Using BioCondition Assessment in the Mary River catchment to evaluate riparian restoration

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Key Points

- Demonstrating the impact of investment in riparian restoration is important but often difficult.
- BioCondition assessment is a useful tool for assessing riparian restoration outcomes within typical project timeframes because it can detect change within twelve months of project activities.
- Preliminary findings suggest that old revegetation sites are plateauing at levels of ecological function that are significantly lower than remnant vegetation and that there is quicker improvement in BioCondition score at sites that have been classified as having a lower potential for natural recovery.
- These findings raise some interesting questions for further exploration regarding the future intervention in old revegetation sites and the targeting of new sites to achieve improvement in ecological function in ways that account for geomorphological processes that impact on riparian recovery.

Abstract

Improving the health of riparian vegetation is one of the key land management actions identified to improve the health of the Great Barrier Reef, but it can involve long time lags between initial investment and ecological outcomes. Monitoring tools that can detect short-term improvements and be used, in conjunction with geomorphological understanding, to identify recovery trajectory of riparian areas can help address uncertainty created by these time lags. This paper presents the preliminary findings of a riparian vegetation monitoring program which used the BioCondition assessment method to detect short term improvements achieved through a $2.4 million riparian restoration project in the Mary River catchment, the southern most of the Great Barrier Reef catchments. Forty vegetation assessments across twenty-two different sites and four different vegetation types have been conducted over the last two and half years. The sites monitored fall into two distinct categories - sites where restoration work has been undertaken within the last four years and restoration sites established 15-20 years ago. The BioCondition assessment method was found to detect changes in ecological function over a period of twelve months. Repeat BioCondition assessments have revealed that the score of the site improves more quickly in the reaches considered to have a lower chance of natural recovery. The paper concludes with recommendations regarding the implications of these results for riparian restoration.

Keywords

BioCondition assessment, recovery potential, Mary River catchment, Great Barrier Reef, riparian restoration, Biodiversity Fund, threatened species, vegetation monitoring.

Introduction

A series of national audits conducted by the Australian National Audit Office over the last decade show that the natural resource management sector continues to face difficulty in demonstrating the achievement of landscape scale environmental objectives as a result of investment of public money (Doolan and Hemming, 2015). In river restoration this seems particularly difficult because most interventions happen in the terrestrial environment with a view to achieving flow on improvements in the aquatic environment. The Index of Stream Condition (ISC) attempts to capture this interconnectedness by using measures related to instream health and the health of riparian vegetation. This measure is aimed at assessing long-term effectiveness of rehabilitation (Ladson et al., 1999). The rate of change in overall ecological health (both instream and terrestrial) in response to interventions in the riparian zone is typically slow and likely to be difficult to demonstrate within the time frame of most funding programs.

This paper outlines progress with, and lessons learned from, using the Queensland State Government's BioCondition assessment tool to assess short-term progress with a riparian restoration program. The project, funded by the Australian Government's Clean Energy Futures project is called "Restoring Riparian Resilience: Implementing the Mary River Threatened Aquatic Species Recovery Plan". It is a six year project which commenced in 2011 and will conclude in 2017. This project targets riparian landholders across a range of tenures who are restoring riparian zones. The focus is on habitat of the five priority species of the draft Mary River Threatened Aquatic Species Recovery Plan: the Mary River turtle (*Elusor macrurus*), Australian lungfish (*Neoceratodus forsteri*), Mary River cod (*Maccullochella mariensis*), Giant barred frog (*Mixophyes iteratus*) and Freshwater mullet (*Trachystoma petardi*) (Department of the Environment and Mary River Catchment Coordinating Committee, 2014).

Project activities include riparian fencing, installation of off-stream stock water supplies, riparian revegetation and weed control including release of viney-weed bio-control agents. In the first four years, the project has targeted twenty-three demonstration reaches along the Mary River and tributaries. Over 150 landholders have been engaged in on-ground work that is undertaken either by the landholders themselves, by local Landcare groups or small private operators. Project interventions have been influenced by the Reach Priority and Recovery Potential as assessed in the Mary River Tributaries and Rehabilitation Plan (Stockwell, 2001) and the subsequent Mary Rivercare Initiatives Priority Action Project (MRCCC 2005). These plans are based on the Riverstyles approach (Brierley, 1999; Fryirs, 1999) in which recovery potential is based upon the capacity of a river reach to attain a suitable river structure and function for the position it occupies in the catchment, and the boundary conditions under which it operates. Condition ratings including geomorphological, riparian zone, water quality and instream habitat attributes were used in conjunction with assessments of conservation status, trajectory and recovery potential to determine Reach Priority.

