The influence of riparian vegetation on stream ecosystem health in the Wet Tropics

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Introduction

River ecologists have known for some time that riparian vegetation has a major controlling influence on the way forest streams function as ecosystems. The growth of aquatic plants (e.g. macrophytes and algae) is limited by shading, and inputs of leaf litter, fruits, terrestrial insects and other organic matter from the riparian zone represent the major source of organic carbon and nutrients that 'drive' stream food webs. Inputs of larger woody debris, such as logs and branches, also provide important habitat for fish and other aquatic life, and contribute to the diversity of flow and substrate conditions that favour high in-stream biodiversity. Riparian zones are also noted for their high biodiversity of terrestrial plants and animals. These are often critical areas of wildlife habitat, because of the availability of moisture, their high productivity compared with the surrounding landscape, and the high structural diversity of the vegetation. Because of these attributes, it is perhaps not surprising that streams and their riparian zones are regarded as the ***ecological arteries*** of our landscape.

These key ecological functions of riparian zones are being studied within the national program of research and development on *Rehabilitation and management of riparian lands* established by the Land and Water Resources R&D Corporation (LWRRDC), in collaboration with the CRC for Catchment Hydrology and the Centre for Catchment and In-Stream Research, Griffith University.

The emphasis of our ecological research undertaken in the wet tropics to date, has been on the influence of riparian vegetation on stream ecosystem health.

Research in progress

Forest streams

Our approach has been to first establish how forest streams in the wet tropics 'work' as ecosystems. To do this, we have measured the rates of primary production and respiration within the streams (i.e. how much organic carbon is being produced by algae and other aquatic plants and, in turn, how much is being respired by aquatic plants, bacteria and animals). The rate of carbon flux is a fundamental measure of ecosystem function and a key indicator of stream health. If streams and their riparian zones are the ecological arteries of the landscape, this could be regarded as a measure of their 'pulse'. Our preliminary work has indicated that the rates of primary production and respiration in undisturbed forest streams in the wet tropics are quite low by world standards (e.g. Gross Primary Production (GPP) ≅ 120 mg $C.m^{-2}.day^{-1}$; Respiration (R) ≅ 250 mg $C.m^{-2}.day^{-1}$). Because the ratio of GPP:R < 1, the streams are net consumers of carbon and are thus reliant on inputs of energy from the surrounding forest.

We are also interested in identifying which of the major sources of energy and nutrients, that are either produced within the streams or enter from the catchment, are important to aquatic consumers. What do the diverse array of aquatic insects, crustaceans and other invertebrates that are present in tropical streams eat? These smaller organisms represent the major food source for higher consumers, such as platypus and fish. The latter may also obtain a significant source of food in the form of inputs of terrestrial insects and fruits directly from riparian vegetation. The measurement of naturally occurring stable isotopes is one of the methods we have used to identify which sources of organic carbon drive the aquatic food web. Preliminary results confirm the over-riding importance of terrestrial sources of carbon to the aquatic food webs of small, low-order tributaries. However, diatoms and other micro-algae appear to be more important to consumers in larger, more-open stream channels.

Cane land streams

The degree of control of riparian vegetation on stream ecosystem function is perhaps best illustrated when the vegetation is cleared for agriculture. In the absence of shading from a dense riparian canopy, aquatic and semi-aquatic plants flourish, triggered by high light levels, increased stream temperatures and the higher availability of nutrients that usually find their way into streams from agricultural land. It is becoming increasingly apparent that the fauna of Australian streams has little ability to cope with this excess aquatic production, and the health of these ecosystems declines.

We have undertaken some experimental work in Bamboo Creek, a tributary of the Johnstone River near Innisfail, to determine the consequences of removal of riparian vegetation. Like many lowland catchments in the wet tropics of north-eastern Australia, very little native riparian vegetation remains and cane is grown up to the high bank. The riparian zone is dominated by para grass, a native of North Africa which was first introduced to Queensland in 1880 as a productive pasture plant. This species is now a major weed in disturbed stream channels in northern NSW and Queensland, and in the wetlands of the wet-dry tropics.

Para grass grows prolifically along the stream margins, often extending into and over the channel (Figure 1). If streams are the ecological arteries of the landscape, this surely represents a considerable cholesterol problem! For a catchment of this size, the active channel was estimated to be 10-15 m, however, the stream was restricted by a matrix of para grass and sediment to a mean width of 1-2 m and mean depth of over 1.0 m. Approximately 20,000 tonnes km^{-1} of sediment is stored in Bamboo Creek (Figure 1). We estimate that this has reduced the channel capacity from approximately three times a 1:50 year flood event to only one third of the capacity of a 1:50 flood event. This increased likelihood of flooding must represent a significant economic cost of poor riparian management.

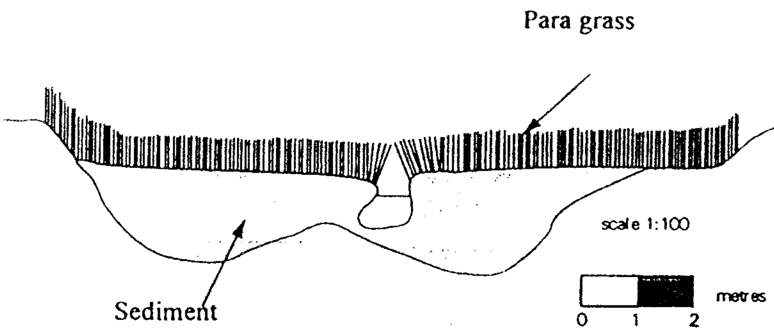

Figure 1: Stream cross-section - Bamboo Creek

Recent studies using stable isotope tracing techniques have identified that carbon from C_4 plants (which includes grasses like para grass and sugar cane) does not get taken up into aquatic food webs. The reason for this is unknown, but neither aquatic herbivores nor detritivores consume it directly, as living or dead plant matter, or indirectly via a microbial loop. This is despite the fact that much of the organic matter in the streams in cane land is of C_4 origin (cane plus para grass). This raises a broader issue for the protection and management of streams draining cane lands. What happens to all of the dissolved organic matter, and fine- and coarse-particulate organic matter that makes its way into the streams from cane lands?

