Mangroves in the Great Barrier Reef World Heritage Area: current status, long-term trends, management implications and research

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Abstract

Mangroves are a coastal marine environment, characteristically biomass-dominated by trees. They support a high biodiversity of marine and terrestrial biota, as well as providing a haven for estuarine fauna, and a nursery ground for other fauna ranging from flying foxes and seabirds, to offshore fish and crustaceans. The uses and benefits of mangroves equate to our direct use of some of these biota but it also includes other indirect benefits such as protection of coastal foreshores and estuarine margins from erosion. Mangrove environments in, and adjacent to, the Great Barrier Reef World Heritage Area are in relatively good condition, although there are clear indications that pressures on them are increasing rapidly. Localised impacts are accumulating to a point where large areas, once thought to be able to withstand change, are now threatened. And, detrimental changes appear to exceed societies' current responses to protect mangrove environments and to reduce the overall impact of the growing number of smaller impacts. Human activities affect the establishment, growth, survival and biodiversity of mangrove plants, and their impacts range from: direct removal and damage of mangrove plants; conversion of mangrove lands to other uses; construction of breakwaters and other alterations to water courses and local hydrology affecting depositional planes and sediment levels; changes to air and water quality as increased dust, turbidity, temperature and the addition of chemicals; catastrophic events of pollution bringing long-term impacts like large oil spills; and the introduction of exotic pests and pathogens from land and sea sources. Pressures on mangrove environments are real, and there is an increasing obligation on environmental management authorities to clearly describe coastal and estuarine areas according to the best scientific advice. Based on these descriptions, the next step would be to apply protection status, and in particular, designating specific areas for total protection with surrounding areas as buffers. There has never been such a profound urgency to have coastal management plans in place if we wish to preserve rare natural stands, especially adjacent to more populated areas in the region. The obligation on management authorities extends to their taking a leading role in advising Governments on the uniqueness, fragility, vulnerability and ecological tolerance of mangrove ecosystems, as well as on their benefits. And, once management authorities and all interest groups have made decisions about which areas are to be preserved, future development proposals cannot be a matter of compromise between special action groups and developers since it is the environment we wish to preserve which ultimately must determine where the limits of change are set. In appreciation of the urgency, it is also recommended that we continue to fill gaps in our knowledge and understanding of mangrove forests by further supporting long-term monitoring programs investigating, in particular: ecological processes; loss of mangrove area; and the restoration of damaged mangrove stands.

Importance and value of mangrove ecosystems

Mangrove forests form a unique ecosystem bordering coastal margins, linking land-based biota with those in the sea. These coastal plants are highly valued and regarded internationally, based on their abilities to thrive in saline conditions of daily tidal inundation, and in their support of a wide range of animals. The canopy of these halophytic, tidal swamp plants is frequented by terrestrial fauna, while other animals walk across the forest floor at low tide. During low tide,

the plants exchange gases with the air, but after the tide returns, a dramatic change takes place. The flooded forests become the domain of estuarine and marine animals. These tidal waters also provide daily nutrition for the trees but they also facilitate the dispersal and propagation of their progeny.

Just as corals form the structural basis for coral reef ecosystems, mangrove plants make up the structural base for this dominant intertidal ecosystem. The complex of roots, stems, branches and foliage support many organisms which would not exist there otherwise. Some animals are full-time residents, while others are transient users, living in mangroves seasonally while still other users of mangroves never live in mangroves but feed offshore on mangrove-reared baitfish and plankton (Cappo 1995a, b). Mangroves are a major and often primary source of carbon and nutrients exchanged offshore into the Great Barrier Reef lagoon (Robertson et al. 1992).

The comparable structural role of mangrove plants and coral colonies, is based on their respective long-lived organisms of each system. Both mangroves and corals mark their growth with seasonal growth rings, although the records for mangroves are expected to be much shorter than those of some corals, in older trees this reaches up to 100 years. A comparison of respective dendrochronologies for mangroves and corals, particularly for associated nearshore communities, might provide further characterisation of longer term trends in coastal rainfall and runoff, past environmental history, and forest demography.

