Ecological Investigations into Streambank Stabilisation Practices in North Queensland

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ABSTRACT: *Tropical streambank stabilisation initiatives have not previously been investigated with a view to improving the ecological sustainability of streambanks. Maintaining the physical integrity of streambanks has been the focus of traditional engineering works. Field survey data from representative stream sites has enabled comment on the ecological effects of different types of stabilisation works. Qualitative vegetation and semi-quantitative aquatic fauna surveys are recommended as useful means of investigating the ecological effects of stabilisation works. It is concluded that unless works designs maximise every opportunity to restore riparian vegetation habitat, stabilisation techniques will remain ecologically unsustainable.*

1. INTRODUCTION

In April 1993, a national workshop was conducted on the research and management needs of riparian zones in Australia (Bunn *et al.* 1993). The following list of the ecological roles of riparian vegetation represents a synthesis of the many varied papers presented at the workshop, coupled with roles and values proposed by the authors of this document. These roles include:

- provision habitat for a high diversity of terrestrial and aquatic faunal species;
- importance as drought refugia for many faunal species;
- acting as a filter for sediment, nutrients and agricultural chemicals when present in catchment runoff;
- protect streambanks from erosion;
- acting as a source of organic matter (including snag formation) for the creek they inhabit;
- provision of shade, thus reducing temperature fluctuations and keeping the growth of plant and algal populations in check;
- functioning as wildlife corridors for terrestrial wildlife;
- exerting an influence on downstream "receiving" systems;
- possessing an intrinsic aesthetic value; and
- possessing an intrinsic conservation value in terms on the unique plant species and communities that grow in these areas.

The widespread clearing of vegetation for agriculture and urbanisation has resulted in the riparian ecosystems of most northern Queensland lowland streams becoming severely impacted. In many cases, the clearing of vegetation to the water's edge has resulted in a disjointed riparian system with consequent disruption to riparian wildlife corridors, reduction in stream inputs and modification of aquatic bank habitat. The extensive clearing of vegetation in catchments has probably resulted in increased run-off rates. This increase, coupled with the tropical climate (i.e. short, high intensity rainfall periods) has altered and hastened natural riverbank erosion processes. The streambank vegetation within the lowland sections of tropical catchments is often the only vegetation remaining and may be the major mechanism controlling this erosion. Further impact on this vegetation may only exacerbate erosion problems.

In collaboration with the Department of Civil and Systems Engineering, James Cook University, the Australian Centre for Tropical Freshwater Research (ACTFR) began research into the ecological aspects of streambank stabilisation in July 1993. The ecological sub-program has the following objectives:

- to compare the environment created by traditional stabilisation practices with intact, remnant riparian ecosystems;
- to assess riparian and instream habitat changes caused by the instability of banks and stabilisation works; and
- to discuss the ecological impacts of different types of stabilisation works and evaluate potential alternatives.

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To date the LWRRDC funded project has had the following outcomes:

- a review of bank stabilisation practices for north Queensland streams; and
- a review of the methods of environmental assessment of streambank stabilisation.

Future outcomes will include the production of a streambank stabilisation guidelines handbook for use by all groups involved in tropical river management.

2. METHODS

2.1 Vegetation

Study sites have been established along five coastal lowland rivers from Mackay to Cairns (Table 1). At each location, the vegetation assemblage at the different stabilisation works sites was compared with a relatively undisturbed riparian vegetation community (control sites). Habit, likely depths of root systems and percentage cover were recorded for the dominant species within a defined area (50 x 30 m) at each location.

Table 1 Sites (listed from south to north)and the types of stabilisation works assessed

Site	Stabilisation Works
Pioneer River	Wire embayment
Burdekin River	Rock revetment
Haughton River	Rock revetment and groyne
Herbert River	Rock revetment with berm
Mulgrave River	Rock revetment and groyne with re-vegetation at top of bank

To assess a variety of stabilisation options, a case study site has been established on the Herbert River and the following stabilisation treatments have been applied to a highly eroded section of streambank dominated by exotic species:

- rock placed at toe of bank with sub-surface drainage;
- rock placed at toe of bank with no sub-surface drainage;
- remnant riparian trees left on toe of bank with replanting on remainder of bank; and
- tree planting only.

