The economic value of riparian restoration in the Mackay-Whitsundays region

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Key Points

- Reach-scale and catchment scale waterway management measures can provide a wider range of ecosystem services and benefits than site-scale interventions.
- Reach-scale management measures constituting vegetation management provide the most positive benefits across a wide range of ecosystem services.
- A range of economic valuation approaches can be used to highlight the benefits in economic terms to encourage co-investment.
- In the Mackay-Whitsundays region, erosion control and tourism yielded the greatest benefits from a catchment-wide riparian restoration program.
- An overall benefit-cost ratio of 1.55 was achieved for a scenario in which maintenance costs were reduced based on considerations of efficiencies that could be achieved from implementing revegetation works on a large scale.

Abstract

Waterway management projects often comprise site-scale management interventions such as structural works, revegetation, and fencing for stock exclusion. These waterway management projects are generally implemented to achieve a singular objective (i.e. protect an asset or reduce sediment loss), focussing investment on localised areas (i.e. an eroding bank). In contrast, well-planned and implemented reach-scale waterway management programs can provide a range of benefits including biodiversity outcomes, water quality treatment, flood mitigation, carbon sequestration, and recreational and amenity outcomes. However, these benefits are often difficult to value in economic terms, which makes it difficult to target investment or develop a business case.

This project was a two-phase research project. Phase 1 reviewed approaches to identifying and classifying riverine and floodplain ecosystem services, identified potential services and benefits associated with different types of waterway management interventions, and analysed different approaches to economic valuation of ecosystem services. Phase 2 was a case study application that assessed the value of ecosystem services provided by a reach-scale riparian revegetation program in the Mackay-Whitsundays region and presented a high-level business case for investment. The process involved identifying how riparian management measures positively impact services, determining the economic value of the ecosystem services, then conducting a cost-benefit analysis.

The categories that yielded the greatest benefits from reach-scale riparian restoration were erosion control and tourism. The project findings indicated multiple funding streams from various beneficiaries will be required to achieve desired region-wide outcomes.

Through highlighting economic benefits of reach-scale riparian rehabilitation, this work is a step towards encouraging investment from relevant beneficiaries to ultimately achieve widespread application of reach-scale riparian rehabilitation programs, which deliver numerous benefits.

Keywords

Waterway management, reach-scale interventions, ecosystem services, economic valuation, riparian revegetation, Mackay-Whitsundays

Introduction

Waterway management projects often involve *site-scale* management interventions, implemented to achieve a singular objective for a localised area. For example, interventions such as structural works (i.e. bank reprofiling, pile field and toe protection), revegetation, and fencing for stock exclusion, may be implemented to protect an asset or reduce sediment loss from an eroding streambank. In contrast, well-planned and implemented *reach-scale* waterway management initiatives have the potential to provide a wider range of benefits.

This research project was the first step in the development of an approach that enables quantification of ecosystem services and benefits of reach-scale waterway management measures, and the identification of beneficiaries to enable targeted investment. The research project was undertaken in two phases:

- Phase 1: Reviewed approaches to identifying and classifying riverine and floodplain ecosystem services, identified potential services and benefits associated with different types of waterway management interventions widely practiced across eastern Australia, and analysed different approaches to economic valuation of ecosystem services.
- Phase 2: Determined the value of services provided by reach-scale riparian revegetation management programs through a case study in the Mackay-Whitsundays region.

Background

Riverine and floodplain ecosystems are highly biodiverse (Dudgeon, et al, 2006) and play an important role in supporting human wellbeing by providing benefits, such as food and water, and regulation of extreme flood events. River-floodplain ecosystems are subject to inundation by lateral overflow; these flood pulses promote a mosaic of riverine and terrestrial habitats. It is this interaction of flood water inundation, moist microclimates, and nutrient influx that makes riparian zones disproportionately rich in biodiversity (Grazino, 2022).

Riparian vegetation filters pollutants in runoff from adjacent floodplains, and supplies woody debris to the channel, which is an important source of shelter and habitat for instream biota. Riparian and floodplain vegetation have the capacity to regulate extreme flood events, rapidly sequester carbon, and as biodiversity hotspots, provide critical habitat for wildlife (Naiman et al., 1997). Due to the ecological functions of riparian zones, and their role as a transition zone between riverine and terrestrial ecosystems, riparian zones have the capacity to deliver a disproportionate number of ecosystem services relative to their extent in the catchment (Sweeney and Newbold, 2014).

