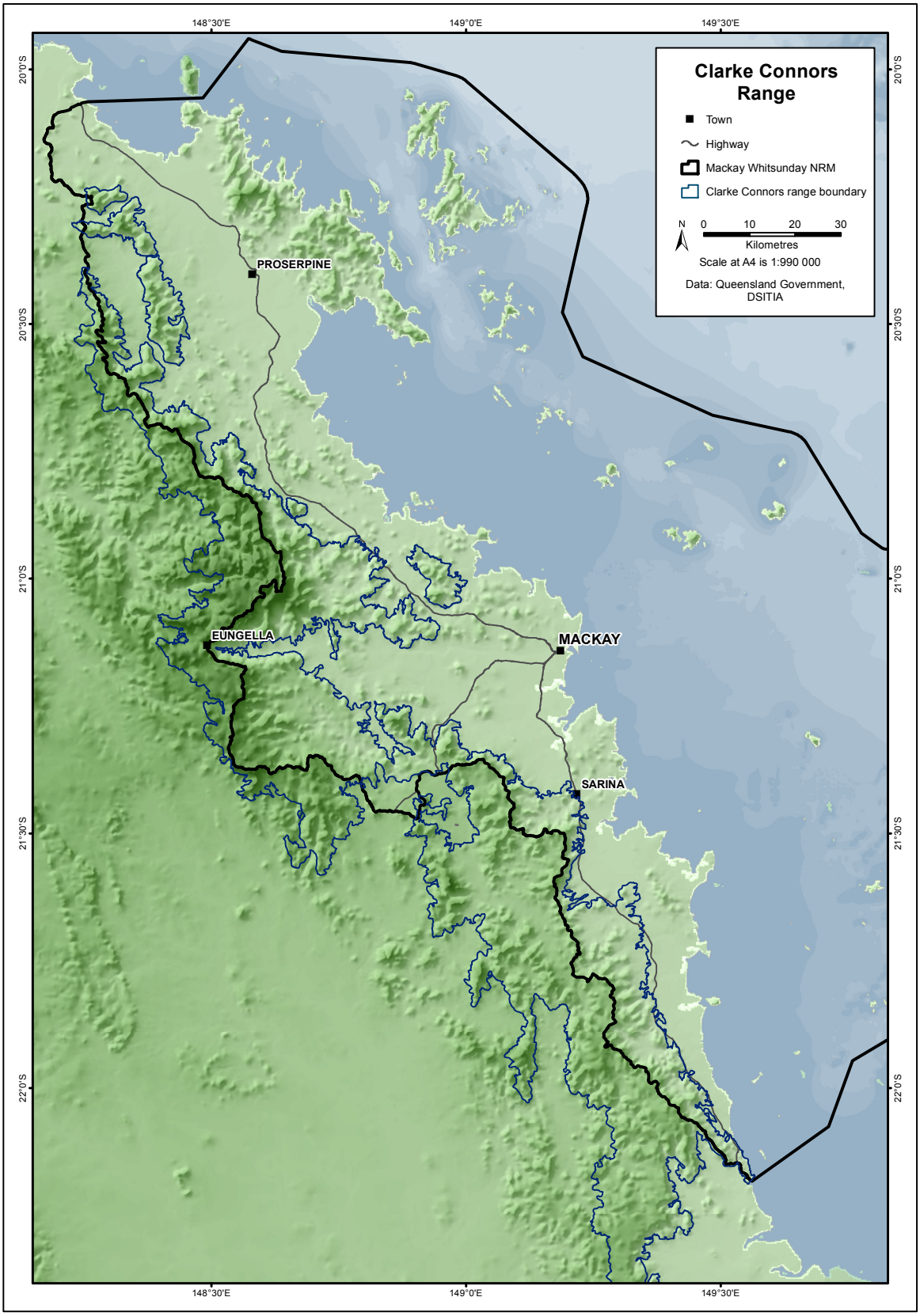

Figure 1 Geography of the Clarke Connors Range

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.

