Spatial and Temporal Distribution of Wetland and Riparian Zones and Opportunities for their Management in Catchments Adjacent to the Great Barrier Reef Marine Park

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Abstract

This paper reviews the role of riparian and wetland areas in ensuring ecosystem function and briefly assesses the status of riparian and wetland areas in catchments immediately adjacent to the Great Barrier Reef Marine Park. We also report in detail on the results of a study undertaken on the floodplain of the Herbert River catchment, that assessed both spatial and temporal changes in the area of riparian and wetland zones. We demonstrate that there has been significant reduction in the riparian and wetland area since European settlement and provide a range of measures to show that landscape diversity and quality have also declined. In response, we introduce and discuss a range of policy, planning and management options that can contribute to more sustainable resource management in coastal environments.

Introduction

The Great Barrier Reef Marine Park covers an area of approximately 350 000 km^2 and spans almost 2000 km of the east coast of Queensland. Fifteen catchment divisions, covering an area of approximately 375 000 km^2, drain directly into the Great Barrier Reef Marine Park (figure 1) (The Condition of River Catchments in Queensland: a broad overview of catchment management issues 1993). Since the mid-1980s, many coastal and catchment areas adjacent to the Great Barrier Reef Marine Park have experienced strong economic growth, underpinned predominantly by solid performance by their agricultural and tourist sectors (ABS 1995). While the long-term performance of these sectors will reflect the quality of their supporting natural resource base, current environmental trends suggest a decline in terrestrial and riverine systems, and on the adjacent marine environment (The Condition of River Catchments in Queensland: a broad overview of catchment management issues 1993; Arthington et al. 1997).

Many of the catchments adjoining the Great Barrier Reef Marine Park have been extensively cleared (Russell and Hales 1993; Sattler 1993) since European settlement. *Melaleuca* (paper-bark) wetlands once covered large areas of coastal floodplains which are now used for intensive agriculture (Tait 1994). Prior to clearing, these wetlands would have provided extensive buffer strips protecting coastal river systems, estuaries and shorelines. Clearing, notably for sugarcane cultivation, has left only remnants of this ecosystem (Russell et al. 1996). Riparian and wetland zones in many of these catchments are frequently narrow and sparsely vegetated and have been invaded by exotic weeds, particularly para grass (*Brachiaria mutica*) and *Hymenachne*, which suppress the process of natural revegetation (Johnson et al. 1997). It is likely that riparian and wetland zones in such poor condition have suffered a corresponding degradation of their intrinsic ecological values (Arthington et al. 1997).

The aim of this paper is first, to briefly outline the extent of change of riparian and wetland areas in catchments adjacent to the Great Barrier Reef Marine Park, and second to examine in detail, changes in space and time of riparian and wetland areas on the Herbert River floodplain. While the focus of the paper is not on impacts of these changes on terrestrial, riverine and marine environments per se, we discuss significant issues that are central to the maintenance and function of riverine and marine resources. In so doing, we hope that readers can make the obvious connection between land, water and marine resource management. We conclude by outlining both a broad policy and planning framework, and some simple management options, that provide

significant potential in addressing fundamental resource management challenges in the region.