Waterway management measures, such as riparian revegetation programs, have the potential to provide multiple benefits such as water quality improvement, habitat improvement, ecological corridors, prevent damage to infrastructure, and create eco-tourism opportunities.

However, often these benefits are difficult to value in economic terms, which makes it difficult to target investment or develop a business case for reach-scale management projects. A challenge associated with valuing benefits of reach-scale management interventions is that the degree of benefit is highly dependent on context, and will vary from catchment to catchment, and from reach to reach. Furthermore, the benefits fall into diverse categories (e.g. private/public, long-term/short-term, ecosystem/economic, local/upstream/downstream) and several benefits are not easily monetised or traded in prevailing markets. As a result, it is difficult to prioritise where to undertake waterway management works and what works to do.

What are ecosystem services?

Ecosystem services support the *benefits* humans derive directly or indirectly from functioning ecosystems (in this case, waterways and adjacent floodplain ecosystems) (Costanza et al., 1997; MEA, 2005; Costanza et al. 2017). The concept of ecosystem services recognises the interdependence of human wellbeing and the natural environment; providing a “whole system awareness” view of humans embedded in society and nature (Constanza et al., 2017).

It is important to distinguish between ecosystem components, processes, and ecosystem services. Functioning ecosystems are comprised of components and processes. Ecosystem components are the physical chemical, and biological components of a waterway (e.g. in-channel morphology, riparian vegetation). Ecosystem processes are the dynamic forces within and between ecosystems (e.g. flow regime, nutrient cycling). Ecosystem processes are biophysical relationships that exist regardless of human benefit (Braat, 2013). Ecosystem services rely on the underlying ecosystem components and processes. The relationship between ecosystem components, processes and services for the Mackay-Whitsundays region is shown in Figure 1. The three main categories of ecosystem services are:

- **Provisioning services** - services that describe the material or energy outputs from ecosystems (e.g. fresh water).
- **Regulating services** – the services that ecosystems provide by acting as regulators (e.g. reduced sediment and nutrient loads).
- **Cultural services** – service directly experienced by humans (e.g. recreation access, aesthetic appreciation, and spiritual experience).

What ecosystem services do waterways provide?

It is widely recognised that riverine and floodplain ecosystems provide a wide range of ecosystems services (Daigneault, Eppink, & Lee, 2017). Phase 1 of the study used thirteen of the ecosystem services provided by river ecosystems (according to the CICES 5.1) to assess the effect of waterway management measures on ecosystem service provision.