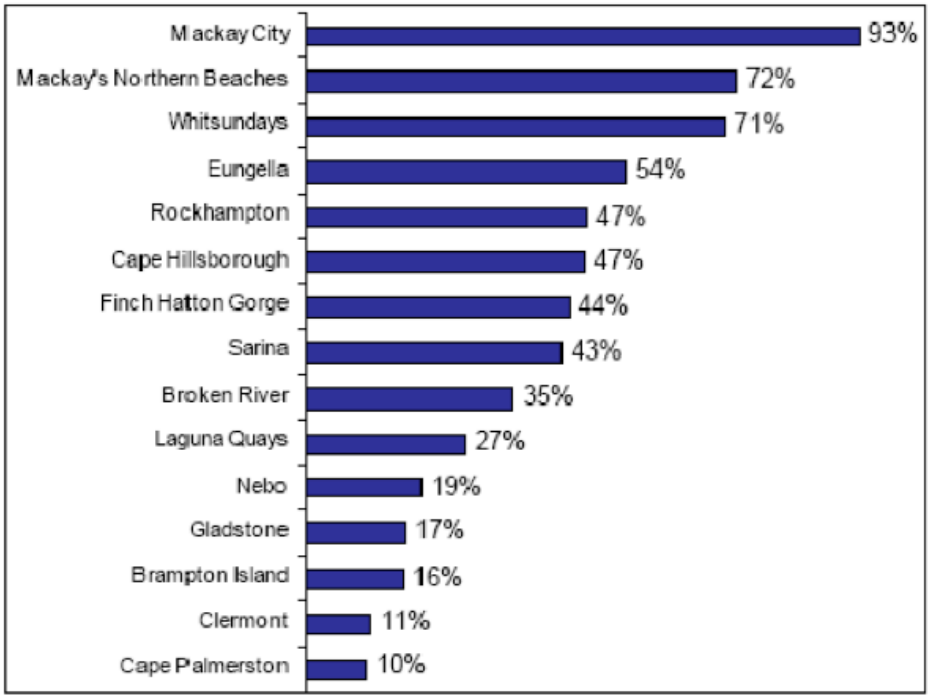

Figure 2 Major tourist destinations in the Mackay Region (reproduced from Anon, 2003).

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.

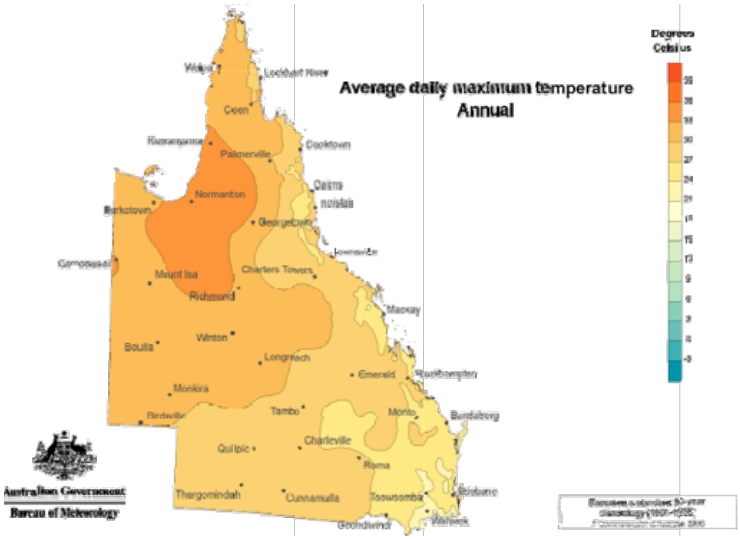

Figure 3 Average daily temperatures

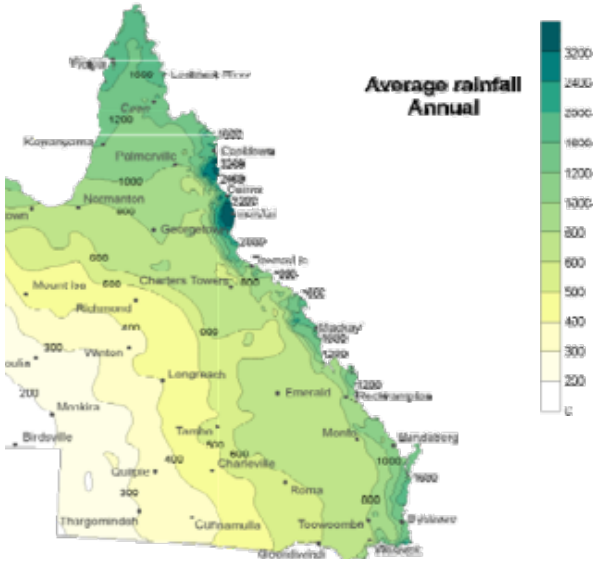

Figure 4 Average annual rainfall

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.

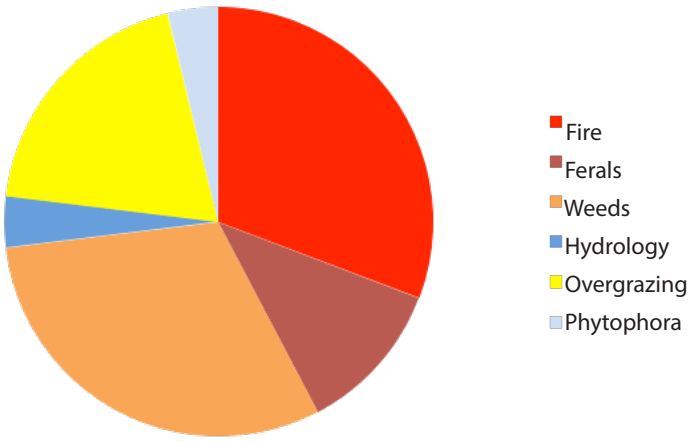

Figure 5 Relative significance of major threats to the 24 regional ecosystems supported by the ranges

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.

