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Linking water quality impacts and benefits of ecosystem services in the Great Barrier Reef

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ABSTRACT

Water quality degradation in the Great Barrier Reef, associated with increased loads of nutrients, sediments and pesticides from agriculture, has become a major concern. Improved management practices and water quality targets were set in the Reef Plan 2013, but with limited success. The causality between water quality degradation, ecosystem health and benefits to society remains poorly understood, questioning the relevance of current water quality targets. We argue that ecosystem service valuation may help identify the benefits generated by ecosystems and help prioritise further investments in water quality improvement.

We estimate the loss of benefits to society resulting from water quality reduction, concentrating on the influence of pollutants on mangroves, seagrass and coral reefs. Our results suggest that failing to meet Government's water quality targets by 1% would result in losses between AU$22 k/year and AU$6.9 M/year depending on the industry. We then discuss the implications stemming from these results for local policy-making.

1. Introduction

The Great Barrier Reef (GBR), Australia, is the largest and one of the most iconic coral reef ecosystems on earth. Stretching 2300 km along Queensland's coast, the GBR is a complex, unique entity hosting a remarkable diversity of living organisms and benefiting local communities in many ways (Fig. 1). The GBR is being managed as a protected area since 1975 and was declared a World Heritage Area in 1981 for its outstanding universal value (UNESCO, 2016). Despite this protection status, coral cover in the GBR has declined by over 50% in the past 30 years (De'ath et al., 2012) and is now in critical condition in some sections (Waterhouse et al., 2017b).

Among the various stressors that affect the GBR, end-of-catchment pollution from agriculture is a major concern (Brodie and Waterhouse, 2012; Butler et al., 2013; Waterhouse et al., 2017b). Dissolved inorganic nutrients originating from fertilisers (Waterhouse et al., 2012), pesticides (Lewis et al., 2009) and fine sediments (Bainbridge et al., 2009; Star et al., 2013) combine to degrade water quality in the GBR lagoon, putting pressure on freshwater, wetland, coastal and marine ecosystems (Waterhouse et al., 2017b).

In 2003, the Australian and Queensland Governments launched the Reef Water Quality Protection Plan (hereafter Reef Plan) with the aim of "*halting and reversing the decline in water quality entering the Reef within 10 years*" (The State of Queensland and Commonwealth of Australia, 2003). An updated Reef Plan was set in 2009 that defined the first water quality targets for the GBR (Table 1). These targets were updated in Reef Plan 2013. Land and catchment targets were also introduced since Reef Plan 2009 to ensure that farmers would follow best management practices. In keeping with the primary focus of government policy, we focus on water quality targets for the rest of this paper.

In 2015, the Australian and Queensland Governments launched the "Reef 2050 Long-Term Sustainability Plan" (Reef 2050 LTSP), fitting existing water quality targets into a longer term perspective (Table 1). Reef 2050 LTSP is an overarching structure that coordinates all actions intended to preserve the long-term health of the GBR (Commonwealth of Australia, 2015). The Reef Plan and related regional or local initiatives such as the water quality improvement plans (WQIPs) developed in each GBR region are all parts of this strategic plan. These different initiatives are supported by a large body of science (Brodie et al., 2013; GBRMPA, 2014; Waterhouse et al., 2017b).

Despite these different initiatives, progress towards the Reef Plan water quality targets remains below expectation. The GBR Report Card 2015 (Australian and Queensland Governments, 2016) reported the following results:

- 18.1% reduction in anthropogenic dissolved inorganic nitrogen (DIN), against a target of 50% by 2018 (i.e. score 'E', very poor)
- 12.3% reduction in anthropogenic suspended sediment, against a