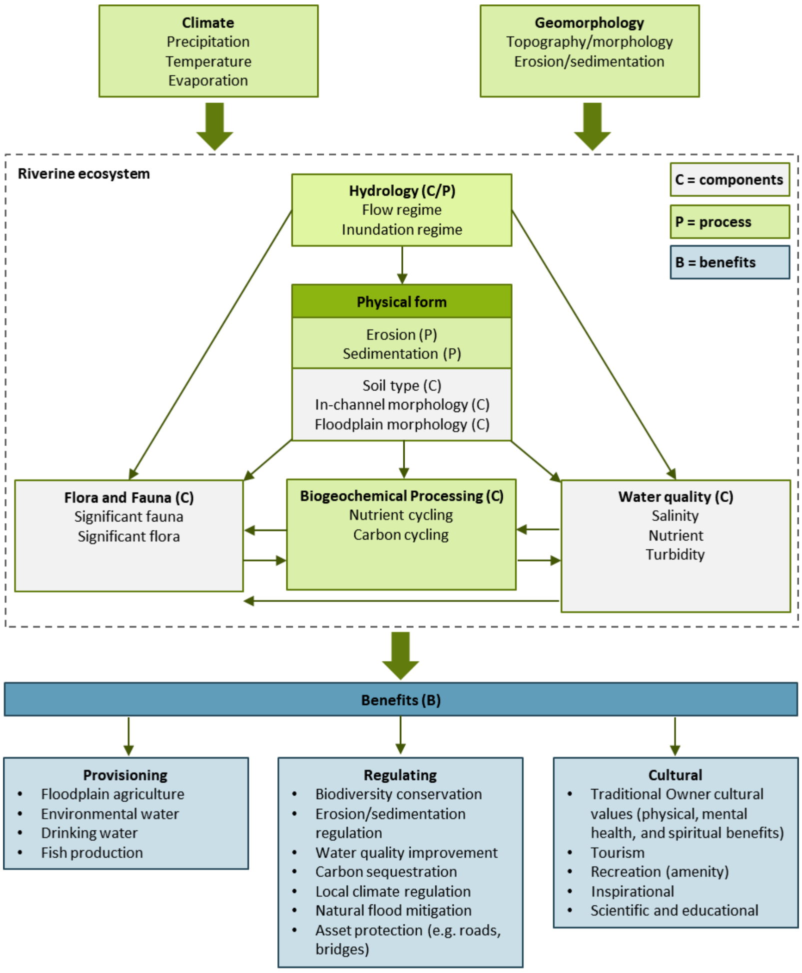

Figure 1. *Conceptual model of the Mackay-Whitsundays regional riverine ecosystem showing the relationship between critical components, processes, and benefits.*

The effect of waterway management measures on ecosystem service provision

The project developed a framework for assessing the effect of different management measures on ecosystem service provision based on work by Gilvear et al. (2013) and Hornung et al. (2019). Nine management measures widely practiced across eastern Australia, ranging from vegetation-based management to structural interventions, were selected for Phase 1 of the project (see).

The waterway management measures included in this study are limited to those associated with ongoing physical processes that can be addressed through direct management of the threatening activity. The measures are used to influence inflow of water and sediment, the extent and condition of riparian (and in-stream) vegetation, or the physical characteristics of the channel. This study does not include management measures that target activities such as changes in land use or environmental water releases, which are also important components of waterway management.

The nine management measures assessed included 1) riparian fencing, 2) buffer strip creation and riparian revegetation, 3) restored floodplain vegetation, 4) weed management, 5) large wood installation for physical habitat improvement, 6) bank stabilisation and revegetation (log and rock groynes/pile fields/rock toe protection,), 7) fishways, 8) grade control structures, and 9) floodplain/avulsion management.

For each of the nine management measures, the impact on ecosystem processes and components were defined. For example, restored floodplain vegetation increases floodplain roughness which improves flood attenuation, and increases instream habitat heterogeneity, among other things. These intermediary impacts were used to inform the assessment of the effect of the management measure on each of the identified ecosystem services. The effect of each management measure on ecosystem services and benefits to humans was scored, based on academic research and expert opinion of the project team from -1 (negative impact) through to 2 (highly positive benefit).

It was noted that the effect of the management measure is dependent on its location on the river network and the scale of the activity relative to the river system size. Additionally, some measures will only lead to benefits downstream (e.g. bank stabilisation for erosion control), whereas others on both the upstream and downstream networks (e.g. fishways).

The Phase 1 assessment determined the three most effective management measures for delivery of ecosystem services to be:

- buffer strip creation and riparian revegetation
- restored floodplain vegetation, and
- bank stabilisation and revegetation.

Overall, management measures constituting vegetation management were found to provide the most positive benefits across a wide range of ecosystem services.

Approaches to economic valuation of waterway services

The study identified approaches to measuring the benefits of the waterway management measures by considering the *types* of values (e.g. direct/indirect use) and the corresponding methods that can be suitably used to quantify the values (Table 1). The main limitations of the various valuation approaches and their respective data requirements were also identified.

Table 1. Summary of economic valuation approaches.

Method	Based on…	Example
Revealed preference methods – using observed behaviour in existing markets		
Market price	Market transactions	Market value for improved crop production
Cost-based methods	Market value as a proxy	Value of heat management through avoided cooling costs Value of coastal protection through avoided replacement costs from damage
Travel cost method	Non-market values from analysis of cost/expenditure for visiting a site or participating in an activity	Value of recreational activities like kayaking
Hedonic pricing method	Non-market values from analysis of market prices for differentiated goods, based on characteristics of corresponding services	Amenity values based on residential prices
Stated Preference Methods—using survey-based methods in hypothetical markets		
Choice modelling	Consumer values for changes to attributes of an environmental asset	Value of biodiversity/species within a natural asset
Contingent valuation	Consumer values for changes to an environmental asset	Value of changes to biodiversity within a natural asset
Other techniques		
Benefit transfer	Corresponding values estimated in similar locations using other techniques	Transfer of use values for a natural asset or non-market values for changes to attributes of natural asset

The value of region-wide riparian revegetation in the Mackay-Whitsundays

The Mackay-Whitsundays region was used as a case study application of using economic valuation approaches to highlight the benefits associated with creating continuous riparian corridors. This case study application constitutes Phase 2 of the project.