The results of this work are still to be determined and will not be considered further in this paper.

2.2 Aquatic Fauna

The quantitative aquatic ecological program has been conducted at three of the five vegetation study sites (Mulgrave, Herbert and Burdekin Rivers). A pilot sampling program showed that dip-netting was the most useful technique for the collection of benthic macroinvertebrates from the instream under-bank habitat. Fish and crustacean traps baited with light (i.e. Cyalume sticks) that were placed close to the bank were successful in providing information on small fish and crustaceans.

Artificial substrates were introduced for the main sampling program; the use of artificial substrates to quantitatively sample deep rivers, or habitats that are difficult to access, has been successful in other investigations (ACTFR 1994). Artificial substrates were the best solution to the instream sampling problems encountered during the pilot program, providing comparable, quantitative macroinvertebrate information (composition and abundance) at both rock revetment and control sites.

Five dip-net samples were collected from the bank habitat at random locations in control and rock areas at each site (10 samples per site) to quantify instream population differences between rock revetment and natural bank. Substrate installation and exposure periods varied between study sites according to the predetermined protocols. Observation and detailed habitat description were used to provide a broad assessment of the aquatic ecology at each study site

2.3 Terrestrial Fauna

Pilot study sampling was undertaken at the Herbert and Burdekin River. At the Herbert River study site two areas were sampled, namely the works area and a control site approximately 500 m upstream. The same survey method was employed at each area, consisting of four lines of 12 small mammal traps placed parallel to the river bank (i.e. a total of 48 traps per area) and fixed-time bird observations.

At the Burdekin River study site three areas were sampled; namely new rockwork, old rockwork 500 m upstream, and a control site a further 350 m upstream. The same survey method was employed at each sub-site. The mammal trapping technique was different from that employed at the Herbert River in that traps were placed in clusters of six; eight clusters in each area gave a total of 48 traps per area. The traps were pre-baited on the first and

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second nights (i.e. trap doors were not opened) and opened for the third and fourth nights. Fixed-time bird surveys were conducted early in the morning during the time of peak activity.

3. RESULTS

3.1 Vegetation

A summary of the vegetation results for the different study sites is provided in Table 2. Works sites are dominated by shallow rooted exotic species and have much reduced vegetative cover when compared with remnant riparian communities. From an ecological viewpoint, the most important result is shown by the figures for the Mulgrave River. Where an attempt was made to incorporate vegetation into stabilisation works, the predominance of exotics was reduced and cover increased.

Table 2 Summary of vegetation results at the different study sites. The first figure listed for each parameter is the works site value, followed by the remnant riparian community value. Figures include both terrestrial and aquatic plant species.

Site	Dominance of exotic species (%)	Predominance of shallow root systems (%)	Cover (%)
Pioneer	78/6	100/50	10/85
Burdekin	50/19	80/30	15/75
Haughton	31/12	100/43	10/90
Herbert	75/18	70/50	15/80
Mulgrave	15/7	40/25	35*/90

* Figure increasing as tree species in planting program mature.

3.2 Aquatic Fauna

Results from the dip-net and artificial substrate samples are still being determined in the laboratory. Quantitative assessments of the instream macroinvertebrate communities will be made after the completion of specimen sorting and identification.

3.3 Terrestrial Fauna

The results of the small mammal trapping at the Herbert River site are presented in Table 3. A similar abundance of two main rodent species was detected at both the control and works areas, with a single individual of a third species detected at the control area; however, there was a great difference in the total numbers of mammals detected by trapping at each area - two species at the works and six species at the control. Three of the additional species at the control area were species typically found in denser vegetation types such as riparian forests. The water rat usually occurs in a range of habitats including grassy banks such as that at the works.

