Answers to frequently asked questions on riparian management

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1. Introduction

A set of frequently asked questions (FAQs) about riparian management was developed by Hawkes Bay Regional Council staff to guide preparation of resources for a training workshop on targeted riparian management in Napier on 8-9 May 2007. The answers to these questions, developed by the course presenters in consultation with NIWA colleagues, provide a resource that is likely to be useful to land and water managers, policy makers, land owners and the public. The answers aim to briefly summarise the state of knowledge on key questions about riparian management identified by council staff.

2. FAQs and answers

2.1 Nutrient Management

a. **Which plants remove what nutrients from the groundwater as it moves through the land to water interface?**

Answer: All living plants will remove nutrients from groundwater, provided that their roots interact with the groundwater flows. If the groundwater is very shallow (say < 0.3 m below the surface) then grasses and sedges will be sufficiently deep rooting to be effective, whereas at < 1 m shrubs would be required and at > 1 m trees with deeper growing roots will be needed.

Plant litter also enhances nutrient removal from shallow groundwater by fueling the microbial processes of denitrification and nutrient uptake into biomass.

b. **Should nitrogen fixing trees** (e.g., kowhai, kaka beak, tutu) **be avoided in riparian buffers intended for nutrient attenuation?**

Answer: Most N-fixing plants are facultative N-fixers, meaning that they will use the available N if it is high rather than putting energy into symbiotic organisms that fix atmospheric N. Consequently, N-fixing plants are expected to do more good than harm in N-rich conditions of riparian buffers receiving high N loads. The effects of such species have not been studied in NZ buffers.

c. **Is it necessary to harvest and dispose of, or relocate (e.g., through grazing), riparian vegetation (e.g., grass) that has taken up nutrients from the water?**

Answers:

(1) If the main nutrient removal process is denitrification of nitrogen, then it is important to build up the soil carbon (that fuels this process) by allowing incorporation of decaying vegetation. Wetland vegetation may also enhance net denitrification in very boggy (highly anoxic) soils by releasing oxygen out from their roots (Matheson et al. 2002). So in these situations vegetation removal is likely to be detrimental.

(2) If the main removal process is via plant uptake of nutrients into their biomass, then there will be a need to remove some of this biomass to maintain long-term functioning. This is probably best done during spring

and mid-summer when nutrient contents in aboveground biomass are likely to be highest (Drake, pers. comm.)

(3) If the main process is trapping of soluble particulate nutrients in overland flow by adsorption onto soil particles, then there is potential for the soil P adsorption sites to become saturated with time. Actively growing vegetation and active soil microbial systems will help to maintain active soil adsorption sites (by removing bound P) so there is a need to manage the system to maintain healthy soils and growing conditions. Here periodic short-term grazing or other harvesting is desirable.

(4) If the main process is the removal of particulates from overland flow by infiltration and deposition, this requires dense groundcover and management to prevent channelisation and compaction. The key aspects to manage differ between forested and grass riparian buffers.

(4a) For forested strips the buildup of plant litter is the main source of roughness that dams up surface runoff allowing particle settling, and this will accumulate with time. It is important that vegetation management does not disturb such layers (e.g., by stock trampling or harvesting/extraction forming flow channels).

(4b) For grass filter strips, dense near-ground vegetation (which slows down the flow and causes a backwater in which settling occurs) and uncompacted soils (with high infiltration rates) are important and these aspects need to be managed to maintain the function. The vegetation density in the bottom 10-15 cm of the grass sward needs to be maintained at a high level and there is a need to avoid development of channels that can short-circuit flows through the filter. This will require some vegetation management – probably light grazing at about 6 monthly intervals. This is probably best timed at early spring (to stimulate spring growth) and in autumn (early enough to insure re-establishment of a good cover before winter). If the terrain permits then hay making (in summer) may be the best option. If stock grazing is being used, this is best if managed to minimise treading damage and compaction of the soil, erosion of streambanks, and direct animal input of nutrients and pathogens to the buffer. Just how this is achieved will vary with the situation. If the grass is long, grazing by cattle is likely to be more effective than sheep grazing. For narrow buffers, it may be possible to allow cattle to browse the vegetation over the fence by adjusting the wires. For wider buffers, short periods of well-controlled mob grazing (to minimize faecal and urine inputs to the buffer) are expected to be better than longer periods of grazing at lower animal densities. This grazing also needs to be timed in a fine weather window to allow some regrowth before a rain event.

d. How effective are marsh areas/wetlands in the upper catchment in stripping nutrients and where do they go?