Four major basins are defined within the Mackay-Whitsundays region – Proserpine River, O'Connell River, Plane Creek and Pioneer River catchments - totaling an area of 7,990 km^2. The region supports a range of land uses and many waterways across the region have been directly impacted by agricultural and urban development since European settlement. However, despite these land use changes many of the waterways still retain important values, which contribute to both regional river health and the Great Barrier Reef (GBR) Marine Park. An example of a high value riparian corridor within the Mackay-Whitsundays region is shown in Figure 2.

Figure 2. *Riparian corridor in the Boundary Creek catchment showing structurally diverse vegetation on the stream bank and adjacent floodplain.*

A stream type assessment based on spatial analysis (Alluvium, 2017) was undertaken to determine the length and width of streams requiring riparian works to create a continuous, resilient, and resistant riparian zone. The required width of riparian works varies depending on the existing riparian condition and the degree of confinement. Degree of confinement is an important boundary condition that controls the form of a channel and determines the degree of lateral erosion possible. A total of 2,381 km of stream length was assessed for riparian condition and confinement, constituting all 3rd order and above streams.

The stream lengths in the Mackay-Whitsundays region, categorised based on riparian vegetation condition (as defined in Alluvium, 2017), is summarised in

. The majority of streams have *good* or *moderate* riparian vegetation condition, however, connectivity through the catchments is often fragmented by reaches in *poor* condition ().

The determination of areas suitable for revegetation was informed by the total stream length categorised by riparian condition (Table 1), baseline vegetation condition (Table 3), and the revegetated (reference case) riparian buffer width that incorporates degree of confinement (Table 4). The area suitable for revegetation was calculated as total area of riparian vegetation under revegetated conditions (reference case) minus the existing total area of riparian vegetation (base case).

Table 2. Stream length, categorised by riparian condition, in the Mackay-Whitsundays region.

Riparian vegetation condition	Stream length	Riparian works required?
Good	1,336 km	X
Moderate	628 km	✓
Poor	337 km	✓
Very Poor	80 km	✓

Table 3. Baseline condition of moderate to very poor vegetation.

Riparian vegetation condition	Woody vegetation canopy cover (baseline condition)	Riparian buffer width (baseline condition)
Moderate	80%	10 m
Poor	45%	5 m
Very Poor	10%	5 m

Table 4. Riparian buffer width based on degree of confinement in the Mackay-Whitsundays region.

Degree of confinement	Riparian vegetation buffer width (on each side)
Confined by bedrock	0 m
Significantly confined by bedrock	10 m
Significantly confined by terraces	10 m
Slightly confined by bedrock	20 m
Slightly confined by terraces	20 m
Unconfined	20 m

Figure 3. *Riparian vegetation conditions in the Mackay-Whitsundays region.*

The creation of continuous riparian corridors in good condition can deliver numerous ecosystem services that result in a diverse range of direct and indirect benefits for humans. Seven ecosystem services were selected for valuation in the region, using the valuation approach most suitable to the specific ecosystem service (Table 5).

Table 5. Summary of services, and benefits for humans, valued in the Mackay-Whitsundays region.

Simple descriptor	Ecosystem service	Benefit for humans
Biodiversity improvements	Provides important habitats, including habitat for native pollinators and nursery habitats	Sustainable populations of useful or iconic species; recreational benefits (e.g. bird watching opportunities), non-use values.
Erosion control	The capacity of vegetation to prevent or reduce the incidence of soil erosion	Reduction in damage costs associated with sediment and nutrient delivery to receiving waters (e.g. impacts of fish supply, and estuary health)
Water quality improvement	Runoff water quality improved via processes in the riparian zone (e.g. denitrification and sediment trapping).	Reduction in damage costs associated with sediment and nutrient delivery to receiving waters
Climate regulation	Sequestration of carbon in riparian zones	Climate regulation resulting in avoided damage costs
Improved visual amenity	Aesthetic qualities of riparian vegetation that make it attractive	Increase in property values
Ecotourism	Opportunities walking, and bird watching.	Higher quality ecotourism experiences
Improved estuary habitat for aquatic species	Improves nursery habitat including estuary and seagrass habitat	Increase in fisheries productivity