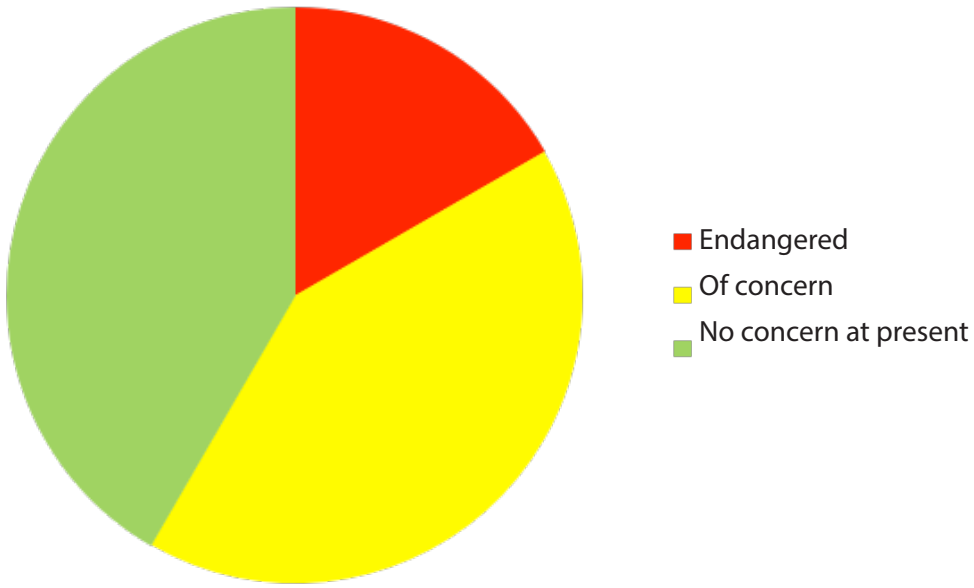

Figure 7 Conservation status of the range's regional ecosystems.

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.