BioCondition is a condition assessment framework for terrestrial biodiversity in Queensland (Eyre et al., 2015). It was developed by the Queensland Herbarium and is based on comparison of the function of a study site with a site of similar vegetation, but in an unmodified or "reference" state. The technique is specifically designed to be used by non-specialists in vegetation assessment (Kelly et al., 2011). It provides a means of assessing ecological equivalence under Queensland's Biodiversity Offsets Policy (Franks, 2012). The BioCondition assessment method has also been used to assess mine site rehabilitation (Neldner and Ngugi, 2014). In the "Restoring Riparian Resilience" project it has been used in conjunction with Index of Stream Condition to measure the recovery of riparian restoration sites. In addition to monitoring new project sites (M), we also undertook BioCondition assessments on 15-20 year old revegetation projects sites (R).

In this paper we present some preliminary findings from two and a half years of monitoring including forty BioCondition assessments on twenty-two different sites. Our focus is on the appropriateness of the BioCondition assessment method for determining the short-term effectiveness of riparian restoration and we offer preliminary observations about BioCondition's relationship with Reach Prioritisation and ISC. In doing so we aim to contribute to the efforts of the natural resource management and river management community to better demonstrate the impacts of the work we do.

Location and Methods

Location details

The Mary River catchment is located in the south-east Queensland bioregion. BioCondition monitoring sites (M) and revegetation reference sites (R) were spread through the catchment, across different Regional Ecosystem and project types (See Figure 1). On-ground work occurred from 2011. The initial condition of the monitoring sites varied from wide grassy buffers with minimal vegetation (greenfield sites) to others with a functional riparian zone where project work aimed to complement existing regeneration, create corridors and increase connectivity.