The likely immediate beneficiaries of each benefit stream were identified to help inform the cost-benefit analysis and logically identify potential co-investment. The key immediate beneficiaries to engage for co-investment opportunities are:

- **Local governments and utility providers**—who benefit the greatest through delayed or avoided investment in water quality treatment, and offset opportunities.
- **State governments**—who benefit from the avoided sediment loads—through avoided water quality management/treatment investment—and potential increases in eco-tourism.
- **Federal Government** agencies (e.g., Reef Trust, GBR Marine Park Authority)—who would consider the beneficial outcomes on the GBR as warranting investment.

Also, while significant benefits are likely experienced by the general population and private landowners, these benefits are primarily ‘public goods’ as the benefits are spread across the broader community. Instead, these benefits could form the basis of broader discussions across local, State and Federal Governments on accessing public funding.

Economic value of benefits from riparian revegetation in Mackay-Whitsundays region

The value of benefits associated with catchment-scale riparian revegetation was compared against the base case (current) situation (Table 6). Erosion control and tourism returned the greatest benefit; $111 million and $52 million, respectively.

Table 6. Benefit valuation under the base case and the reference case.

Benefit category	Valuation approach	Present value of benefits under the base case (BAU)	Present value of benefits under the reference case (revegetation)	Incremental benefits (i.e. reference case minus base case)
Biodiversity	Benefit transfer (based on Willingness to Pay for protecting and expanding vegetation types)	$27 million	$39 million	$12 million
Water quality improvement (erosion control)	Avoided cost (of investment in water quality improvement for Great Barrier Reef)	$0 million	$111 million	$111 million
Improved runoff water quality (total nitrogen)	Avoided cost (of water quality treatment and offsets)	$0 million	$18 million	$18 million
Carbon abatement	Market price (Australian Carbon Credit Unit price)	$0 million	$1.8 million	$1.8 million
Tourism	Benefit transfer (consumer surplus values per trip)	$173 million	$225 million	$52 million
Property value improvements	Monetary benefit (property value increase)	$839 million	$858 million	$19 million

A cost-benefit analysis (CBA) was then undertaken to estimate the ratio of benefits to costs of catchment-scale revegetation (Table 7). A benefit-cost ratio (BCR) greater than one indicates that the benefits outweigh the costs, and the investment is economically viable.

The initial CBA assessment returned a BCR of 0.65, indicating that the investment is not economically viable, as the benefits fail to justify the associated costs. However, an additional scenario was assessed, incorporating the potential cost advantages resulting from the project's scalability. For this scenario, the same initial capital costs were used, while maintenance during the establishment period was reduced based on considerations of efficiencies, including more efficient irrigation and weed maintenance programs, that could be achieved from implementing large-scale revegetation works. These efficiencies of scale include:

Using these costs a much-improved BCR of 1.55 was achieved. The BCR result indicates that the benefit categories would economically justify the cost of investment and would incur a gain of $76 million.

Table 7. Cost-Benefit Analysis results

	Initial Cost -Benefit Analysis	Cost-Benefit Analysis (economies of scale scenario)
Present value of costs	$326 million	$138 million
Present value of benefits	$214 million	$214 million
Net present value	-$112 million	$76 million
Benefit-cost ratio	0.65	1.55
Benefit-cost ratio range (90% C.I.)	0.64 - 1.23	1.51 - 2.92

While the initial BCR indicated the program was not financially viable, this is likely to be a highly conservative estimate given that:

- Costs are based on smaller projects from local suppliers whose businesses have not been developed to implement large-scale revegetation programs. There are often issues with plant supply, staff shortages and lack of equipment for these smaller projects which all tend to increase the cost.
- Not all benefits have been accounted for in this higher-level study. The additional benefits associated with ecological connectivity, recreational and commercial fisheries, flood mitigation, land productivity and asset protection are likely to add to the total benefits significantly.

Key outcomes

Region-scale riparian rehabilitation is required to help protect biodiversity, threatened species, and improve water quality and floodplain productivity in the Mackay-Whitsundays region. However, it is likely that multiple funding streams from various beneficiaries will be necessary to undertake the large-scale works. The economic benefits identified within this study can help in the planning of future steps to help achieve the desired outcomes.

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