The microbial breakdown of this accumulated organic matter in the stream undoubtedly leads to a deterioration in water quality. Dissolved oxygen levels measured in the open water in Bamboo Creek fluctuated wildly, indicating that rates of production and respiration were high and unstable. The surface sediments of the stream were anoxic and, not surprisingly, few invertebrates were sampled from the stream bed. Such anoxic conditions can lead to the release of nutrients and other contaminants from stream sediments and result in a further decline in water quality.

Restoring cane land streams

To assess whether shade from riparian vegetation alone was sufficient to control highly invasive weeds such as para grass, we conducted a shading experiment on Bamboo Creek. Large blocks of 90% and 50% shade cloth were strung across the channel to simulate the effect of riparian trees. Over the three month study period (August to November), the mean standing crop of para grass in the unshaded control plots increased by 50%, growing at a rate of $\cong$ 4 g $m^{-2}.day^{-1}$ (Figure 2). In contrast, the grass declined in both shade treatments, particularly under the 90% shade cloth where the final biomass was only half of that at the start.

This simple experiment confirms that shading alone can be an effective control measure for nuisance weeds in disturbed stream channels.

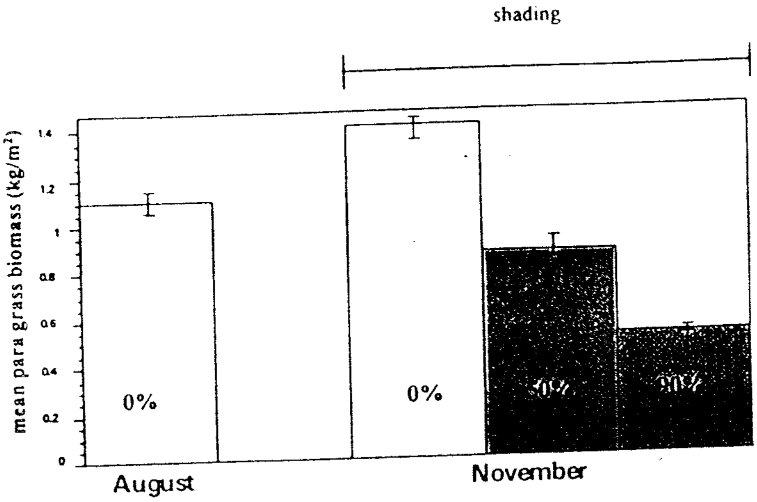

Figure 2: Effect of shade on para grass

Restoring riparian vegetation would provide a source of energy and nutrients for stream food webs, including an increased source of terrestrial insects for fish. Such direct riparian inputs are of particular importance in catchments largely under cultivation for sugar cane or other C_4 plants which apparently are not readily incorporated into aquatic food webs. In addition, shading by riparian vegetation is seen as the most cost-effective long-term control of invasive weeds, such as para grass, compared with chemical or mechanical strategies. These latter means of control may be less successful because of re-invasion or the likelihood of weed by weed replacement. Without such control, these plants will continue to contribute to water quality problems through high levels of respiration, both from living plants and unconsumed detritus. They will also continue to act as an efficient trap for sediments, destroying benthic habitat, further reducing water quality and decreasing the channel capacity.

Unfortunately, eliminating para grass may mobilise the vast quantities of sediment currently stored in the active channel, which could pose problems for coastal marine systems. Cane land streams cannot be regarded as a permanent store for sediments, however, as high discharge events inevitably will lead to scouring of the channel and downstream transport of both sediment and associated high biomass of plant matter.

Effectiveness of riparian rehabilitation

Considerable resources have been (and continue to be) expended on the rehabilitation of riparian zones throughout Australia. This may be for aesthetic reasons, to enhance bank stability, filter sediment and nutrients, protect river ecosystems and improve water quality, or for provision of wildlife corridors. Unfortunately, little effort has been made to determine whether such re-planting have actually achieved the desired function.

This important question is being addressed in a comparative study of sites on the Atherton Tableland that differ in the time since rehabilitation, together with monitoring of selected sites and after restoration. Comparison with data from forested sites will enable us to .nine the effectiveness of riparian revegetation on improving stream ecosystem health.

,treams in open pasture without riparian cover, have high rates of primary production and respiration (at least 5 times that of the forest sites). In the older rehabilitated stream sites on the Atherton Tableland (e.g. Clemenson Creek), it appears that shading has reduced plant biomass and the rates of aquatic plant production. However, many of the sites still have vast amounts of fine sediments stored in the channel, presumably trapped by reeds and other aquatic vegetation prior to revegetation. As observed in Bamboo Creek, the direct presence of this sediment and low oxygen levels resulting from microbial decay of accumulated organic matter effectively eliminates habitat for bottom dwelling stream invertebrates. Recovery of these streams will depend on whether the fine sediments can be mobilised by scouring flows once the aquatic weeds are gone. This issue will be examined under the *Physical and Chemical Processes* component of the Riparian Program, coordinated by Dr Ian Prosser.

Further reading

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