The abundance of *Melomys cervinipes* at the works area was not anticipated as this is typically a closed forest species. However, the pattern of the trapping returns for this species suggests that many of these individuals may have been drawn by the scent of the baited traps from the adjoining, more densely vegetated bank area. The attraction of small mammals to baited traps outside their usual home range area can cause problems in small areas such as the rockworks where it is impossible to provide a large buffer area between the habitat being studied and the adjoining habitat. This can lead to spurious results when attempting to describe the fauna of a small area.

The number of bird species detected during observations at each of the areas were similar. Eleven bird species were detected at the works area and thirteen at the control. There was a clear difference in the types of species encountered. Six of the species from the works area were ground-dwelling species commonly found in shrubby or grassy areas; however, none of these species were detected at the control area where the bird fauna was dominated by forest birds.

Table 3 Small mammal trapping results at the Herbert River study site

Site	Species	Abundance
Works	*Melomys cervinipes*	25
	Rattus sordidus	11
Control	*Melomys cervinipes*	28
	Rattus sordidus	14
	Rattus fuscipes	1
	Uromys	2
	Hydromys	2
	Perameles nasuta	3

The results of the small mammal trapping at the Burdekin River site are presented in Table 4. Mammals were not abundant at any of the Burdekin River sites. The old rock work area had the highest capture success with 5 individuals from two species, one being the introduced House Mouse (*Mus musculus*). Only two individuals were trapped in the control area which, although selected as the comparison area for the works, was highly disturbed by exotic weed invasion and subsequent canopy mortality. Furthermore, the remnant riparian community along this reach of the Burdekin River is disjointed and this may have an effect on mammal populations. Greater numbers of animals were expected for this area although previous survey work in the Burdekin River delta area has shown that small mammals generally occur in low densities even in riparian communities.

Table 4 Small mammal trapping results at the Burdekin River study site

Site	Species	Abundance
New Works	*Melomys burtoni*	1
Old Works	*Melomys cervinipes*	4
	Mus musculus	1
Control	*Melomys cervinipes*	2

A total of four hours of bird observations were undertaken at each site. The new works and control area had the highest diversity of species with 17 and 16 respectively, while only seven species were detected at the old works area. A similar suite of species were seen at both the new works and control sites and consisted predominantly of canopy species. At the new works, most birds were observed to be briefly visiting the two clumps of fig trees remaining within the rocks and very few individuals were observed to utilise the remaining area. These observations highlight the ecological importance of leaving established vegetation wherever possible amid rockwork. Since the work has only recently been finished there is little substantial vegetation in the area so that even ground-dwelling birds do not appear to be utilising the area.

The total number of birds detected at the new works site may reflect the ease of bird observation at the site as compared to the vine thicket community of the control site where a number of birds were unable to be identified as a result of the dense vegetation.

4. DISCUSSION

4.1 Vegetation

A few ubiquitous traits of artificial stabilisation practices in northern Queensland appear evident. Where there has been streambank stabilisation work conducted on the riverbank, the vegetation community is distinct from the intact riparian vegetation. Native species do not establish easily in the stabilisation work and often it is mostly colonised with exotics. There appears to be little regeneration of the stabilisation gaps by the adjacent native vegetation, although this may occur with time. Establishing weeds also act as seed sources for further invasion of any relatively intact remnant riparian vegetation communities. Traditional works thus provide a mechanism for an increase in the distribution of exotic species throughout a given catchment. Increases in exotic species abundances and distributions recorded during this study include declared plants (e.g. *Riccinus communis*), the management of which is governed by the Rural Lands Protection Act (1985-1990). Aquatic weeds also appear to be concentrated in the still backwaters of many of the stabilisation works.

The works have also resulted in the fragmentation of otherwise continuous riparian wildlife corridors. The importance of corridors in the maintenance of riparian and catchment integrity are widely accepted (Bennett 1990). Environmentally based stabilisation techniques such as tree planting can reduce the fragmentation effect of works programs (e.g. Mulgrave River), but the reduction will remain minimal if rock work is extensive or the main focus of a particular project (e.g. Burdekin River site). Streambank modification also results in the loss of bank habitat structures and morphology for the aquatic and terrestrial fauna.