Specifically, mangrove ecosystems are recognised for their abilities: in stabilising coastal foreshore areas, in providing high levels of primary production and atmospheric carbon fixation, and in their role of sheltering and feeding juvenile fishes and crustaceans during seasonal migratory cycles (Roberston and Alongi 1992). A specific account of the values of mangrove wetlands is given by Lugo and Brinson (1978), and the chief points are listed briefly in Table 1.

In this paper, I briefly review the current status of our knowledge of mangrove habitats in and adjacent to the Great Barrier Reef World Heritage Area (GBRWHA). Also included, are recommendations for their management and the direction of future research on mangroves. For convenience, mangroves are described both within the GBRWHA and those bordering its coastal low water boundary since the relationship between mangroves and coastal waters is intimate. For this reason, it is suggested that mapping coastal boundaries using the seaward fringe of the mangrove canopy is inappropriate in defining coastal terrestrial margins since this line matches mean sea level, while for coastal areas without mangroves, the boundary chiefly coincides with highest astronomical tides.

The extent of mangroves in the Great Barrier Reef World Heritage Area

Mangrove forests and saltmarsh vegetation occupies approximately 4000 km^2 of the coastline bordering north-east Queensland and within the GBRWHA. The distribution of forested stands is analogous to the distribution of reefs in this region, where isolated reefs and coral islands of the Great Barrier Reef form an archipelagous string extending north-south. Mangroves also form an impressive string of stands, although they chiefly hug the coast, filling the mouths of coastal estuaries and bordering embayment enclaves along coastal margins, as well as nearshore islands.

The extent of intertidal vegetation, notably mangrove and saltmarsh, in sections of the GBRWHA was estimated partially by a number of authors (Table 2) although their estimates differ. It seems likely that these values reflect differences in interpretation of remote sensing images, or in the relative accuracy of measurements, but it is not believed they indicate any real

worlds genetic variation in mangrove plants. Some species, like *Avicennia marina*, *Rhizophora stylosa* and *Bruguiera gymnorrhiza*, are widespread in the Indo West Pacific biogeographic region, while others, like *Ceriops australis*, *Bruguiera exaristata*, *Diospyros littoralis*, are more restricted to the Australasian region, and only *Lumnitzera* X *rosea* is more-or-less restricted to the GBRWHA. It is also of interest that *Avicennia marina* var. *eucalyptifolia* merges more with a south-eastern Australian variety, var. *australasica*, towards the southern boundary, south of the Tropic of Capricorn.

Table 2. Estimates of areas of mangrove vegetation in the Great Barrier Reef World Heritage Area

	Coastal Regions	Area of mangrove in km² (plus saltpan area)			
		Galloway (1982)	Dowling and McDonald (1982)	Danaher (1995)	Ebert (1195)
1	Cape York to Evanson Point	354	395	240 (261)	—
2	Evanson Point to Bathurst Head (Princess Charlotte Bay)	93	10	99 (420)	—
3	Bathurst Head to Cardwell	243	230	>94 (>149)	—
4	Cardwell to Lucinda (Hinchinbrook Island and Channel)	216	120	—	>214
5	Lucinda to Clairview Bluff	645	365	—	—
6	Clairview Bluff to Bustard Head	498	935	—	—
7	Islands of the GBRWHA	20	—	—	—

Factors influencing the distribution of mangroves

The number of mangrove taxa in the GBRWHA generally decreases with increasing latitude south (Fig. 1) such that in some northern locations, like the Olive River, there are around 27 species, while in the south, a floristically diverse site at Port Clinton has only 13 species. This indicates the importance of temperature through the region, but species diversity is also correlated with a range of variables, including rainfall, river catchment size, estuary length and geological history (Duke 1992). In Fig. 1, the relationship between rainfall and species numbers is shown by the numbers of species reaching their southern distributional limits in the south of the three wetter regions (marked by the 1400 mm mean annual rainfall isohytes). In general, highest species diversity is found in sites where rainfall is higher, and in riverine estuaries with larger catchment areas.