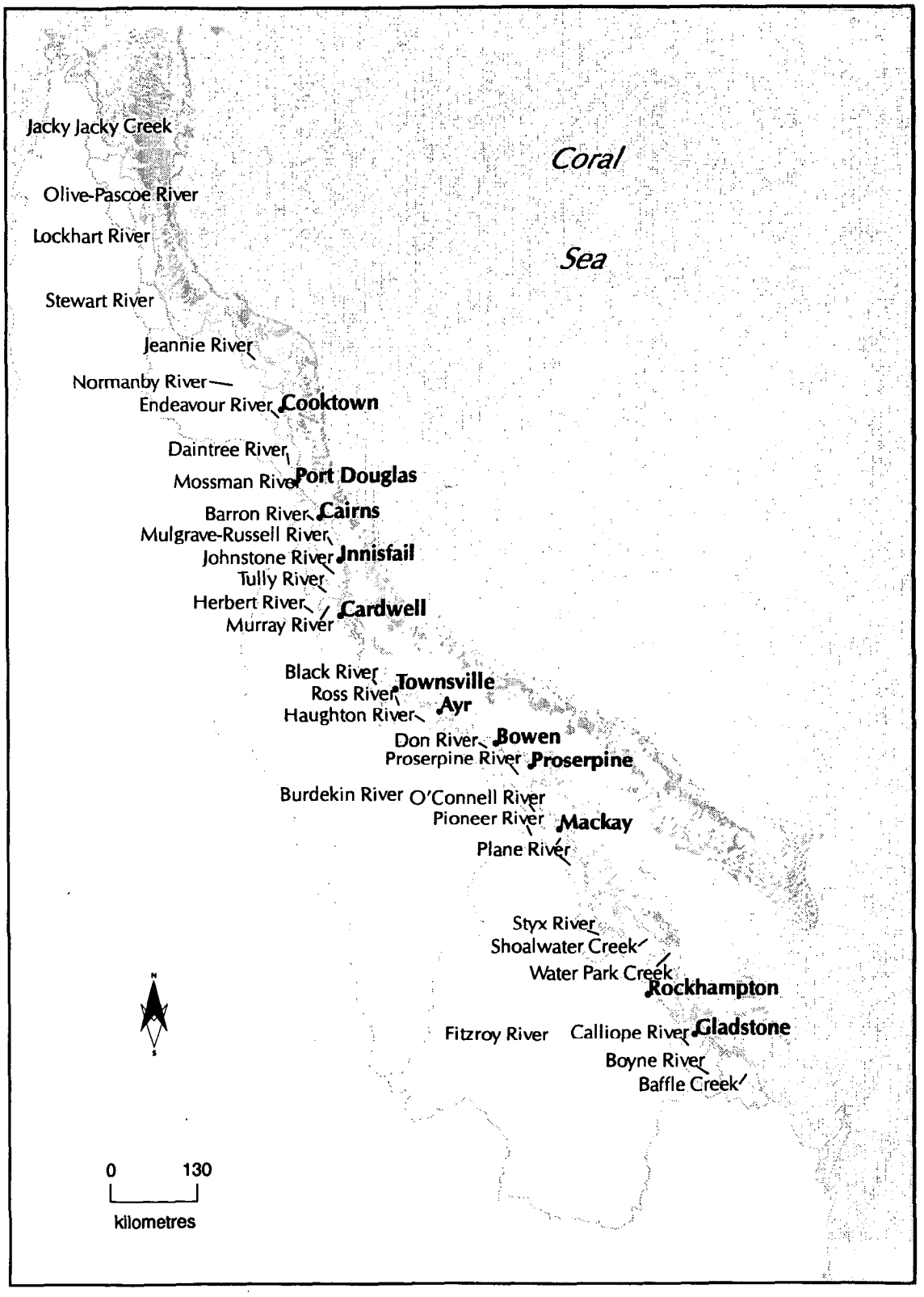

Figure 1. Catchment areas draining into the Great Barrier Reef Marine Park

What Role for Riparian and Wetland Areas?

Riparian and wetland areas play an important role in maintaining the biological health of the aquatic and terrestrial ecosystems associated with watercourses (Raisin 1995). Wetlands, swamps,

billabongs and waterholes are important wildlife habitat areas and form an integral part of a hydrological regime. Changes to the hydrological regime of swamps and wetlands (e.g. drainage), alter both the habitat and the vegetation. Wetlands are important habitat for birds, amphibians and other wildlife. They are also important as nursery areas for several species of commercially important fish such as barramundi. Maintenance of these values is dependent upon annual flushing and recharge during wet season floods. Important ecological functions of riparian and wetland areas include (Bunn 1993; Campbell 1993; Catterall 1993; Cummins 1993):