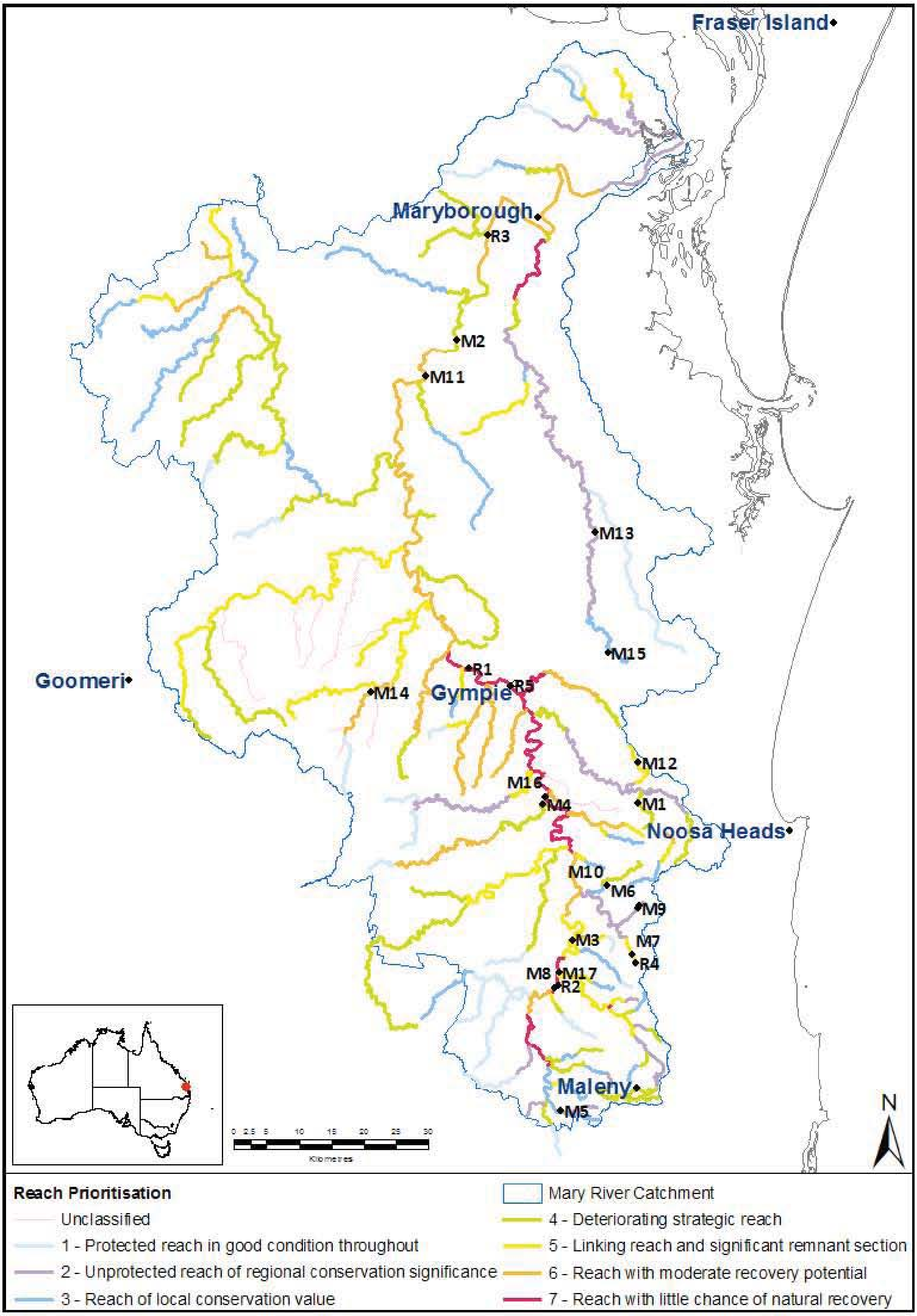

Figure 1. Map showing the Mary River catchment, Reach Prioritisation and monitoring (M) and revegetation reference (R) sites.

Project sites were located on recent Quaternary alluvial systems (alluvial river and creek flats). Four Regional Ecosystem types were encountered during BioCondition monitoring. Four monitoring sites were classified as Regional Ecosystem 12.3.1 – Gallery rainforest (notophyll vine forest) on alluvial plains, eight were classified as 12.3.2 – *Eucalyptus grandis* tall open forest on alluvial plains, nine were classified as 12.3.7 – *Eucalyptus tereticornis*, *Casuarina cunninghamiana subsp. cunninghamiana* +/- *Melaleuca spp.* fringing woodland and one site was classified as 12.3.11 – *Eucalyptus tereticornis* +/- *Eucalyptus siderophloia, Corymbia intermedia* open forest on alluvial plains usually near the coast.

The Mary River catchment is dominated by summer rainfall and "unpredictable and intermittent" flow (Kennard et al., 2010) which can constrain and influence project activities and timeframes for achieving functional biodiversity condition. Recent one-in-one-hundred-year floods have resulted in extensive damage to riparian zones at some locations and the impact was reflected in the repeat site assessments.

Assessment Methods

The basic unit for the BioCondition assessment is a 100 x 50m plot, within which 50 x 10m and 50 x 20m plots, a 100m transect and five 1 x 1m quadrats are assessed for the different aspects of the score. The plots were located to capture the change expected as a result of the project activities. The BioCondition field assessment sheet was used to record large trees, tree canopy height, recruitment of dominant canopy species, tree canopy cover, shrub layer cover, coarse woody debris, native plant species richness, non-native plant cover, native perennial grass cover and litter cover. For each of these parameters, the BioCondition method includes both weightings and thresholds which each parameter needs to reach to contribute to the final score. These site-based attributes make up 80% of the BioCondition score, which are compared to a benchmark based on the Regional Ecosystem type.

The remaining 20% of the score was derived from assessing landscape-scale attributes including patch size, connectivity and context. To obtain overall BioCondition scores, site-based and landscape-scale attributes were combined and then rated from 1 (for 'functional' biodiversity condition) to 4 (for 'dysfunctional' biodiversity condition). This paper focuses on the site-based attributes score because the landscape scale are outside the scope of our project activities.

Monitoring using the BioCondition assessment method occurred between December 2013 and July 2016. Each year new assessment sites are included in the monitoring program and sites assessed in previous years are re-assessed. Both authors of this paper were present at all BioCondition assessments except one, and collected the majority of the data.