Although current attempts at tree planting (e.g. at the top of rock dominated works) will partially re-establish a riparian corridor, they do not satisfactorily replace the original stream habitat. It is also unlikely that this landscaping approach to planting will provide long-term solutions to local bank stability problems. Further, unless specific design components (e.g. berms) are integrated with tree planting schemes, they are of little or no ecological benefit.

Traditional works also allow for the encroachment of exotic species into adjoining remnant riparian vegetation communities, which leads to further long-term degradation of stream and river ecosystems. Exotic species are usually shallow rooted when compared with native species. It follows that vegetation communities either side of the works will, over time, become more susceptible to stability problems as the exotic species invade. For stabilisation practices to fit within an ecologically sustainable framework, rock work should be minimised (e.g. restricted to the toe of the bank only) or completely absent in work designs.

The remnant riparian communities documented during this survey are highly diverse both floristically and structurally. Unfortunately, it is usually well beyond the resources of most vegetation schemes to re-establish this level of diversity. Once the replanting scheme has been in place for sufficient time for trees to approach maturity (flowering, fruiting and canopy cover becoming continuous), this

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recorded diversity could be utilised as a baseline to monitor the longer-term success of a planting program.

Another ecologically unsustainable impact of the use of rock in stabilisation works is the removal of the material from elsewhere in the catchment (usually granitic hills and mountains). This indirectly compounds the ecological impacts associated with the placement of this material in the streams and rivers of a particular region.

4.2 Aquatic Ecology

Though sorting and analysis of the macroinvertebrate samples is incomplete, some general observations can be made. Macroinvertebrates were present at both control and stabilisation works sites. At the stabilisation works sites, the community is generally diverse, but has a different structure than at control sites, particularly due to an absence of shredders (e.g. Trichoptera). It is likely that construction of revetments and other forms of stabilisation works has catastrophic, short-term consequences to invertebrate communities; however, recovery is probably rapid. The newly established macroinvertebrate community is diverse and abundant but appears to show structural and species compositional differences compared with undisturbed communities in nearby control sites. Stabilised streambanks, particularly rock armouring, provide complex habitat for instream invertebrate colonisation but attract species from less common hard and muddy substrate areas.

In large streams and rivers, small lengths of bank stabilisation are unlikely to force significant changes to instream macroinvertebrate communities; however, long sections of stabilised bank (hundreds or thousands of metres) such as those on the banks of the Burdekin River pose concerns for the integrity of stream systems. Following a full analysis of the results further conclusions may be drawn including an adjustment to those outlined above.

4.3 Terrestrial Fauna

The results have confirmed the expected species composition and patterns of distribution for birds and mammals. The impact of bank slumping and subsequent rock revetment on riparian vertebrate ecology is plain since the riparian corridor is disrupted and, most often, native vegetation species are not replaced or are replaced by exotics. Essentially, the vertebrate fauna reflects the riparian habitat quality. Continued investigations of the riparian zone were, therefore, not deemed necessary and subsequent description of the riparian zone was based on vegetation and habitat quality.

An intact riparian zone is clearly important to the riparian fauna. Loss of vegetation resulted in a reduction in species abundance and a restriction to faunal movement. An altered species composition was observed for the birds as ground dwelling, grassland species (e.g. finches and quail) replaced forest dwelling (e.g. doves and orioles) species at the works sites.

Aquatic vertebrate species of birds and mammals seemed little affected by the stabilisation works because these species are known to move greater distances and range over large areas and, normally, the scale of the river bank impact caused by streambank instability and revetment is small. However, it is important to note that at sites such as the Burdekin River, the length of continuous river bank under rock work has already reached an alarming scale which may be detrimentally affecting aquatic birds and mammals (particularly with regard to nesting and roosting sites).

5. REFERENCES

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