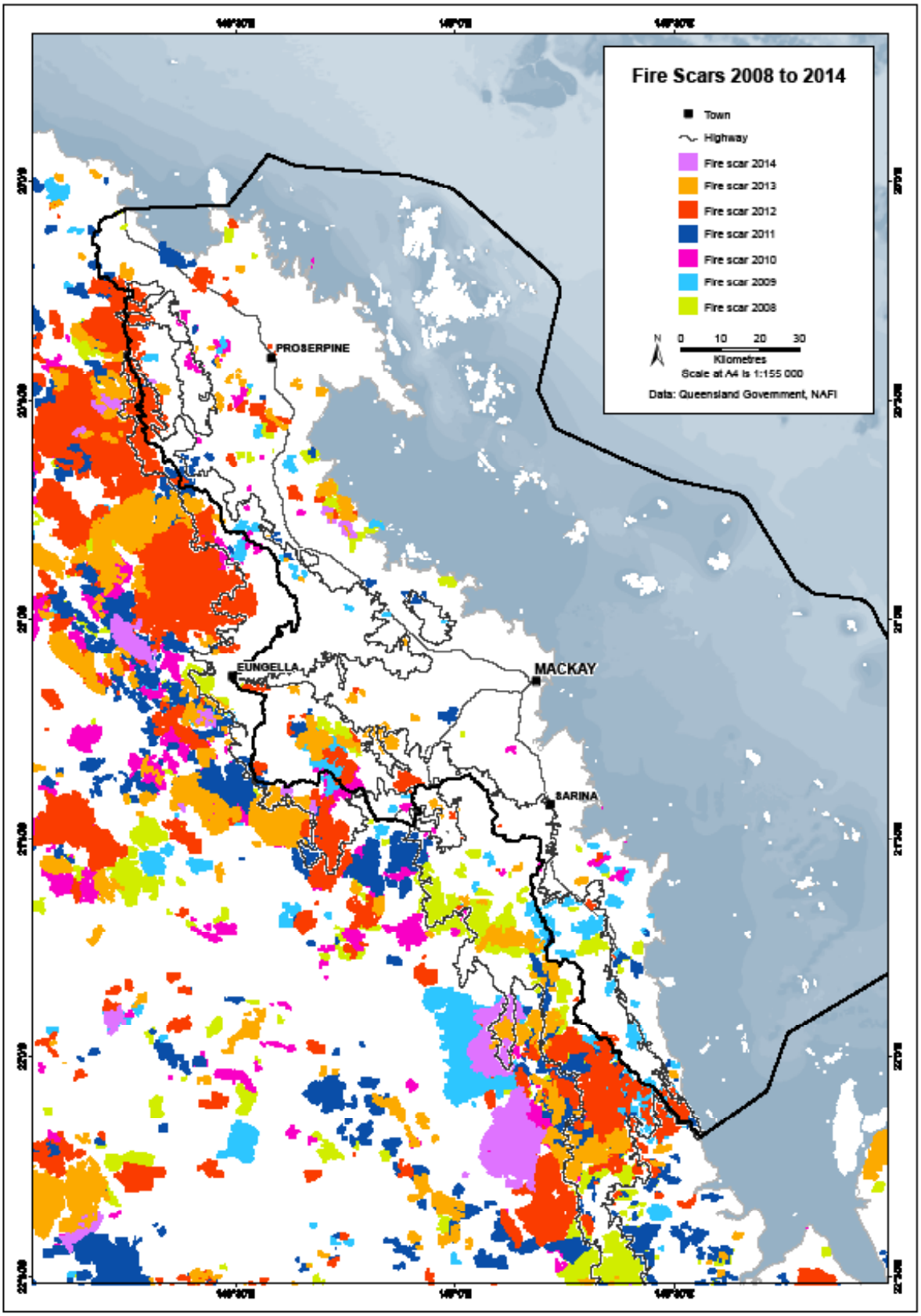

Figure 8 Fire scars in and around the region 2008-present

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)

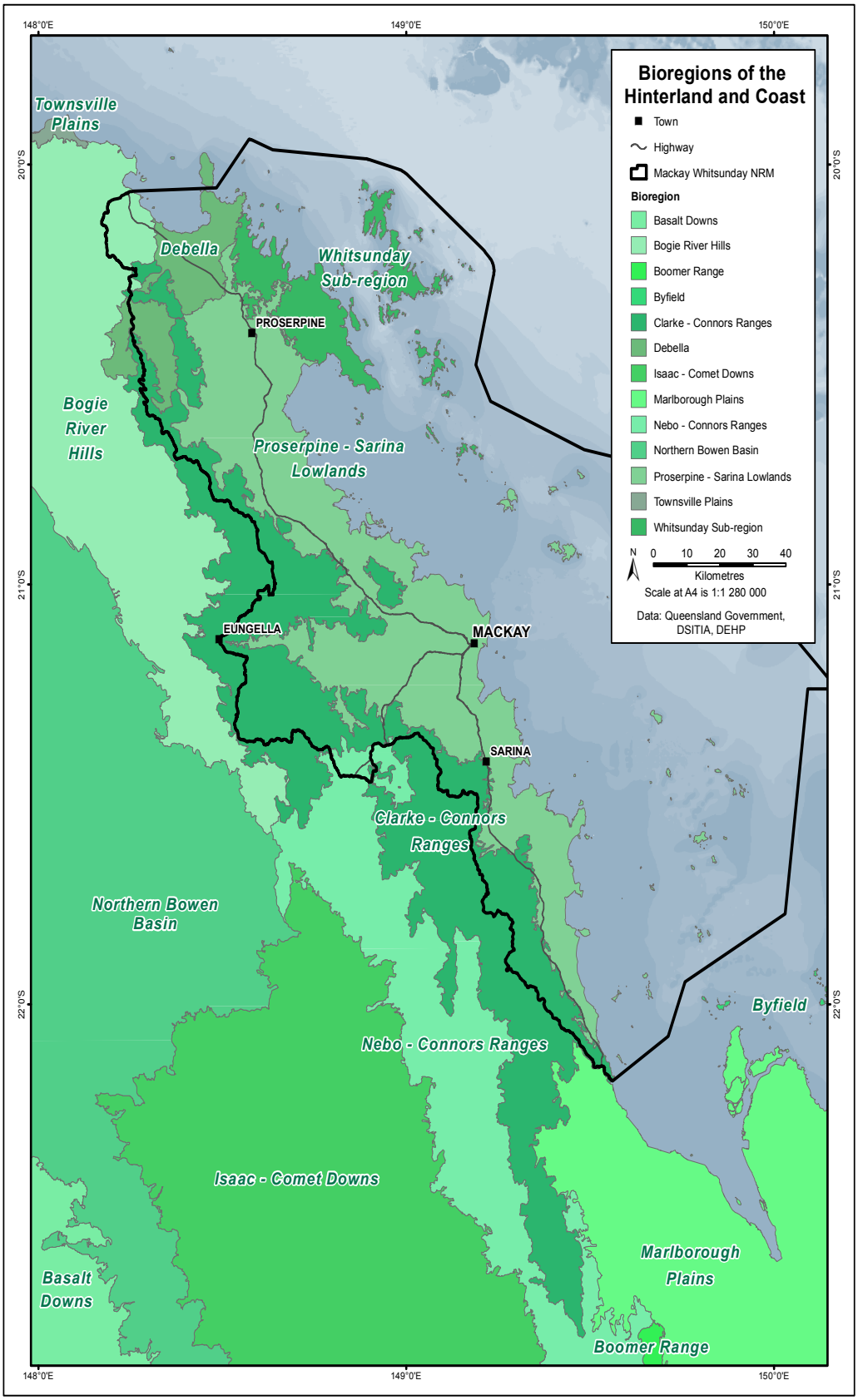


Figure 1 Central Queensland Sub-Region

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.

