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Targeting for pollutant reductions in the Great Barrier Reef river catchments

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ABSTRACT

The declining health of the Great Barrier Reef (GBR) from poor water quality has increased the urgency for pollutant reductions at the same time that available financial resources and knowledge regarding the most appropriate interventions are limited. Prioritisation of water quality interventions in the Great Barrier Reef catchments is the process of identifying which land based actions can achieve the largest environmental benefits at the lowest cost. For prioritisation to be effective a focus is required on the outcomes of pollution reduction activities as compared to the inputs. In this paper we set out a framework for prioritising actions to improve water quality into the Great Barrier Reef, as well as providing a case study analysis using 47 individual river basins across the six large scale catchments, three pollutants and two industries. The results identify the most cost-effective options for water quality improvements aligning to locations of medium risk to reef health. The outcomes of the analysis highlight the importance of seeking pollutant reductions where the most effective outcome can be achieved rather than simply targeting an industry or a catchment.

1. Introduction

Internationally there is increasing pressure to protect coral reefs from climate change, agricultural pollutant run-off and coastal development, resulting in a number of integrated coastal management plans (Thia-Eng, 1993; Gibson et al., 1998; Meliadou et al., 2012; Tabet and Fanning, 2012). In Australia the declining health of the Great Barrier Reef (GBR) has resulted in specific management actions focused on agriculture as identified under the Reef Water Quality Protection Plan (Reef Plan) (State of Queensland, 2013). There have been large investments over the past decade by the Australian and Queensland governments in changing farm management practices through incentives, regulation, market based instruments and extension. The two main industries of focus for improvements in farm Best Management practices (BMP) are sugarcane for dissolved inorganic nitrogen (DIN) run-off and grazing for sediment run-off (Carroll et al., 2012). However the increase in the adoption of BMP's to date has been slow despite the high level of investment across the GBR. For example high risk grazing management practices still cover 36% of grazing land, while sugarcane has 32% of cane lands managed using high risk management practices for pollutant run-off (State of Queensland 2016).

Internationally there have various approaches to changing farm management practices to reduce non-point source pollution (Logan, 1993; Ripa et al., 2006; Baumgart-Getz et al., 2012), along with methods for identifying the most cost effective outcomes for multiple objectives and with limited budgets (Claassen et al., 2008). Similarly, the complexity of managing large diverse catchments (adjacent catchments to the GBR cover 424,000 km^2) which have objectives that can be translated from a catchment framework to a paddock scale action has proved challenging (Lu et al., 2004; Doole et al., 2013; Gurnell et al., 2016). The Great Barrier Reef Water Quality Protection Plan identified priority pollutants and industries to target based on loads entering the marine environment (Reef Plan 2013). On-ground incentive funding has been allocated to landholders through catchment-level natural resource management groups to improve awareness and make changes in management activities. However the scale, industries, process and parameters used to design programs and allocated funding has varied significantly between groups (Beher et al., 2016; Beverly et al., 2016; Star et al., 2017).

The need for prioritisation of where and how to achieve pollutant reductions in the GBR is driven by three critical factors. First, there is high heterogeneity in the performance of different management

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practices in different places based on geographic and biophysical parameters (Newburn et al., 2005; Bryan and Crossman, 2008), which underpin variations in benefits for the GBR per dollar spent, particularly when the time to achieve benefits is factored in (Bainbridge et al., 2009; Star et al., 2011). Second, the different management practices vary in effectiveness at reducing pollutants, costs, time lags to be effective (Meals et al., 2010; Bartley et al., 2014), adoption rates by landholders (Feather and Amacher, 1994; Greiner et al., 2009; Greiner and Gregg, 2011; Rolfe and Gregg, 2015; Rolfe and Harvey, 2017) and risks of success or interruptions (Prokopy et al., 2008; Doole and Pannell, 2011; Rolfe and Gregg, 2015; Star et al., 2015a, 2015b). Third, the effect of reductions on the most important marine assets varies significantly across the six major catchments (Waterhouse et al., 2017; de Valck and Rolfe, 2018).

Earlier funding schemes took limited account of the variations in benefits from farm management changes, focusing on flat rate grant schemes and engagement with multiple landholders. Since those initial design stages, there have been large improvements regarding the science information, economic costs and farm management factors which allows a more systematic approach to prioritisation then was possible in the past (Waterhouse et al., 2017). This improved information also reveals that none of the potential management changes achieve the high benefit, high effectiveness and low cost priorities together (Rolfe and Windle, 2011; Waterhouse et al., 2017), forcing an appraisal of which combinations are preferred (Naidoo et al., 2006). The resource budget is not sufficient to do everything, forcing some level of selection (Paton et al., 2004; Brodie et al., 2012; Star et al., 2012). An important addition to the scientific knowledge is that there are large variations in levels of exposure on marine assets by different river systems, meaning that it is important to go beyond end-of-catchment targets in prioritising water quality improvements (Brodie et al., 2017). This paper presents a prioritisation approach for improving water quality into the Great Barrier Reef which integrates improved science and cost information and aligns to the information collected in the Reef Plan Report Cards (2013-14), allowing an improved consistency in approach across regions. It presents a prioritisation across all 47 individual river catchments in the Great Barrier Reef catchment, covering the industries of sugarcane and grazing. The focus at the catchment level and only two industries is necessary to keep the analysis tractable while still demonstrating how priorities can be set.

