Effects of rural land use (especially forestry) and riparian management on stream habitat

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Abstract

Mature plantation forests provide broadly similar stream habitat conditions to native forest and streams in these land uses typically have quite similar invertebrate and fish faunas. However, logging and replanting create regular disturbances to streams in plantations that can impact adversely on aquatic habitat and biota. Streamside riparian areas occupy the interface between the land and water and recent New Zealand studies have shown that maintaining forest vegetation in the riparian area during logging, together with sound land management practices elsewhere in the catchment, can protect streams from much of the disturbance that otherwise occurs during and after logging.

Introduction

New Zealand was mostly covered with a cloak of forest before humans arrived and streams would have had relatively low inputs of nutrients and sediment, shaded headwaters, and faunas adapted to forest conditions. Human colonisation and land clearance to produce food and fibre has reduced native forest cover from around 85% to 29% (including 6% in plantation forests), with the remainder mainly in pasture. This change in vegetation cover from forest to pasture produces distinctly different headwater stream faunas, reflecting the changes in predominant food resources (more algae and less leaf litter), habitat (less wood, more fine sediment, flashier flows, lack of riparian vegetation for life cycle completion by adult phases of many insects) and water quality (e.g. higher temperature maxima and fluctuations, more nutrient and agrichemical input) (Quinn 2000).

Pastoral development also tends to homogenise habitat conditions along the river system: high light conditions become universal compared with natural forest streams that have shaded headwaters that open up as the stream widens downstream. This loss of habitat variability tends to reduce biodiversity. Replacement of native forest by pine plantations has much less impact on streams than conversion to pasture, but logging and replanting create regular disturbances that alter stream habitats substantially (Fahey *et al.* 2004).

The challenge for resource managers is to control the impacts of land use for food and fibre production to maintain the intrinsic values and ecosystem services of aquatic ecosystems (e.g. clean water for human use and livestock, uncontaminated food, recreation). In broad terms, such efforts need to focus on reducing contaminant loads (e.g. by managing inputs and connectivity to water) and maintaining key habitat features of aquatic ecosystems. Streamside riparian areas occupy the interface between land and water and exert a disproportionately large influence on stream conditions in relation to the area they occupy. Thus management of vegetation and disturbance in riparian areas is an important element in the tool-box of management measures to control land use impacts on aquatic ecosystems.

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Riparian buffer influences on logging impacts

Recent research on the influence of logging operations on Coromandel Peninsula streams has shown the protective function of riparian buffers. Where streams had no riparian buffers (i.e. catchments are clearcut), we found streams had wider channels, more bank erosion, higher light input and maximum water temperatures, invertebrate communities with lower diversity and altered composition (more tolerant species), and very low abundance of banded kokopu (Rowe *et al.* 2002, Boothroyd *et al.* 2004, Quinn *et al.* 2004). In contrast, streams that retained intact buffers of riparian forest (average 18 m wide either side) throughout logging operations had the following characteristics:

- Maintained low light conditions, that prevent undesirable blooms of algae and keep water temperatures below levels that are lethal to sensitive aquatic invertebrates and fish (Boothroyd *et al.* 2004).
- Maintained desirable cool air temperatures in the near-stream area used by the adult phases of aquatic insects (Meleason & Quinn 2004).
- Reduced stream bank erosion (Boothroyd *et al.* 2004).
- Maintained the diversity, richness and community composition of stream invertebrates and native fish similar to that in mature pine and native forest streams (Quinn *et al.* 2004, Rowe *et al.* 2002).

Additional studies in this area have also shown that riparian buffers reduce the input of "logging slash" to stream channels (Fahey *et al.* 2004). Buffers that were continuous along the perennially flowing channel were more effective than those that started just upstream of the study reach, probably because the latter stream reaches imported heat and sediment from the clearcut area upstream (Quinn *et al.* 2004). However, stream habitat conditions are expected to improve with distance downstream through the buffered area (Scarsbrook & Halliday 1999).