Species occurrence is also characterised by their distribution upriver which may be described in terms of either, or both, downstream and upstream limits. These limits are essentially correlated with salinity, and as such, they are comparable between river systems, such as for example, Alligator Creek (a dry climate, smaller catchment system; Fig. 2), the Mulgrave River (a wet climate, larger catchment system; Fig. 3), and the Claudie River (a wet climate, medium catchment system; Fig. 4). Thus species might be described as upstream or downstream species, with overlapping ranges within an estuary. For the Claudie River (Fig. 4), the line through the centre of the figure serves not only to notionally divide upstream and downstream species, but it also marks the upstream limit of mangroves defined by Danaher (1995), based on satellite imagery. The Danaher study therefore missed four key upstream species, including *Nypa* the mangrove palm (found in only six other river systems in the GBRWHA), and *Sonneratia lanceolata* (found in only one other river system in the GBRWHA). Other upstream species missed in this report, in other river systems, include *Dolichandrone* (found in only one river system in Australia and in the GBRWHA) and *S. caseolaris* (found in eight river systems only in the GBRWHA). Satellite remote sensing is considered to be unsuitable for mapping riparian estuarine vegetation. Thus, although the mapping study by Danaher (1995) has considerable value, it is also important to understand its limitations and to make appropriate

adjustments when applying these results in the management of estuarine mangrove ecosystems, describing fish habitats, and so on, since these maps do not account for key mangrove species which characterise particular drainage systems. It is the current view that mangrove species distributions in the GBRWHA are essentially relict (Duke 1992), and they comprise distinct and genetically isolated populations, further emphasising their fragility and vulnerability to environmental change.

Table 3. Mangrove plant taxa in the Great Barrier Reef World Heritage Area

Family	Taxa
Acanthaceae	*Acanthus ebracteatus*
	Acanthus ilicifolius
Arecaceae	*Nypa fruticans*
Avicenniaceae	(*Avicennia marina* var. *australasica*)
	Avicennia marina var. *eucalyptifolia*
Bignoniaceae	*Dolichandrone spathacea*
Bombacaceae	*Camptostemon schultzii*
Caesalpiniaceae	*Cynometra iripa*
Combretaceae	*Lumnitzera littorea*
	Lumnitzera racemosa
	Lumnitzera X *rosea*
Ebenaceae	*Diospyros littoralis*
Euphorbiaceae	*Excoecaria agallocha*
Lythraceae	*Pemphis acidula*
Meliaceae	*Xylocarpus granatum*
	Xylocarpus mekongensis
Myrsinaceae	*Aegiceras corniculatum*
Myrtaceae	*Osbornia octodonta*
Plumbaginaceae	*Aegialitis annulata*
Pteridaceae	*Acrostichum speciosum*
Sterculiaceae	*Heritiera littoralis*
Sonneratiaceae	*Sonneratia alba*
	Sonneratia caseolaris
	Sonneratia X *gulngai*
	Sonneratia lanceolata
Rhizophoraceae	*Bruguiera cylindrica*
	Bruguiera exaristata
	Bruguiera gymnorrhiza
	Bruguiera parviflora
	Bruguiera sexangula
	Ceriops australis
	Ceriops decandra
	Ceriops tagal
	Rhizophora apiculata
	Rhizophora X *lamarckii*
	Rhizophora mucronata
	Rhizophora stylosa
Rubiaceae	*Scyphiphora hydrophyllacea*