Answer: These are often very effective particularly under low flow conditions and when the inflows occur as seepage rather than surface flow. Under these conditions we would expect 60-90% removal of N and 30-50% removal of P for suitably sized wetlands (e.g., wetland area = 1-3% of catchment area drained). They don’t work so well if the inflow is as surface flow (rather than sub-surface seepage) or at high flows if flow is channelised resulting in short-circuiting of the wetland with little interactions of the surface flow and the wetland soils (Rutherford & Nguyen 2004). Engineering to spread the flow across the wetland (e.g., the “rice-paddy concept” involving placing timber (say 150 mm x 50 mm on edge) across preferred flow paths to slow flow, or developing a “grass hedge” at the upper edge of the wetland) are expected to improve wetland performance.

Nitrogen is removed by four processes in wetlands (Burgin and Hamilton 2007): (1) plant and microbial uptake into biomass which is harvested and removed or sequestered in long-lived plant tissues (e.g., wood) and/or accumulates as humic matter (e.g., peat); (2) respiratory denitrification of nitrate to N gases that are released it to atmosphere (N_2O (a greenhouse gas) and N_2 (inert = the desirable product)); (3) anammox (anaerobic ammonium oxidation to N_2); and (4) nitrate reduction to ammonium, which tends to occur in highly anoxic conditions in wetlands that lack plants that otherwise pump some oxygen into the sediments thus favouring the denitrifying process (Matheson et al. 2002).

Dissolved P is removed by interaction with soil microbes and bound to cations (Fe, Ca, Al, Mg…) and some P will be taken up into plant biomass. Particulate P is initially settled with solids, so that settling and infiltration processes are important. In erosive environments, the accumulated sediment, P and organic N may be lost downstream when/if wetland is eroded in a high rain event (e.g., high slope, with periodic high rainfall). Fragile wetlands could be stabilized by strategic planting (e.g., kahikatea, swamp maire, raupo, flax, toetoe) or managed by periodic dredging (say every 10 years) with spreading of the accumulated nutrient-rich soil in a safe location.

Stock access can cause channels (through compaction and grazing) that reduce nutrient removal effectiveness by allowing water to bypass the wetland soil. Direct inputs from stock to the area also increase nutrient/pathogen export greatly, with very high faecal output while the stock are in the wetland. Wetlands are saturated areas that are directly connected to the streams so stock should not be in them. Seasonally saturated areas can be grazed by sheep (that do less damage than cattle) in the dry season to remove accumulated biomass.

e. What width of protection is needed to stop, or significantly reduce, nutrient movement into the waterway?

Answer: The width required for trapping of particulate nutrients in surface runoff varies as a function of slope length, slope angle, clay type and drainage (how the water moves across the landscape). It can be estimated for NZ situations using Table 1 below from guidelines produced for the Department of Conservation in 1995 (DOC 1995). Generally conditions that produce larger runoff volumes such as higher rainfall, lower drainage, greater soil erodibility and steeper slopes will decrease trapping efficiency. Trapping for particulate nutrients is likely to be similar to those estimated for sediment. Dissolved nutrients in surface runoff are retained primarily by infiltration of runoff (and subsequent uptake by soil microbes and plants) and thus higher soil permeability and flatter slopes will increase removal (assuming the riparian zone soil is not saturated). No similar summary guidance is available on buffer dimensions for attenuation of nutrients in shallow groundwater inflows to streams through riparian areas.

