Managing catchments to minimise downstream effects

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Abstract

Change agents from catchments that may have downstream effects on the Great Barrier Reef lagoonal, reefal and associated estuarine environment include:

- increased export of sediments and increased turbidity in marine waters;
- changes to freshwater input hydrographs;
- increased export of nutrients and heavy metals;
- export of poisons such as pesticides and weedicides; and
- direct destruction of habitat such as foreshore mangrove communities and fresh to brackish floodplain wetlands.

While data is being collated on the magnitude of these potential change agents, there is a lack of data on the impacts of these agents on the suite of communities that comprise the Great Barrier Reef World Heritage Area.

In this environment of poorly defined impacts, resource managers are working under the precautionary principle that the closer change agents mirror the pre-European 'natural' conditions, the less will be the impact on the Great Barrier Reef and its environments.

Resource management activity within contributing catchments is proceeding on a series of fronts. These include the formulation and implementation of community based Catchment Management and River Management Strategies, the direction of land allocation within an integrated resource management framework, Landcare and property management planning initiatives which address the combined goals of sustainability and productivity, vegetation management and revegetation programs, formulation of policy and its implementation for floodplain management and improved techniques for on farm and urban land management. Implementation is undertaken cooperatively through partnerships between Government and community wherever possible. Regulatory mechanisms reinforce these resource management activities and include licensing, prosecution and special area management such as fish habitat areas.

This paper reviews information available on change agents, details resource management activity and calls for a more integrated and focused research development, extension and implementation program which will both document the impact of change agents on those Great Barrier Reef World Heritage Area key environments likely to be affected, particularly the Great Barrier Reef lagoon, and secondly, minimise the nature, extent and size of these change agents beyond what is considered to be baseline.

Scan of the catchments and resource condition

Contributing catchments

From the basin of the Burnett River, along Queensland's east coast to the Torres Strait, there are over 410 000km^2 of land draining into the Great Barrier Reef lagoon. As shown in Fig. 1,

this is a substantial proportion of the State's drainage basins. Within these catchments are some of Queensland's most extensive river systems. In terms of mean annual discharge, the Burdekin River (10 100 000 ML) and the Fitzroy River (7 130 000 ML) are the largest. Other significant discharging catchments include the Herbert, Johnstone and the Tully-Murray Rivers, with mean annual discharges between 3 and 4 million ML for each of these catchments.