- *Assisting in maintaining bank stability.* The roots of riparian plants bind stream bank materials and help to reduce slumping. This constrains the width of stream channels and may allow banks to become under-cut without collapsing, thus creating habitat for aquatic organisms (Bunn 1993). Clearing of riparian vegetation increases the chances of stream channels migrating (Barling and Moore 1994).
- *Providing a filter strip to reduce sediment input into a watercourse.* Riparian and wetland areas form a buffer between streams and surrounding systems which can filter nutrients, pesticides and suspended sediment in run-off water. The mechanisms of this filtering function are both physical and biological including deposition, vegetative uptake and conversion by micro-biological processes such as denitrification (Lowrance et al. 1984). In a similar manner, riparian and wetland areas can act as a sink for nutrients carried in solution via overland flow during floods. Clearing and draining riparian and wetland areas prevents water from being filtered as it enters stream systems or the marine environment.
- *Creation of habitat for fish and other aquatic organisms.* Riparian vegetation provides shade and reduces both light and heat reaching the stream (Arthington et al. 1997). Riparian shading also alters the wavelength of light reaching streams, filtering out much of the ultraviolet spectrum and favouring green in the visible spectrum. Water temperature increases in unshaded streams (Pearson and Penridge 1992), and this is frequently associated with a reduction in dissolved oxygen levels in the water and the progressive death of sensitive aquatic organisms. This can be particularly significant in north Queensland during the dry season when natural biological oxygen demand can be high (Arthington et al. 1997). An increase in water temperature at this time may eliminate some taxa from a stream (Pearson and Penridge 1992). In unshaded streams with dense growth of aquatic plants, trophic status may fluctuate between production and respiration depending on cloud cover; several overcast days in succession may result in anoxia in such streams (Bunn and Davies 1996; Bunn et al. 1997). Shade also renders fish less visible to predators such as birds and thus provides them with some protection (Koehn 1992). This may be especially important in streams with little structural in-stream cover. The deposition of leaf litter into the watercourse is a major component of the food chain. Riparian vegetation contributes woody debris which has an integral and often profound influence on stream morphology and ecological processes in most natural streams (O'Connor 1986). The surface of the wood also provides habitat for invertebrates (O'Connor 1991). This is particularly significant in large silty and sandy rivers where woody debris can be the major invertebrate habitat and is consequently also very important as feeding habitat and shelter for fish (Arthington et al. 1997).
- *Provision of habitat for terrestrial birds, mammals, reptiles and amphibians and insects.* Riparian and wetland areas may also act as critical refuges for the maintenance and replenishment of wildlife populations during times of drought or after fire (Catterall 1993). Riparian and wetland habitats provide important corridors for wildlife movement and dispersal, especially in catchments cleared for human use, where areas of riparian vegetation link bushland remnants (Catterall 1993). Remnant wetland habitats in the coastal lowlands of catchments, such as bulkuru sedge swamps in the Tully-Murray catchment, are important as nursery areas for silver barramundi (*Lates calcarifer*). Waterfowl species are also dependent upon these wetlands. Further clearing of riparian and wetland areas on the coastal lowlands should be examined carefully, considering the generally low agricultural suitability of these areas and their important functional and habitat roles. Tait (1994) suggested that these areas be

conserved and incorporated into farm drainage systems. In practice, however, there are few operational examples of such approaches.

- *Benefits for agricultural systems.* Benefits to agricultural production systems can also be gained from conserving and restoring riparian vegetation. Riparian zones, particularly riparian wetlands, play a key role in regulating the natural hydrological cycle, particularly in minimising flood peaks following heavy rainfall. They help reduce soil loss from bank erosion (Moss et al. 1996) and from run-off. Riparian areas also increase the abundance of beneficial insects in adjacent crops (Lowrance et al. 1985). Recent research has also clearly demonstrated that rat damage to sugarcane crops can be significantly minimised by establishing closed canopy vegetation in harbourage areas (riparian areas, drainage lines and hillsides). Shade trees impede grass and weed growth, providing a long-term solution to rat control (Tucker 1996; Brodie 1996).

Status of Riparian and Wetland Zones in Catchments Adjacent the Great Barrier Reef Marine Park

The status of riparian and wetland areas in catchments adjacent to the Great Barrier Reef Marine Park has been reviewed by a number of authors (e.g. Arthington and Hegerl 1988; The Condition of River Catchments in Queensland: a broad overview of catchment management issues 1993; Blackman et al. 1996). Accounts of these areas have increasingly confirmed their outstanding biological richness, diversity, geographical extent, and importance as habitat for a similarly rich and diverse biota. Of the 19 Queensland wetlands identified as having national importance (Blackman et al. 1996), 8 are located in areas immediately adjacent to or within the Great Barrier Reef Marine Park. Tables 1 and 2 provide summary information on the catchment areas that drain into the Great Barrier Reef Marine Park and include an overview of the dominant tenure, land use and disturbance patterns for wetland and riparian areas.