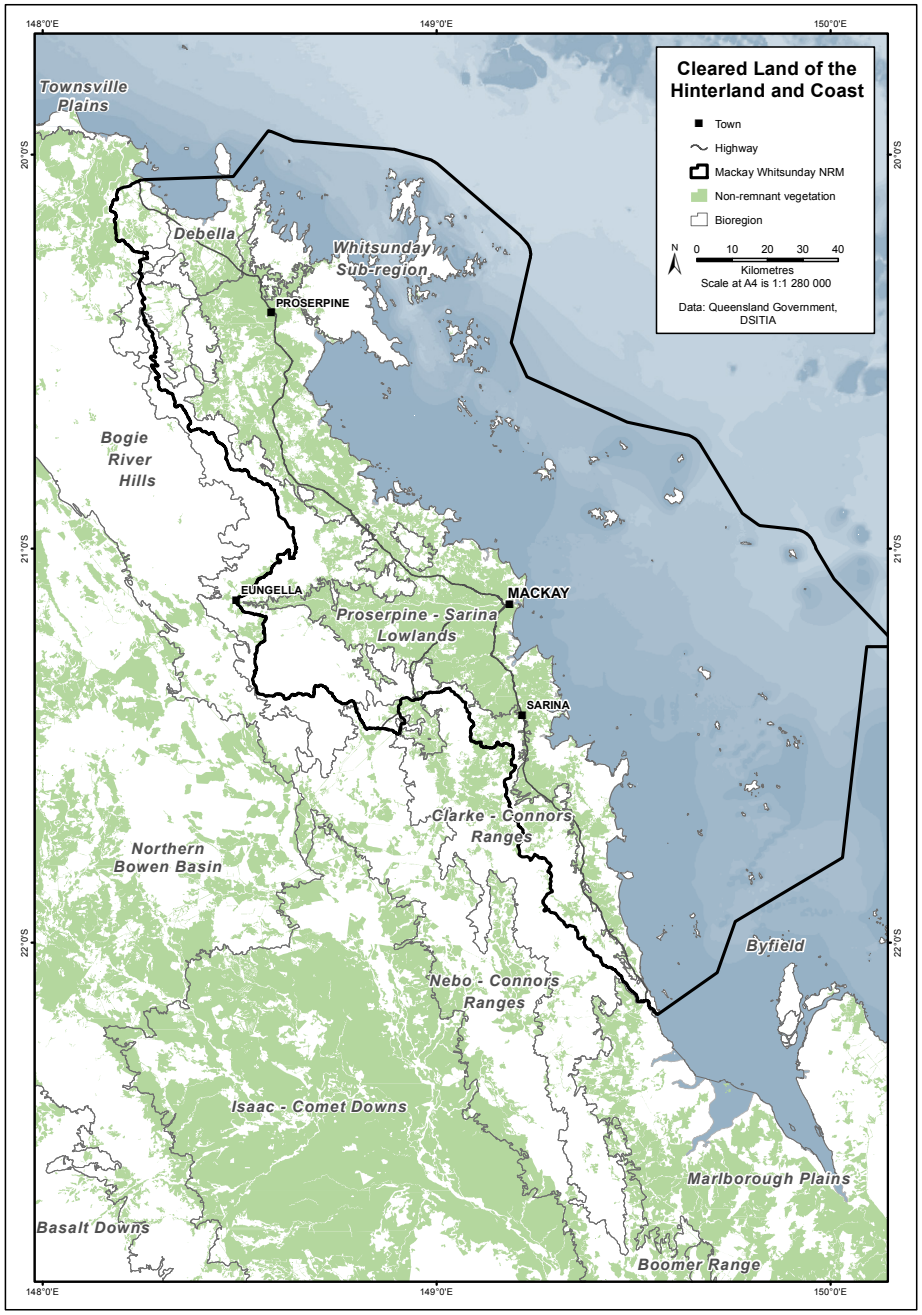


Figure 2 Non remnant vegetation in MWI region

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)