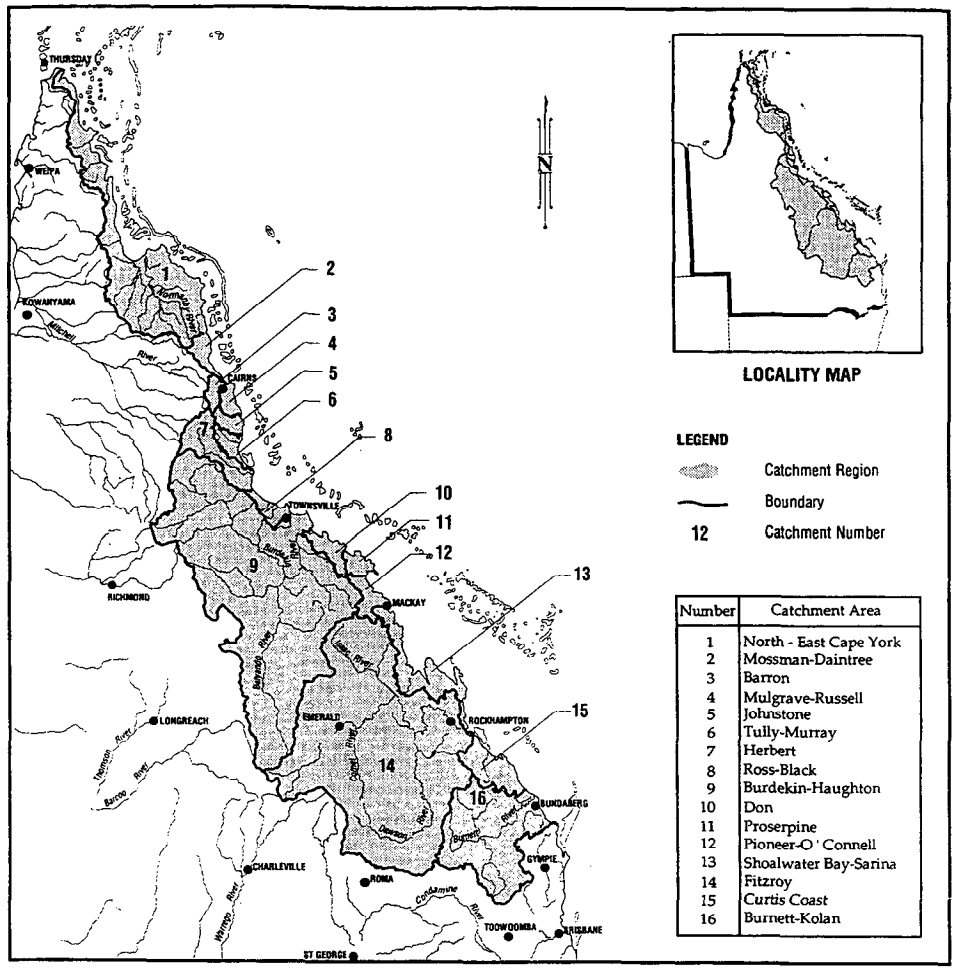

Figure 1. Catchments contributing to the Great Barrier Reef lagoon

Prior to colonisation, these rivers would have flowed through 'pristine' vegetated catchments comprising woodlands and grasslands in lower rainfall areas of some upper catchments, dry sclerophyll and wet sclerophyll forests, rainforests for much of the range section and rainforest/wetland systems for the coastal floodplains. Riparian and wetland communities would have been intact, and the water that drained from these basins would have contributed to the Great Barrier Reef lagoon's natural biological, chemical and geological processes. Pulses of floodwater carrying abnormally large loads of sediments and nutrients certainly occurred, as evidenced by the extensive floodplain development on all major catchments. However as various catchment based studies on the impact of land uses have shown, the levels of sediment discharged to the marine environment would likely be at most in the range of $^{1}/_{8}$ to $^{1}/_{6}$ of sediment yield from current day catchments which are dominated by agricultural and urban land uses. Additionally, the discharge pattern would be close to a modulated sinusoidal pattern as compared to the high peaks and rapid recessions of flow that typify disturbed catchments.

Vegetation change

Vegetation change that has accompanied land use development and changes to water quality and quantity has been substantial. As one example, consider floodplain wetlands. Figure 2

details changes in areal extent to floodplain wetlands in the last 50 years for the Johnstone catchment. In summary, much of the fresh to brackish and fresh wetland of the floodplain has been drained to support agriculture, principally sugar cane.

Common practices for reclamation have included the construction of drains with some existing water courses channelised and their riparian vegetation removed or severely depleted. Flood gates or tidal gates are commonly installed to prevent inundation by floodwaters or tidal backup. These severely limit fish access and therefore available habitat. The trend is towards simplified, reduced area, weed infested wetlands and a reduction in diversity amongst estuarine communities, particularly a decline in seagrass beds and the brackish fringing vegetation to mangrove communities.

Impacts are various, including loss of habitat, reduction in fish carrying capacity and thus fish populations, more rapid water discharge following rain events, reduced dampening of flood events and reduced filtering out of sediments and nutrients from run-off. It is also interesting to note that mangrove areas have increased. This reflects increased sedimentation with muds replacing sand spits and mangroves aggressively colonising these areas. Declines in aquatic and estuarine habitat such as seagrass beds have also occurred. While there is world wide scientific evidence to confirm that land use impacts would have caused a decline in seagrass extent and productivity, no quantitative data is available on changes to seagrass extent since European settlement. Investigations are warranted and may need to focus on changes to the nature of sediments and to light penetration levels as an indication of changes to biota such as seagrasses.

Riparian lands

The rapid assessment protocol for determining riparian condition (Russell et al. 1994) demonstrates the link between adjacent land use and riparian condition. Most sites assessed on the tablelands (80%), and coastal lowlands (72%) adjacent to agricultural uses were in poor or very poor condition. Sites on the coastal range, most of which fall within the World Heritage area, were in either good or excellent condition. Similarly, a high proportion of sites (60%) in the estuarine zone were classified as either in good or excellent condition.