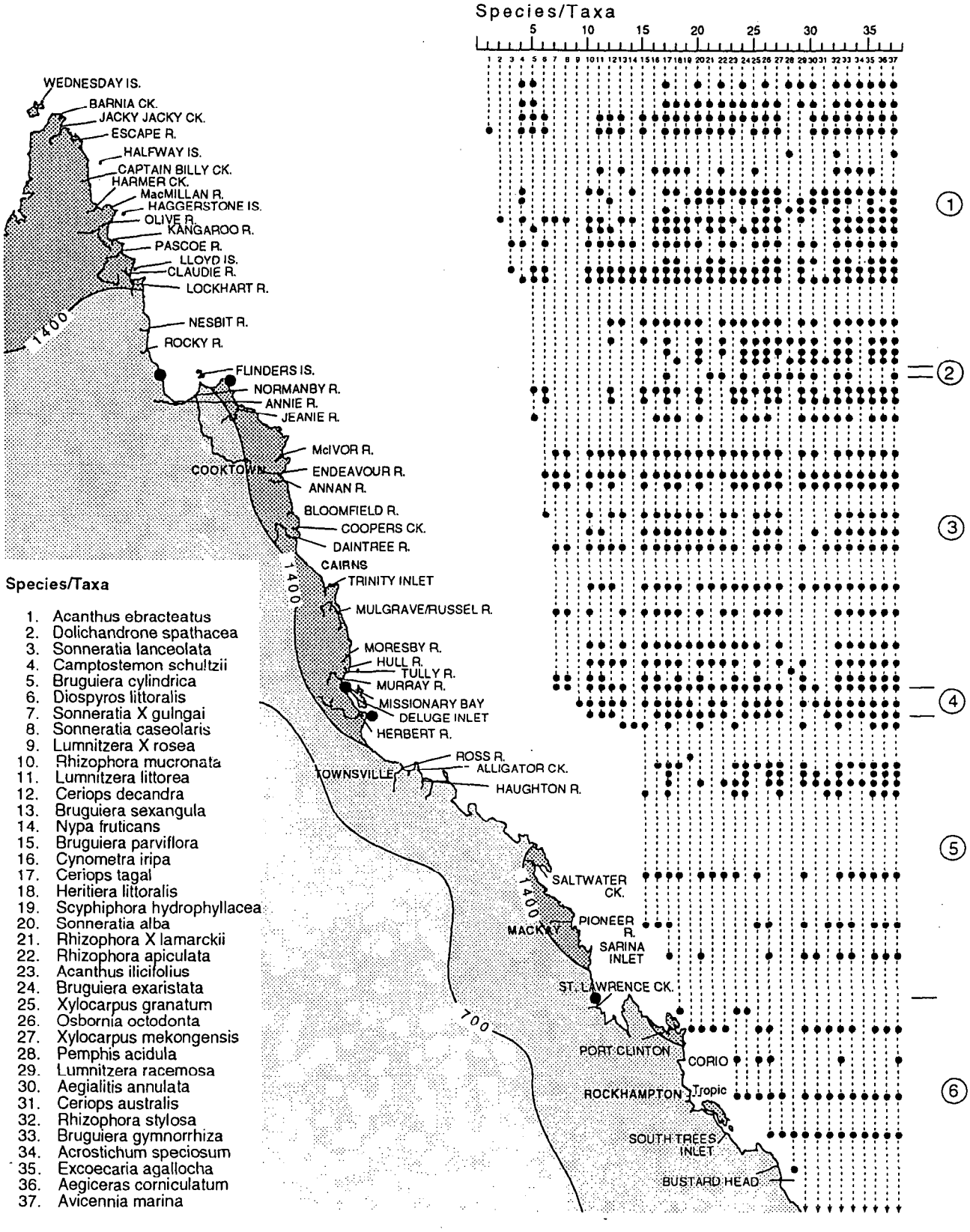

Figure 1. Distribution of mangroves in the GBRWHA. The six regions described in Table 2, are marked by filled circles on the coastline, and numbers in circles.