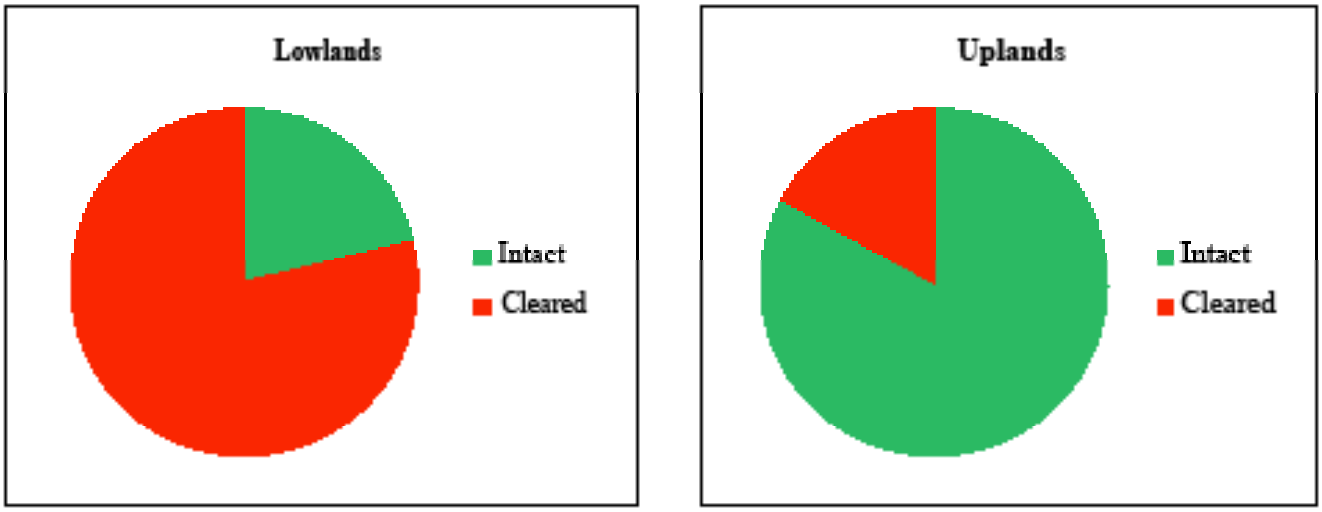
Feral pigs are prevalent across the hinterland plain, coastal hills and ranges and significantly impact biodiversity and agricultural assets. Wild dogs also inhabit most landscapes in this area and periodically have significant social, economic and environmental impacts. Although more rarely observed 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 + poler gum woodland, or poler 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, ± poler 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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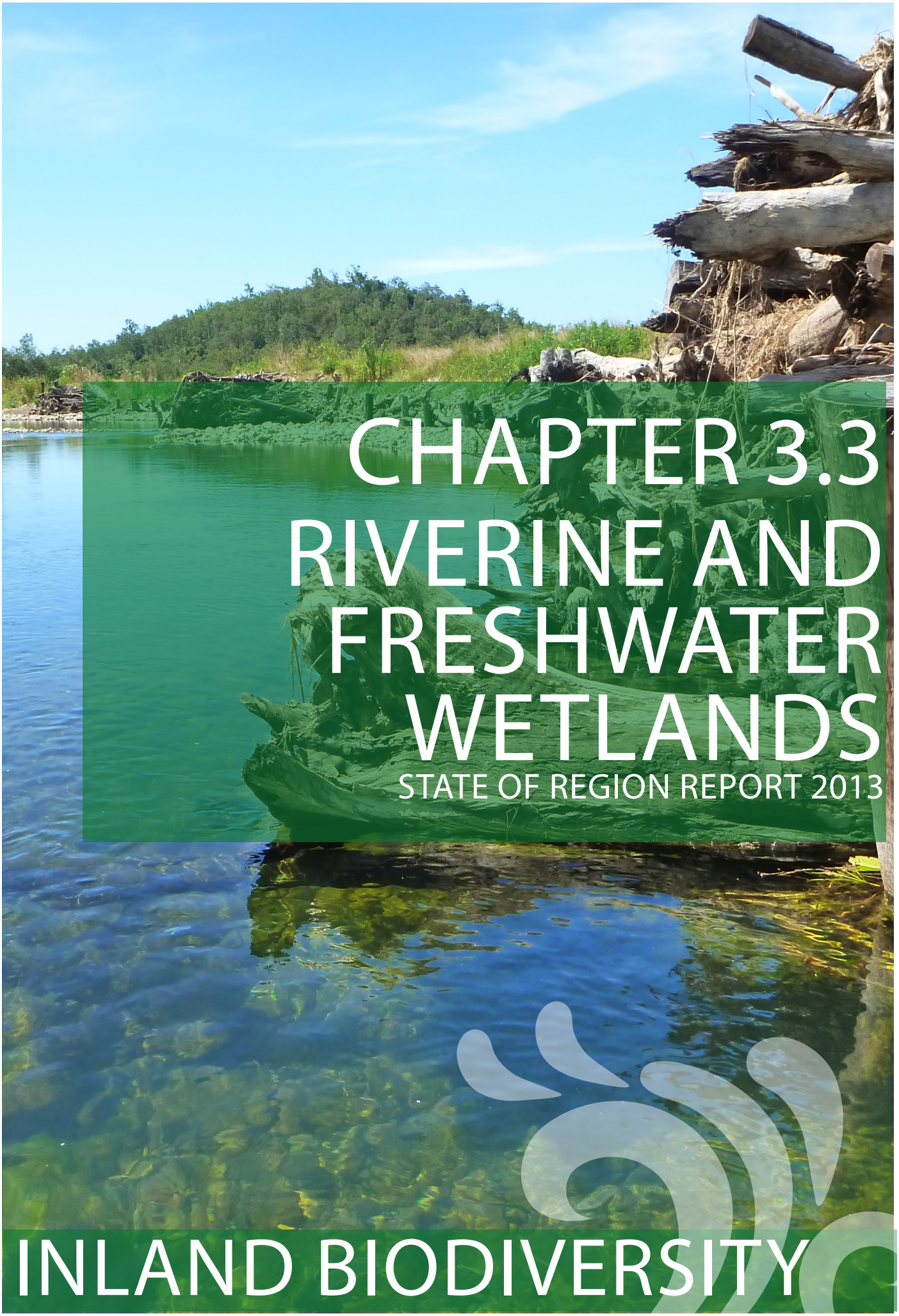