Long-term monitoring indicates that invertebrate communities in small Coromandel streams (c. 3-5 m wide channels) take about 7-10 years to recover from the effects of clear-felling and removal of logging slash from the stream. This is the time taken for riparian regrowth to control instream algal blooms and reduce summer temperatures below stressful levels (Author's unpublished data). Retaining riparian buffers during logging can eliminate this period of habitat and faunal disturbance, that otherwise lasts for about one third of each forest rotation.

Photo 1: *Views of Coromandel stream channels with10 m wide native forest riparian buffers.*

These findings demonstrate that forested riparian buffers can be very effective for controlling the disturbance of clearfell logging on stream habitat and biota and maintaining the benefits to streams of afforestation. Earlier research on riparian buffers along pastoral streams in Southland showed similar benefits for channel morphology (Williamson *et al.* 1992) and invertebrate communities (Quinn *et al.* 1992). In pastoral catchments, fenced and planted riparian buffers have the added benefit of excluding stock that damage streambanks (Trimble & Mendel 1995) and input excreta.

Buffers and sediment control

Riparian buffers in planted forests also have potential to act as filters of sediment and associated nutrients in runoff from cutover areas and forest roads, thus protecting water clarity and controlling downstream export. Buffers can do this by providing layers of undisturbed litter that can slow diffuse runoff, encouraging sediment settling before it reaches the stream. However, where runoff is concentrated in gullies, as often occurs with runoff from water-tables along forest roads (Croke & Mockler 2001), buffers may be less effective. Buffers may help to control hillslope mass movement by buttressing the base of hillslopes through root reinforcement, however they are expected to have limited ability to control sediment input from upslope slip erosion.

Buffer width for vegetation stability

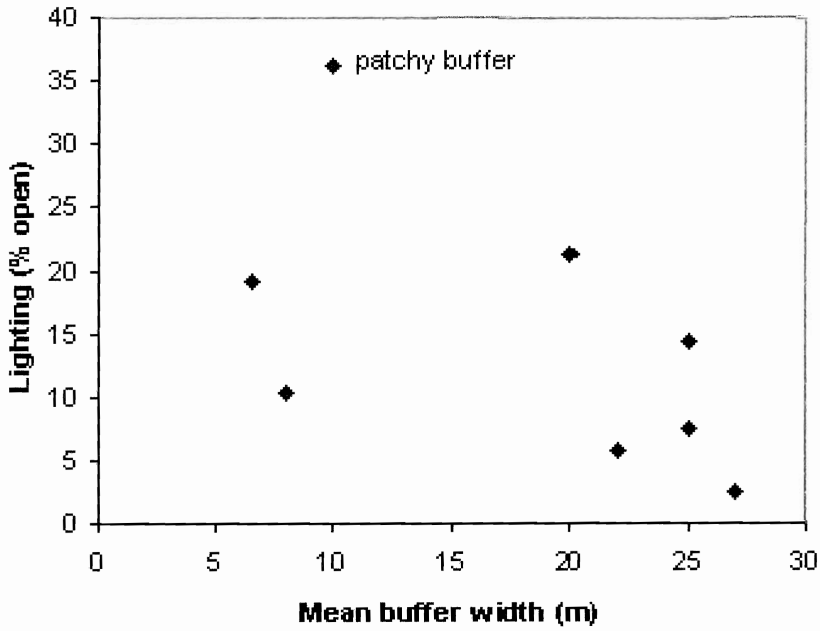
A review of minimum buffer widths for sustainable riparian native forests concluded that 20 m was optimal and 10 m would be the minimum recommended width to provide conditions for self-regeneration and minimal management intervention for weed control in agricultural catchments (Parkyn *et al.* 2000). The situation in planted forests differs to that in pasture because the pine forest around the native riparian forest buffer extends the forest conditions, protecting the riparian forest from the climatic extremes of (wind, air temperature etc) that occur in pastoral landscapes during the mid-late phase of the forest rotation (from about 8-25 years).