The structure of the riparian zone, both in terms of width and composition, is also an important indicator of condition. On the tablelands and coastal areas there are few sites where the riparian zone consisted of tree corridors greater than 30 metres wide.

Consequences of degradation of the riparian zone include a decrease in shading and subsequent increase in weed growth (Gregory et al. 1991) and increased erosion and sedimentation (Delong and Brusvan 1991). The proliferation of para grass (*Bracharia mutica*), an introduced pasture species which can invade shallow water courses (Middleton 1991), has caused problems by restricting water flow and promoting sedimentation. Para grass can also affect the distribution and abundance of some fish species (Arthington et al. 1993). Overall, without concerted community action, the trend is towards depauperate riparian lands, weed infested and fragmented in extent.

Water quality

Depressed pH values, as low as 2.8, are a feature of lower floodplain locations and indicate problems associated with the disturbance and drainage of acid sulphate soils. Fish kills and red spot disease problems are well documented. Turbidity and siltation are endemic problems in all but the high velocity gorge sections of the rivers.

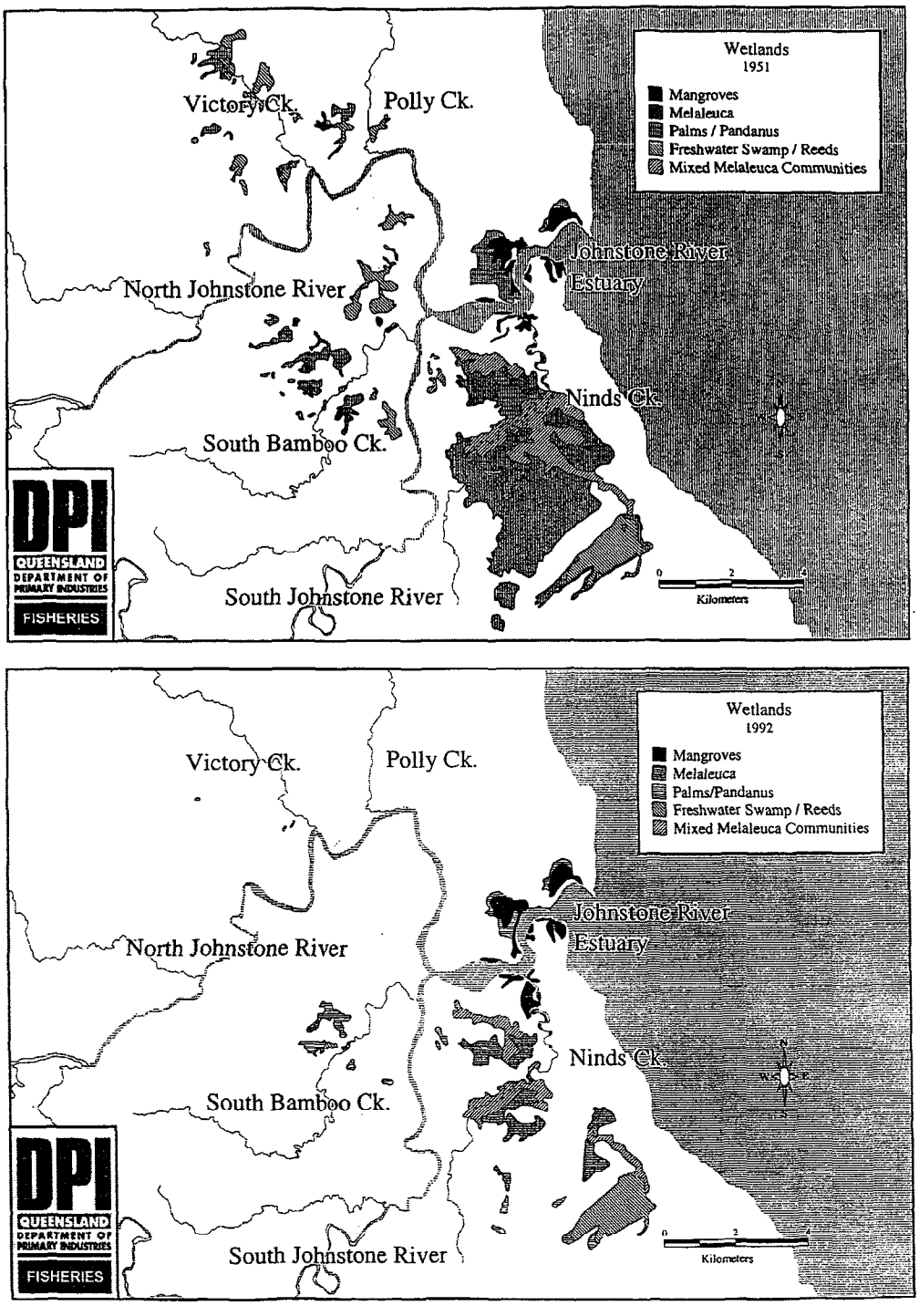

Figure 2. Change in wetlands - Lower Johnstone River catchment (from Russell and Hales 1993). a) Wetlands of the Johnstone Floodplain, 1951. b) Wetlands of the Johnstone Floodplain, 1992

Wetland	1951 (ha)	1992 (ha)	Net Change (ha)	
Mangroves	176	202	26	(15%)
Melaleuca forests	1277	282	-995	(-78%)
Mixed *Melaleuca* communities	462	258	-204	(-44%)
Palm/Pandanus	439	160	-279	(-64%)
Freshwater Reed Swamps	499	225	-274	(-55%)
TOTAL Wetland	2853	1127	-1726	(-60%)

colonisation (Bell 1992) and thus incremental and possibly irreversible changes to community structure. The microhabitats which exist in coral cavities can also be plugged by sediments, directly impacting on other components of the community.

After a cyclone and a period of flooding in 1992, die off occurred in 1000 km^2 of seagrass beds. In shallow areas, a lack of full recovery was linked to sediments burying propagules (Preen 1995). The primary cause of seagrass die-off is thought to be light reduction - a consequence of increased sediments (Robertson and Long 1991). An ongoing monitoring program of lagoonal habitats, focussing on seagrasses and historical changes to bottom sediments would assist in quantifying the biotic impacts of increased sediments to the Great Barrier Reef.

Nutrients