The prioritisation approach presented here is a much more comprehensive and internationally relevant approach to improving water quality than simply targeting investments by action or pollutant, allowing a more strategic and efficient program design. It applies a cost-effectiveness analysis framework, similar to those used to evaluate major water quality proposals in Europe (Balana et al., 2011). The scale of assessment across all catchments and key industries accounts for the critical biophysical, social and economic parameters which more commonly accounted for in individual or separate approaches (Brodie et al., 2003; Ruitenbeek et al., 1999; Coiner et al., 2001; Roebeling et al., 2009; Cools et al., 2011; Doole, 2012; Star et al., 2013). The contribution of this paper to the literature is to demonstrate how scientific, economic and uncertainty information can be combined in a cost-effectiveness analysis to identify the most effective options for water quality improvements.

2. Background and study area

The GBR covers two thirds of the coast of Queensland or 35,000 km^2 (Gordon, 2007). There are six catchments that enter into the GBR, all which have a number of sub-catchments: Cape York at the most northern, Wet Tropics, Burdekin Dry Tropics, Mackay-Whitsunday, Fitzroy and the Burnett Mary at the most southern part of the GBR system (Fig. 1). Under Reef Plan (2013) a number of targets were set which include a 20% reduction in Total Suspended Sediments (TSS) and a 40% reduction in pesticides and nutrients (specifically Dissolved Inorganic Nitrogen (DIN)), and an allied target of 90% of land managers to be using best management practices by 2018. To achieve these reductions a number of Australian government programs have been implemented since 2009. From 2009–2013 the federal government allocated $366.8 million in incentives across the reef catchments to be allocated to on-ground change and support of landholders wanting to change management practices. Under the extension program, $30 million was provided for extension support to both government and industry organisations, with another $30 million allocated to 2019. (Queensland Science Taskforce 2016). The Australian Government recent committed a further $443.3 million in its 2018 budget.

The current progress towards the Reef Plan targets has been tracked through the Reef Plan report cards, underpinned by the Paddock to Reef Monitoring and Modelling (P2R) program to capture progress towards the targets (Carroll et al., 2012). The program monitors adoption and ground cover, along with river flows and water quality monitoring sites across the GBR catchments. These monitored parameters are collated into a Source Catchments model, accounting for the biophysical parameters and geographical features, which then allows the end-of-catchment pollutant reductions to be predicted for different farm management changes (Carroll et al., 2012).

Changes in farm management are summarised into a management framework of practices classified A,B,C,D that involve a range of likely risk states from "A" very low water quality risk through to "D" high water quality risk with "B" described as current best management. Adoption levels of better management practices continue to be low across the 47 individual river basins which are contained in the six catchments that enter into the reef. The 2016 GBR report card reported that a total A and B Class best management practice systems were used on approximately 39 per cent of sugarcane land for pesticides (173,042 ha), 18 per cent for nutrients (77,423 ha) and 40 per cent for soil (176,962 ha). In grazing approximately 29 per cent of grazing land was being managed under A and B Class best practice management systems for practices related to erosion from pastures (8,976,761 ha), 55 per cent for practices relating to streambank erosion (60,390 km of streambanks) and 25 per cent for practices relating to gully erosion (7,599,458 ha) (State of Queensland, 2017).

3. Methods

The method applied in this analysis uses an economic framework of cost effectiveness to evaluate pollutant reductions from the priority pollutants and industries set under Reef Plan (State of Queensland, 2013). The intermediate benefits in this analysis are the loads of pollution reduced, while the final benefits account for the reduced risk to the health of the GBR. The exercise does not involve a benefit cost analysis as the value of improvements in reef health are not available in monetary terms at a catchment level (Fabricius and De'ath, 2004), although various estimates have been generated at the whole GBR level (e.g Rolfe and Windle, 2012). The cost-effectiveness task therefore can be summarised as identifying the relevant actions, estimating the expected pollutant reductions and the potential improvements in reef health, and comparing these summarised pollutant reductions to the costs involved.

The scope of the work was limited to the priority industries of grazing and sugarcane and the specific management practice changes categorised as A, B, C, D. Sediment reductions were assessed from sugarcane and grazing, while nutrient and pesticide reductions were assessed from sugarcane alone. This resulted in 329 combinations of assessments for sediment reduction, 94 combinations of assessments for nutrient reduction and 94 combinations of assessments for pesticide reduction (Fig. 2). The challenge for prioritisation is to identify which of these combinations are most cost-effective.