At the time of the initial BioCondition assessments, a partial ISC assessment including streamside zone, physical form and water quality (resulting in a maximum possible score of 30) was also completed.

Analysis Methods

The data was analysed to identify patterns related to the age of the project, the vegetation type, the reach prioritization and the initial functional status of the site. The paper focuses on two aspects of this analysis: 1) trends over time across all sites including revegetation reference sites, 2) observations regarding the change observed on sites with multiple assessments.

To detect trends over time, a scatter plot was generated in which the site-based attribute scores were plotted against the age of the site (years since the project commenced). Using the *PAST statistics package* (Hammer et al, no date), the fit of several non-linear models was tested and a logistic curve was found to provide the least loss of information (indicated by the smallest Akaike Information Criterion value of all models tested).

Variations of the general logistic model are widely used to describe population, community and ecosystem recovery following disturbance, for example Krebs (2009).

To detect relationships between the change in BioCondition scores and other measurements, the *PAST statistics package* was used to generate generalized linear models which identify whether the scatter of data points is statistically different from a random distribution. A p-value less than 0.01 indicates higher than 99% confidence that there is a linear relationship between the data points.

Results

Overview

The initial functional condition of BioCondition monitoring sites varied considerably. Due to the positioning of the transects to capture change, there were a mixture of dominant vegetation types including grass, scattered trees, intact riparian vegetation or a combination. This is reflected in the site-based attributes scores. Across all twenty-two monitoring sites, the least functional site was Tinana Creek – Wedgewood (M13) which scored 10.5/80 for site-based attributes (Figure 2.) and the most functional was Cedar Creek Headwaters (R4) which scored 70.5/80 (Figure 3).

Figure 2. Tinana Creek – Wedgewood (M13)– least functional biodiversity condition of sites assessed up to July 2016.

Figure 3. Cedar Creek Headwaters (R4) – most functional biodiversity condition of sites assessed upto July 2016.

Change in BioCondition scores over time

Figure 4 shows the scores for the monitoring (M) and reference (R) sites plotted against the time since project work began at each site. Points with an x-axis value of zero correspond to initial assessments that occurred before on-ground works commenced. Figure 4 includes twenty-one of the twenty-two monitoring sites. Mary River – Home Park (M11) was excluded from the analysis because the only intervention of Cat's Claw biological controls was unlikely to be detected in the score. The sites cover four different Regional Ecosystems (12.3.1, 12.3.2, 12.3.7 and 12.3.11) and include transects with differing baseline conditions based on the amount of established vegetation. To better understand the implications of the variation in baseline condition, two different logistic curves have been fitted. The first curve includes data from all sites and the second includes data from sites dominated by grasses with a few scattered trees (greenfield sites). The second curve, based on greenfield sites, has been extracted from the entire dataset in order to enable comparison of the recovery trajectory of these sites, which involve very similar projects activities, maintenance and management schedules, to the full range of sites with more varied histories.

All sites shown have included stock exclusion (when applicable) and revegetation, with three exceptions. Restoration at Moy Pocket – Pickering Island (M3) has been focused on physical weed control only, including Cat's Claw vine. Mary River – Beauanda (R1) which is a 20 year old revegetation site where stock were only excluded for the first three years. For R1, physical viney weed control was undertaken in 2015 and stock have been excluded since the later assessment. Although this site is an old project site, the recent project activities have been used as the starting point as the change observed in the BioCondition score relates directly to these. The third exception is Widgee Creek – Webb Park (M14) where the only activities were Cat's Claw vine control. For the sites with multiple assessments, all but two sites stayed the same or increased between assessments. The sites where the scores decreased over time are located in adjacent sub-catchments (Cedar Creek – Bluepool (M7) and Belli Creek – Bellambleon (M9)) which experienced intense and localized rainfall causing flash-flooding between the two assessments. This resulted in a decrease to the site-based attributes score, primarily due to loss of leaf litter and reduced recruitment of dominant species.