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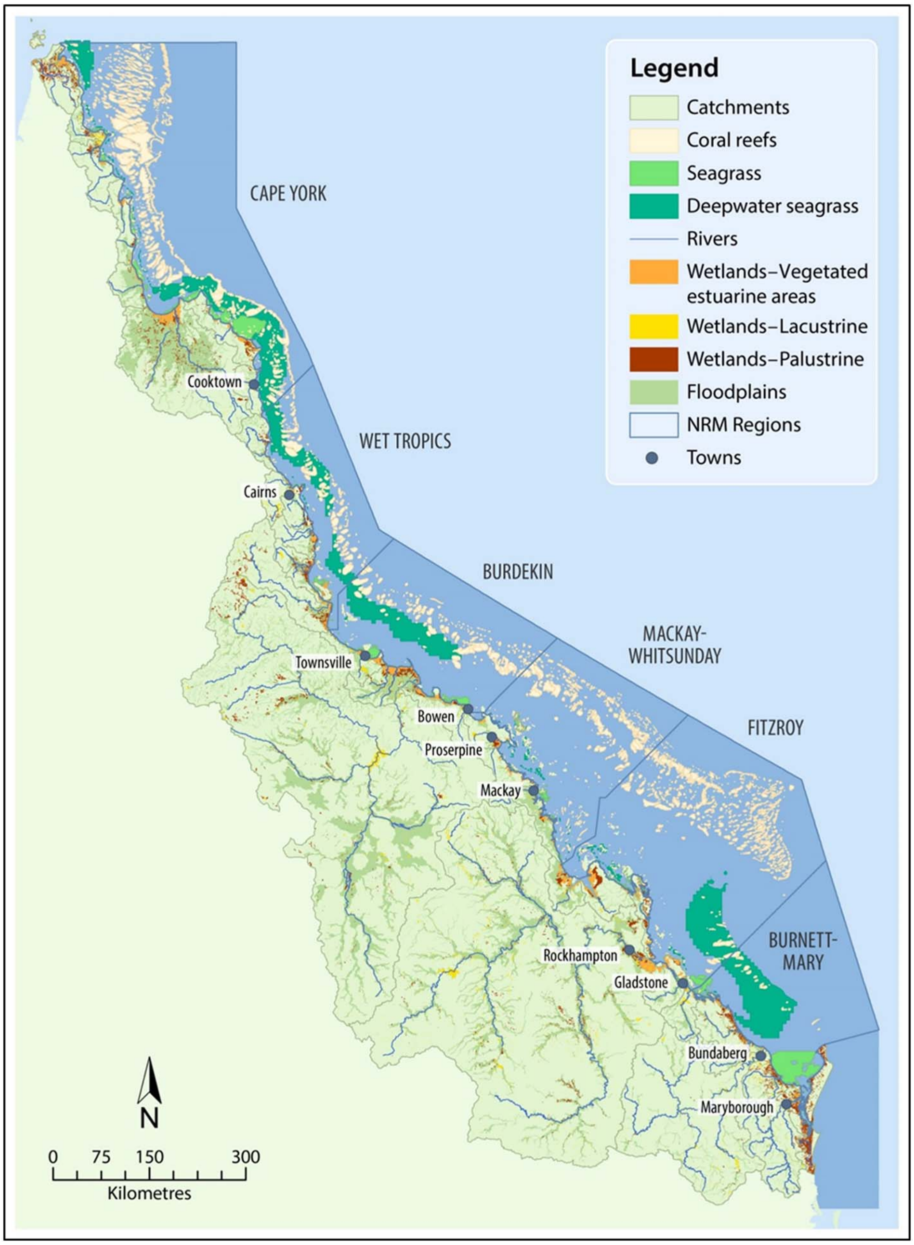

Fig. 1. Key catchments, ecosystems and regions in the Great Barrier Reef (GBR).
(Source: Waterhouse et al., 2017a.)

Table 1
Water quality targets as defined in the different versions of the Reef Plan.

Initiative	Water quality targets
Reef Plan 2003	No specific target
Reef Plan 2009	By 2013: • Min. 50% reduction in nitrogen and phosphorus loads at the end of catchments. • Min. 50% reduction in pesticides at the end of catchments. By 2020: • Min. 20% reduction in sediment load at the end of catchments.
Reef Plan 2013	By 2018: • Min. 50% reduction in anthropogenic end-of-catchment dissolved inorganic nitrogen (DIN) loads in priority areas. • Min. 20% reduction in anthropogenic end-of-catchment loads of sediment and particulate nutrients in priority areas. • Min. 60% reduction in end-of-catchment pesticide loads in priority areas.
Reef 2050 LTSP	By 2018: • Min. 50% reduction in anthropogenic end-of-catchment DIN loads in priority areas, on the way to achieving up to an 80% reduction in nitrogen by 2025. • Min. 20% reduction in anthropogenic end-of-catchment loads of sediment in priority areas, on the way to achieving up to a 50% reduction by 2025. • Min. 60% reduction in end-of-catchment pesticide loads in priority areas. • Min. 20% reduction in anthropogenic end-of-catchment loads of particulate nutrients in priority areas.