Agricultural, residential and industrial land uses across catchments all contribute nutrients to river systems. Residential and industrial related nutrients are generally exported as point sources. Sewage contains the highest concentration of nutrients with stormwater run-off containing about 10% the nutrients of sewage, being diffuse sources of nutrients from within urban and industrial areas. More difficult to manage are the nutrients lost from agricultural and grazing lands.

The three nutrients of major concern are carbon, nitrogen and phosphorus. Carbon is mostly connected with point discharges from sewage plants, sugar mills and abattoirs (Hunter and Rayment 1990). Carbon is readily quantified and data available suggest that carbon does not pose a threat in comparison to nitrogen and phosphorus.

The addition of nitrogen and phosphorus as fertilisers has increased with the expansion of agricultural lands. The loss of these nutrients from the land is closely related to the movement of sediments, as 40% of nitrogen and 80% of phosphorus are bound to soil particles. Therefore, the rate of increase in nutrient export from fertilisers is likely to be in the same order of magnitude as the increase in sediment load shown in Fig. 5.

Sediments act as sinks for nutrients until large flood events lead to their transportation (Mitchell et al. 1991). During periods of high flow, a higher percentage of nitrogen (N) and phosphorus (P) are particle bound (Hunter and Rayment 1991). Storm flow derived nutrients probably contribute to a large proportion of the total nutrients that are transported annually (Pailles and Moody 1995). The rate and location at which nutrients dissociate from soil particles is often influenced by salinity in estuarine areas. Up to 80% of phosphorus is lost from fluvial sediment before reaching the marine environment (Pailles and Moody 1995).

Nutrients may impact on the reef in a variety of ways. Phosphorus affects calcification in corals (Furnas and Brodie 1995) and the number of cavities in the coral matrix. Nitrate is toxic to prawn larvae (Hunter and Rayment 1991). Organic sediments can also lead to the production of hydrogen sulfide which promotes the growth of filter and detrital feeders, potential competitors with coral (Bell 1992).

Of primary concern, however, is the growth of algae which is encouraged by increased nutrients. The blue-green algae, *Trichodesmium*, can block light from corals and hence affect calcification processes (Bell 1992). Seagrasses can suffer from smothering, if nutrients lead to extensive growth of epiphytic algae (Robertson and Long 1991).