This might suggest that narrower buffers are sustainable in planted forests compared with in pasture. However, forested buffers are prone to windthrow damage due to the change in climate between logging and regrowth of the plantation timber trees, particularly in the first few years after logging before the riparian trees become "wind-hardened" (Grizzel & Wolff 1998). Some overseas studies indicate that the trees on the outer edge of riparian buffers are most likely to be subject to windthrow after logging (Wilson 2004), and the narrower the buffer the bigger proportion of the buffer will be affected by windthrow. Nevertheless, studies in eastern Oregon (Steinblums *et al.* 1984), coastal Oregon (Andrus & Froehlich 1992), and Quebec (Ruel *et al.* 2001) did not find a relationship between riparian buffer stability and buffer width.

Other factors that influence windthrow susceptibility

Photo 2: *Headwater pine plantation stream protected by a riparian buffer after logging.*

Fig. 1: Relationship between stream lighting (as % of an open site, i.e., 100% = zero shade) and mean riparian buffer width in recently logged pine forests of Coromandel Peninsula (redrawn from data in Boothroyd et al. 2004).



are: wind climate, conditions that restrict rooting depth (e.g. hardpans, bedrock, shallow water tables), low soil strength and stand attributes (e.g. species composition, height/diameter ratios of trees and exposure to flood flows) (Wilkinson *et al.* 1999, Wilson 2004). Windthrow affected 33% of buffer trees (range 2-92% across the individual sites) in a study of 40 forest riparian buffers in northwestern Washington. Other studies in the Pacific Northwest reported averages of 5-29% windthrow in forest buffers (Grizzel & Wolff 1998). Grizzel and Wolff (1998) concluded that windthrow was not a significant source of sediment delivery to channels in their study streams.

Whether wood input to the channel from windthrow is seen as a positive (e.g. providing instream wood as a habitat diversity enhancer and retainer of instream sediment) or a negative (e.g. potential for downstream problems with wood blockage and damage to engineering structures and fences in floods) will depend on site-specific issues.

New Zealand riparian buffers are often dominated by kanuka and tree ferns, species that offer less wind resistance than tall conifers. As a result we might expect lower rates of windthrow in NZ conditions. The issues of post-logging riparian buffer stability and weed invasion are being addressed in a current study by Forest Research.

Buffer width and stream shade

The influence of buffers on stream lighting/shade has a bearing on the "how wide?" debate. Steinblums *et al.* (1984) described the relationship between stream shade and buffer strip width in logged forests of eastern Oregon and found typical shading provided by a 15 m wide buffer was about half that provided by a 40 m wide buffer.

However, the limited data from the Coromandel study (only 8 sites) indicates a weak relationship between stream shading and buffer width over the range 6.5 to 27 m for buffer width (Fig. 1). This relationship is somewhat confounded by the variation in channel widths (2-9 m wide) in the study and more data are needed to provide a sound basis for using buffer width/shade relationships for guiding buffer dimensions. Nevertheless, the Coromandel findings indicate that a buffer of riparian forest as narrow as 6.5 to 8 m can provide stream lighting of <20% of open sites, which was sufficient to prevent algal blooms after logging (Boothroyd *et al.* 2004).

Riparian buffers as a component for integrated catchment management

Recent research at Coromandel Peninsula supports the use of forested riparian buffers as a tool to reduce the disturbance of stream habitats and biota that would otherwise occur during logging. By managing the vegetation and disturbance of the riparian area that is in most intimate contact with the stream, we can help protect the stream from effects of land disturbance elsewhere in its catchment. However, this does not remove the need for sound land management practices beyond the riparian area to both maintain the productive capacity of the land and reduce loss of contaminants that may otherwise overwhelm the buffering capacity of riparian areas.

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