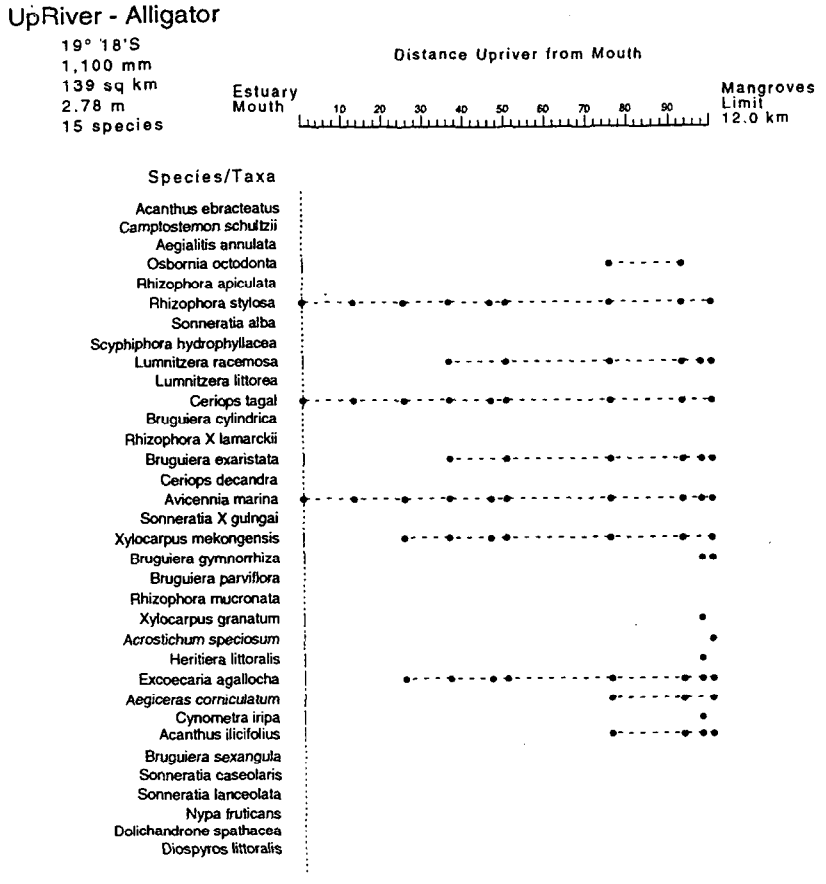

Figure 2. Upriver checklist of mangrove species in Alligator Creek

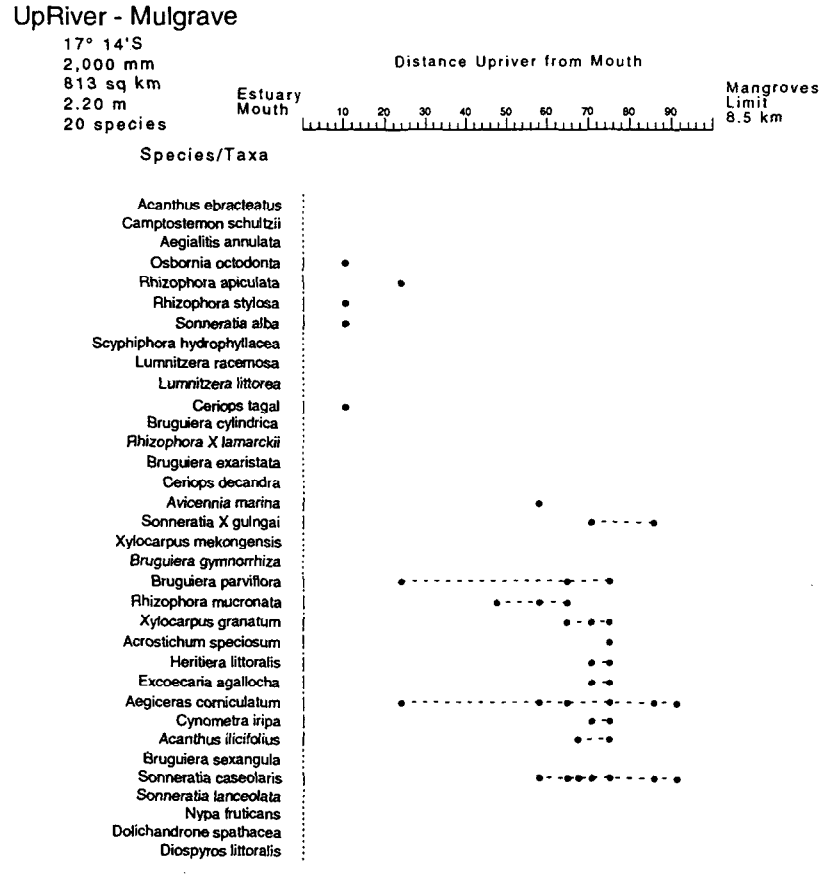

Figure 3. Upriver checklist of mangrove species in the Mulgrave River