Table 1. Estimated extent of coastal wetland and riparian areas and their relative conservation significance in catchments adjacent the Great Barrier Reef Marine Park (Adapted from The Condition of River Catchments in Queensland: a broad overview of catchment management issues 1993; Blackman et al. 1996)

Catchment	Catchment Area (km^2)	Wetland Area (km^2)	Significance
Curtis Coast	9 225	462	High
Fitzroy	142 645	1 329	High to Very High
Shoalwater Bay–Sarina	11 270	4 127	Very High to High
Pioneer–O'Connell	3 925	263	High
Proserpine	2 485	214	High to Very High
Don	3 985	110	High
Burdekin–Haughton	133 510	1 494	Very High to High
Ross–Black	2 890	719	Very High to High
Herbert	12 130	499	Very High to High
Tully–Murray	2 825	504	Very High to High
Johnstone	2 330	116	Very High to High
Mulgrave–Russell	2 020	124	Very High to High
Barron	2 175	10	High
Mossman–Daintree	2 615	61	Very High
North-east Cape	43 300	8 376	Very High to High

Wetland areas adjacent to the Great Barrier Reef Marine Park are only partially protected from development and specific protection is frequently restricted to the coastal fringe via the *Fisheries Act 1994* or Marine Parks legislation. In most cases, existing wetland areas are in a sound

Table 2. Tenure, land use and disturbance profiles for wetlands in catchments adjacent to the Great Barrier Reef Marine Park (Adapted from Blackman et al. 1996)

Catchment	Dominant Tenure		Dominant Land Use		Significant Disturbance/Threats	
	*On site**	*Surrounds**	*On site*	*Surrounds*	*Current*	*Potential*
Curtis Coast	LH, FH, WR, NP, FHR, MP	MP, NP, LH, FH, ML	Fishing, grazing, conservation, recreation	Recreation, fishing, grazing, industrial	Few – minor	Tourism, mining, urban
Fitzroy	LH, FH, Cons, NP, H&M, MP	FH, NP, LH, MP	Fishing, grazing, transport, conservation	Grazing, urban, transport, fishing	Grazing, dams, agriculture, weeds,	Weeds, tourism, mining
Shoalwater Bay–Sarina	Milit, LH, FHR, ML, NP, MP	Milit, MP, NP, ML, LH, FH	Military, fishing, grazing, conservation,	Recreation, fishing, grazing, agriculture,	Minor, weeds	Weeds, tourism, mining, fishing
Pioneer–O'Connell	LH, FH, WR, NP	MP, NP, LH, FH	Fishing, conservation, recreation	Agriculture, recreation, fishing, urban	Minor, some clearing	Clearing for agriculture
Proserpine	LH, FH, WR, NP	MP, NP, LH, FH	Grazing, conservation, recreation	Grazing, conservation, agriculture	Minor, weeds	Agriculture
Don	LH, FH	LH, FH, MP	Grazing	Grazing	Few – minor	Tourism
Burdekin–Haughton	NP, LH, FH, FHR, NP, MP	BRIA, MP, NP, LH, FH	Fishing, grazing, conservation, recreation	Grazing, agriculture, conservation	Agriculture, BRIA, weeds, dams	Agriculture, BRIA, weeds, dams
Ross–Black	LH, FH, WSR	FH, MP, NP, LH	Grazing, conservation, agriculture	Grazing, agriculture, conservation	Weeds, water extraction	Weeds, water extraction, urban
Herbert	LH, FH, WR, NP, FHR	LH, FH, NP, SF, MP	Conservation, agriculture, recreation	Fishing, agriculture, conservation, recreation	Agriculture, weeds, run-off and drainage	Agriculture, weeds, run-off and drainage
Tully–Murray	FH, NP, FHR, Cons, LH	NP, FH, NP, MP	Conservation, agriculture	Agriculture, conservation, recreation	Agriculture, weeds, run-off and drainage	Agriculture, weeds, run-off and drainage
Johnstone	FH, AP, NP, LH	NP, FH, LH, MP	Conservation, agriculture	Agriculture, conservation, recreation	Agriculture, weeds, run-off and drainage	Agriculture, weeds, run-off and drainage
Mulgrave–Russell	FH, NP, FHR, LH, H&M	NP, FH, LH, MP	Conservation, agriculture, tourism	Agriculture, conservation, recreation, tourism	Agriculture, weeds, run-off and drainage	Agriculture, weeds, run-off and drainage
Barron	FH, LH	FH, MP, NP, LH	Fishing, recreation, tourism	Fishing, tourism, urban, industrial	Agriculture, run-off, drainage, urban	Agriculture, run-off, drainage, urban
Mossman–Daintree	NP, FH, LH	MP, NP, LH, FH	Conservation, fishing, tourism, agriculture	Conservation, agriculture, tourism, recreation, urban	Agriculture, weeds, run-off, drainage	Agriculture, tourism, urban, weeds
North-east Cape	IT, ML, LH, MP, FHR, NP	IT, ML, LH, MP, FHR, NP	Traditional, grazing, conservation, mining	Traditional, grazing, fishing, conservation, mining	Weeds, ferals, mining, tourism	Weeds, ferals, mining, tourism