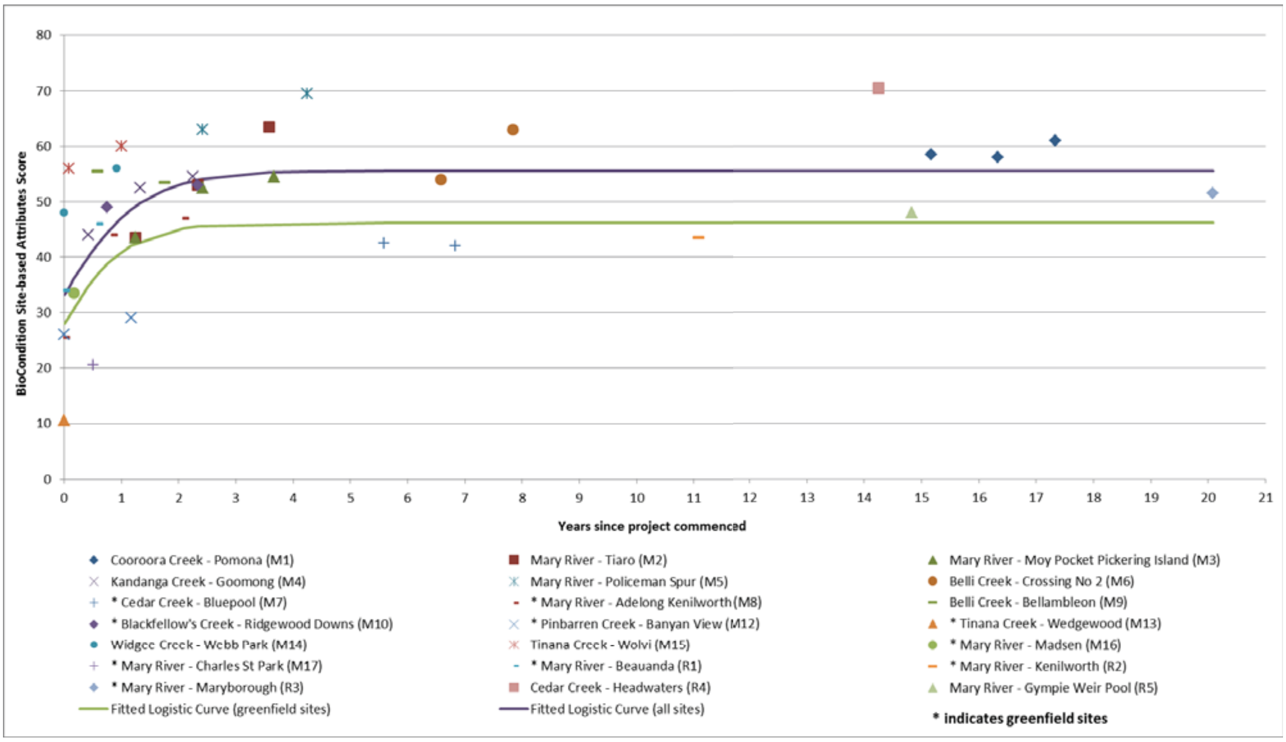

Figure 4. BioCondition monitoring scores of site-based attributes in years since on-ground work commenced

The logistic curves fitted to the data points in figure 4 suggest that, over a 20 year timeframe, most improvement in the BioCondition score is seen within the first four years after project activities occur. In greenfield sites (indicated by an asterisk at the beginning of the site name) this improvement is seen within the first two to three years before plateauing, indicating that sites with a similar baseline follow a similar pattern to the overall dataset. The plateau is notable as it occurs at a level well below the score of 80 which indicates high ecological function. However this plateau could be a result of the dataset so continued monitoring, including repeat assessments and assessments of more revegetation reference sites, will improve confidence in these curves and provide a better understanding of the recovery trajectory of riparian restoration project sites.

Relationship between BioCondition and other parameters

Figure 5 summarises the results of an analysis of relationships between BioCondition assessment initial scores (out of 80), rate of change in BioCondition scores (calculated as points per month), Reach Prioritisation as assessed in the Mary River Tributaries and Rehabilitation Plan and our partial ISC assessment scores (out of

30). The data analysed for Figure 5 is based on the fourteen sites which have been assessed multiple times using the BioCondition assessment method.