CHAPTER 3.3 RIVERINE AND FRESHWATER WETLANDS

STATE OF REGION REPORT 2013

INLAND BIODIVERSITY

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.

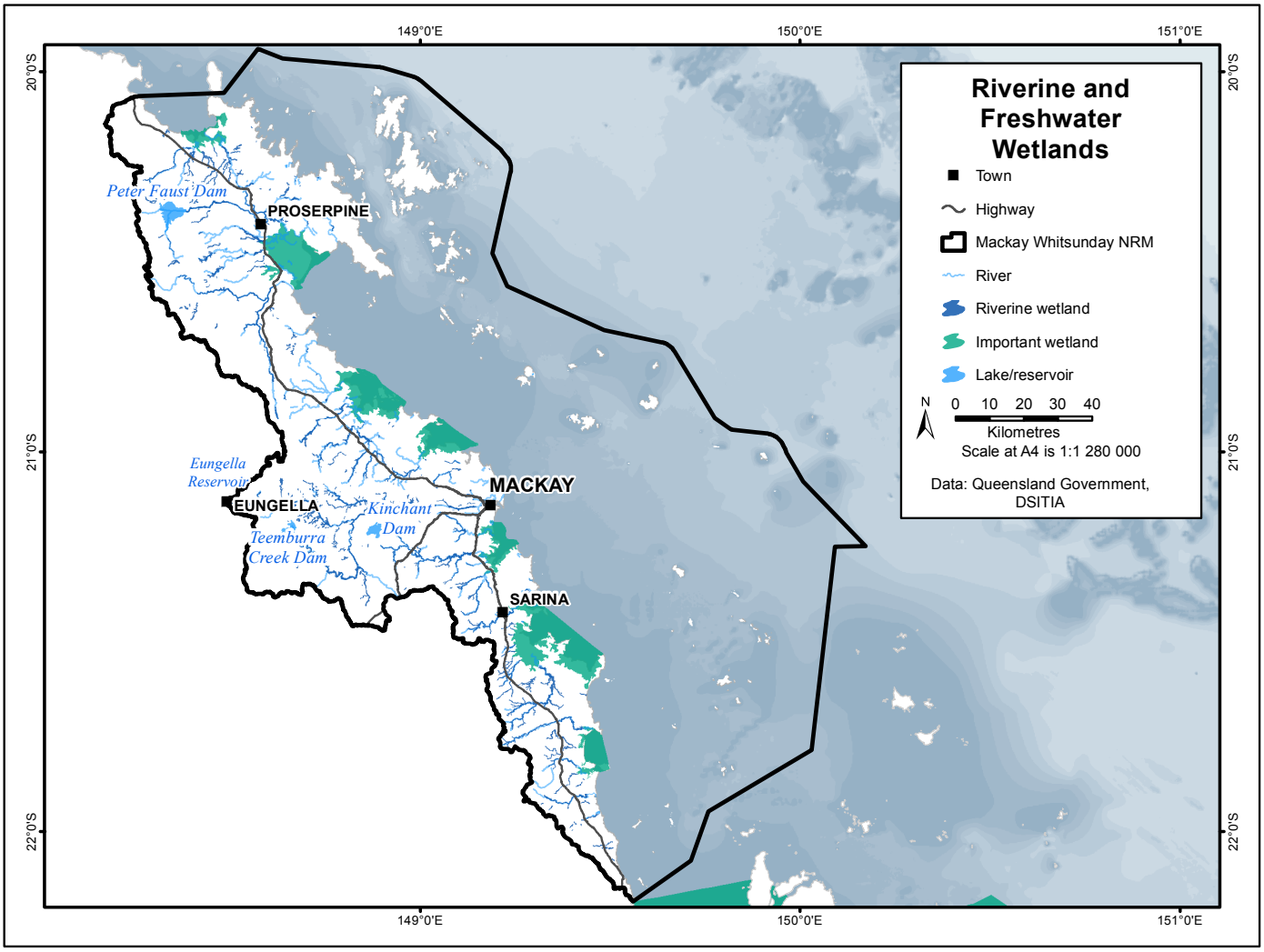

Figure 1 Riverine and freshwater wetlands of the region

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, Gooseponds, 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	L H	
Event water quality	B	D	C	C	B	Crop & grazing priority actions	L H	
Flow	B	D	C	C	B	Implementation of voluntary irrigation restrictions to maintain waterhole during low flow	L H	100
Barriers to Migration	A	C	B	B	A	Monitoring & maintenance fishways & incorporate fish passage into new barriers	L H	100