*LH – Leasehold, FH- Freehold, WR – Water Reserve, NP – National Park, FHR – Fish Habitat Reserve, MP – Marine Park, Cons – Conservation Tenure, H&M – Harbours and Marine, Milit – Military Use, SF – State Forest, AP – Commonwealth Action Pending, ML – Mining Lease, IT – Indigenous Peoples Tenure, BRIA – Burdekin River Irrigation Area

Spatial and Temporal Distribution of Riparian and Wetland Zones in the Herbert River Catchment

The Herbert River Catchment drains an area of approximately 10 000 km^2 to the Coral Sea and is the largest of the river systems located in Australia's sub-humid to humid tropical north east (lat. 15–19°S, long. 145–146°E) (figure 2). Large areas of the catchment remain under natural vegetation, although approximately 35 to 40% of the coastal lowland area has been cleared for crop production or improved pastures. Agricultural and pastoral activities are the largest users of land (in area) in the catchment. The catchment has two major population centres and a population of approximately 18 000 (1993 Census), of which 75% are located in the lower catchment.

Methods

Land cover of the lower Herbert River catchment was mapped from aerial photography acquired in 1943, 1961, 1970, 1977, 1988, 1992, 1993, 1994 and 1995. SPOT Panchromatic and MSS imagery were used to map land cover in 1996. Land cover boundaries were mapped onto a geo-referenced digital base. Classification drew heavily on previous vegetation (Tracey 1982; Perry 1995) and soil surveys (Wilson and Baker 1990; Heiner and Grundy 1994) in the region. Wetland areas were classified using the method of Blackman et al. (1992). Ground truthing of mapping units and mapped boundaries was conducted by vehicle and foot traverses. Classification of units and boundaries not inspected was undertaken by extrapolation from equivalent photographic units.

In addition to mapping observed land cover, an estimate of land cover prior to European settlement (early 1860s) was derived from observed relationships between remaining stands of native vegetation and the known distribution of soils, topography, relief, hydrology and rainfall. Although mapping was conducted for the entire Herbert catchment, this paper only reports on land cover on the coastal lowlands below an elevation of 13 m AHD (Australian Height Datum) i.e. the zone of seasonal inundation with direct influence on coastal wetlands and the adjacent marine environment.

A time series was developed to elucidate spatial and temporal change in land cover, with a focus on measurement of interaction within riparian and wetland areas. An analysis of floodplain landscape pattern, emphasising the dynamics of riparian and wetland areas. Tables 3 and 4 detail mathematically the analyses performed and figure 3 illustrates the derivation of 2 key spatial parameters. The usefulness of these measures and indices is as follows:

- Edge:area ratio quantifies the amount of irregularity in the shape of remnant stands of vegetation;
- The forest island dissection index, DI, compares the amount by which any one island is more dissected than another and, therefore, would have a greater edge to interior. Any index greater than 1 is a measure of such irregularity in comparison to an index of 1, which is circular in shape.
- Since 'edge effect' can influence vegetation composition and structure, total edge was calculated from individual edges measured for each island. The landscape dissection index (DL) measures the edge:area ratio and is cumulative for the entire landscape in which the island exists;
- The island distribution index (IDI) measures aggregation and is similar in logic to the nearest neighbour statistic. IDI emphasises the pattern of islands in the landscape. IDI = 1 in a randomly distributed population, < 1 in an aggregated population and approaches uniformity if the value is close to 2.1491, where islands would have maximum spacing, in which case they are regularly distributed in a hexagonal pattern;
- Diversity and Evenness indices compare changes in richness and landscape apportionment;
- Number and density of islands, and cover class as a % of total area, measure landscape pattern.