The p-values indicate that the highest confidence of a linear relationship exists between Reach Prioritisation and rate of change in BioCondition score (points per month) ($p = 0.000014$) (Figure 5.a). The highest rate of change in BioCondition scores was observed at sites with the lowest Reach Priority. A statistically significant relationship was also detected between the Reach Priority and ISC score ($p = 0.00054$) (Figure 5.d). This suggests that sites with a higher Reach Priority also have higher ISC scores, drawing on the parallels between the ISC assessment method and the aforementioned parameters considered in Reach Prioritisation.

There was a lower level of confidence in the relationship between Reach Prioritisation and the initial BioCondition score ($p = 0.017$) (Figure 5.c), and ISC and rate of change in BioCondition scores ($p = 0.034$) (Figure 5.b). The lack of a highly statistically significant relationship between these parameters is likely due to the inclusion of factors such as instream habitat, bank stability and water quality in the ISC and Reach Prioritisation, whereas BioCondition score only considers the vegetation.

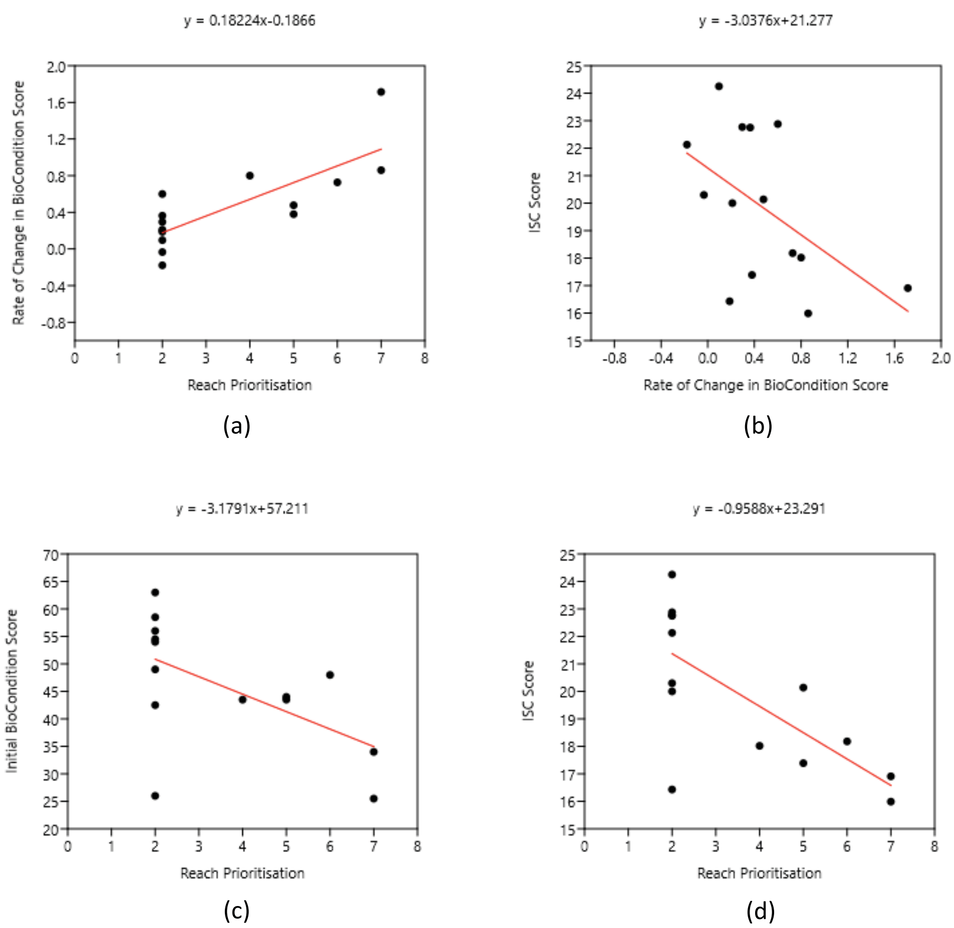

Figure 5. a) Reach Prioritisation versus Rate of Change in BioCondition Score (p = 0.000014), b) Rate of Change in BioCondition Score versus ISC Score (p = 0.034), c) Reach Prioritisation versus Initial BioCondition Score (p = 0.017), and d) Reach Prioritisation versus ISC Score (p=0.00054)

Discussion

This section focuses on the appropriateness of the BioCondition assessment method in the riparian restoration context and provides preliminary observations regarding the relationship between this assessment and the Reach Prioritisation. Some potential implications for riparian restoration are also identified.