Instream Habitat	A	C	B	C	B	Restoration & stabilisation of 10 priority reaches	L H	1,000
Riparian Vegetation	B	D	C	C	B	Active restoration & connectivity of priority reaches. Grazing management on riparian land	L H	500
Estuary Modification	A	B	A	B	A	Active restoration & management to encourage recovery, natural habitat & channel stabilisation	L H	300
Mangroves & Saltmarsh	B	D	C	D	C	Management to encourage recovery	L H	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.

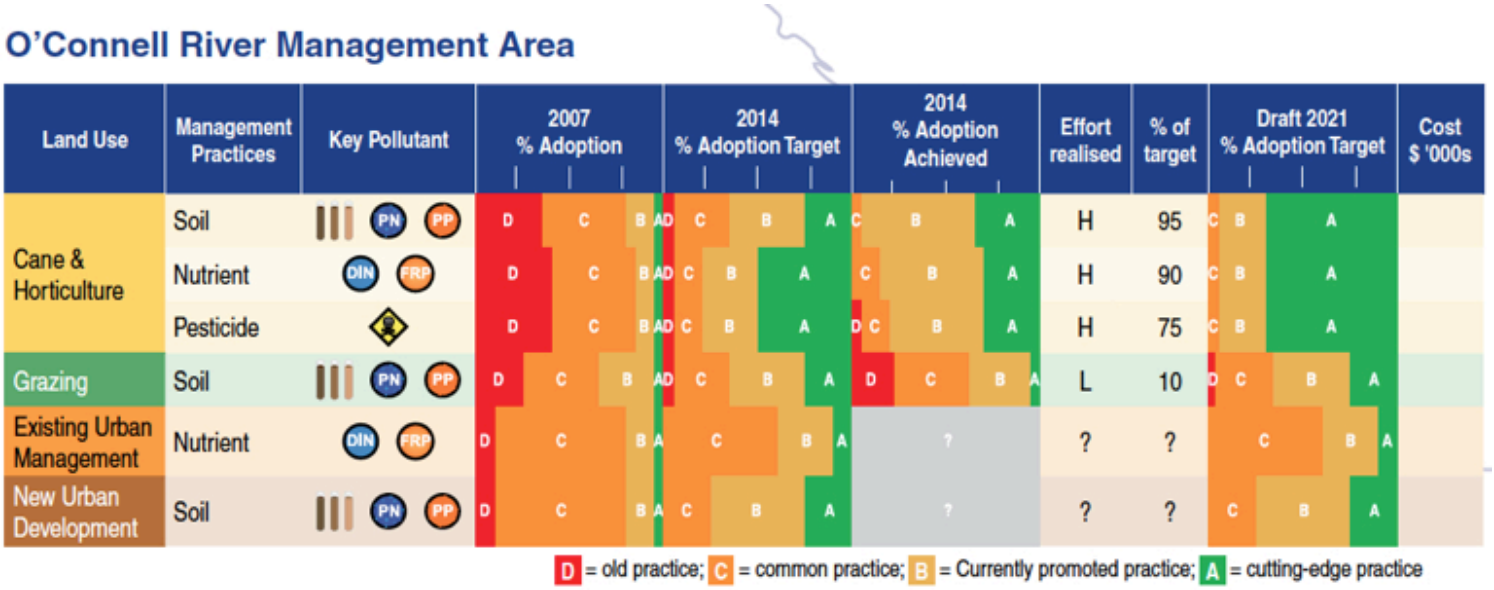

Figure 3 O'Connell River Management area adoption rates and achievements according to land use

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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