BioCondition is useful in a riparian restoration context

Based on our analysis, we suggest that BioCondition does provide useful information for assessing riparian restoration projects. It has sufficient precision in the ten assessable attributes to detect change within twelve months of implementation of a revegetation project or weed control project and to detect ongoing change after that. Sites M2, M4, M5, M6, M8, M10 and M12, where active revegetation project work was undertaken illustrate this capacity of the assessment method (see Figure 4). Other sites where on-ground work was focused primarily on invasive species management (both physical and with bio-control agents), including M3, M14, M15 and R1, also show an improvement in BioCondition over 12 months.

BioCondition scores change faster in reaches with lower priority

The data we have collected indicates that BioCondition scores changed more quickly in sites that are considered to have lower priority according to previous rehabilitation prioritization processes (Stockwell, 2001; MRCCC, 2005). The lower priority could be due to their location in more degraded and/or geomorphologically unstable sections of the river. With the lower priority comes the assumption that more investment is required for recovery, that natural recovery is less likely and that there is more risk involved in investing in these sites. According to the BioCondition score, the lower priority sites appear to be recovering function of riparian vegetation at a quicker rate in the short-term than higher priority sites which pose some interesting questions that require further exploration.

This observation may be due to weightings and thresholds used to calculate the BioCondition score. The ten attributes of the score are weighted differently and, particularly at the lower end of the scale, thresholds in the scoring calculation cause change in the overall score that is greater than the relative change in the attribute being assessed. Furthermore, particular site characteristics that change significantly as a result of a revegetation project are given significant weight in the scoring. For example, Mary River – Adelong (M8) increased from 25.5/80 to 44/80 following revegetation of the BioCondition plot between the two assessments. This 23% increase in BioCondition score was largely due to the number of native species of trees, shrubs, grasses and forbs changing from 8 to 32. This resulted in native species diversity contribution to the site based attribute score changing from 5 points at the initial assessment to 12.5 points at the second assessment. As BioCondition is designed to measure function, it follows that a change in species composition like at site M8, and the change in score that results, reflects a corresponding increase in ecological function. The accuracy of the measurement of change in function is a question that requires some further analysis and consultation with the designers of the method.

Evidently BioCondition does not take into account the broader geomorphological issues that could affect the recovery of the site in the long term. However, these preliminary results do suggest that there may be merit in working in sites traditionally considered to be low priority, provided some of the geomorphological risks can be mitigated (e.g. planting in geomorphologically stable areas, facilitating regeneration in unstable areas etc.) and that the landholder at the site is highly committed to the project.

BioCondition Scores from old sites suggest ongoing management is needed

Our data suggests a plateauing of improvement in function at the older revegetation sites we assessed. A factor at play in this analysis is the kind of management that has occurred over the long term. To a large extent, the Reference sites had been left to their own devices post the initial project activities. Since then, some had experienced ongoing stock access, others had become dominated by exotic grasses and some had experienced severe erosion during major floods over the last decade. These observations raise several questions. Firstly, is the plateau actually occurring or is it a product of the particular data we have collected? Secondly, if the sites have plateaued at a functional state considerably lower than what remnant vegetation of the same type reaches (based on the regional ecosystem benchmarks), should further interventions be undertaken to kick-start a new recovery trajectory or is this a new stable state that has sufficient ecological function? The BioCondition Assessment results could be used to help further explore these questions and evaluate interventions which aim to prompt a new phase of recovery.

Conclusions

The BioCondition assessment method can be used to take account of time lags between investment and environmental outcomes because the scoring method is specific and able to detect small changes in condition. It is useful for identifying the impact of factors which affect the recovery, like cattle access and weed threats, and incorporate this knowledge into site management plans. We have identified a preliminary recovery trajectory of revegetation and other restoration sites and identified some patterns in site recovery relevant to the Mary River catchment.

Our observations and analysis of the data have in some ways raised more questions than they have answered regarding the ecological function of long term revegetation sites and expectations regarding the speed of recovery of sites of different recovery potential. As our data pool increases and we undertake more repeat assessments we will be able to build a greater understanding of the relationships discussed and be able to draw more definitive conclusions.

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