Table 1: Predicted optimal filter width and performance for suspended sediment removal as a function of land slope class (L = <8˚, M = 8 - 20˚, H = >20˚), drainage class (L = <4 mm h^{-1}, M = 5-64 mm h^{-1}, >20 mm h^{-1}), and clay content of the topsoil (from the Land Resources Inventory: L = <20%; M = 20-40%; H = >40%) (DOC 1995). Note that these predictions are based on performance of well-designed grass filter strips with dense groundcover. Somewhat lower removal efficiencies might be expected from real-farm buffers.

SITE CHARACTERISTICS			FILTER WIDTH (% hillslope length)	FILTER PERFORMANCE (% reduction)
SLOPE	DRAINAGE	CLAY		
L	L	L	1	95
		M	5	90
		H	9	80
	M	L	1	95
		M	2	90
		H	4	80
	H	L	1	95
		M	1	95
		H	3	85
M	L	L	2	90
		M	7	70
		H	15	50
	M	L	1	95
		M	4	80
		H	11	55
	H	L	1	95
		M	2	85
		H	4	60
H	L	L	5	45
		M	15	30
		H	30	20
	M	L	3	60
		M	7	50
		H	13	35
	H	L	3	75
		M	4	70
		H	11	50

f. What vegetation cover is best to strip nutrients inside the protection fence, what is practical?

Answer: The best vegetation cover will vary depending on whether the flows are surface or sub-surface runoff. A grass filter is probably best for surface flows but stable litter layers can also dam up surface flows causing settling. If flows are sub-surface and deeper than 0.3 m, then shrubs and trees may intercept the water (deeper roots). Multiple tiers of vegetation (e.g., grass filter strip on pasture edge, then deeper rooted production trees that are harvested at intervals, then conservation trees maintained on the streambanks are expected to be most effective (Lowrance et al. 1997).

g. **Does a grass cover inside the fence need to be managed to maximise stripping ability or can it be left year after year? If the former, what management is appropriate?**

Answer: If surface runoff is a major flowpath, the grass will probably need controlled grazing or mowing to maintain dense sward rather than rank growths through which the water can channel (see above). Erect grasses are desirable in areas where the depth of the surface flow exceeds a few mm, whereas grasses that form clumps or are highly flexible (so that they lie down when exposed to a surface flow) are less desirable.

h. **Does a tree (shrub) cover effectively strip nutrients or does it just provide other values such as shade, litter, temp reduction?**

Answer: Yes trees remove nutrients by (i) increasing infiltration of water into the soil, resulting in filtration and removal of particles and dissolved nutrients into the soil ecosystem; (ii) forming litter layers that may dam-up surface runoff (creating settling conditions), and filter particulates; (iii) tree and shrub roots that intercept groundwater will take up nutrients into plant biomass and provide carbon for denitrification. Trees & shrubs can also enhance streambank stability, provide cover for fish and habitat for adult phase of stream invertebrates for life history completion, provide wood input, and enhance the aesthetics of streams.

i. **Other than sediment interception areas do riparian zones have a use in commercial forestry?**

Answer: Yes riparian zones play key roles in reducing the stream habitat disturbance associated with logging (e.g., removal of stream shade, loss of organic litter input after logging) and consequent ecological disturbance (Quinn, 2005). They also reduce ground disturbance near the channel, and air temperature (for stream insect adult phases). It needs to be remembered that in commercial forest logging situations there are other sediment pathways that may bypass the riparian area and need to be managed (e.g., runoff from roads, earthworks, landings and landslides).

j. **Point sourcing. In terms of water quality, if stock are restricted to designated access points would they have more or less environmental impact than if they could access a longer length of stream?**

Answer: Ideally troughs or nose-pumps would be used for off-channel watering, because this is better for the health of stock and the stream. However, if this is impractical, we consider that having a single access point in a paddock is beneficial because of reduced spatial extent of damage to stream banks and riparian vegetation. It is best if the access point is sited at a stable area of the stream (e.g., bedrock outcrop or cobble area) and runoff from the access can be minimised by locating it where the lead in area of direct drainage is minimised. Stock and access should be managed to allow them to drink but not wallow/loiter in the stream. This is particularly important for cattle are more likely to defecate when in water and for deer, that have often wallow in water/wet areas.

k. **Is riparian fencing just a band-aid on the real problem - stocking densities & inappropriate fertiliser use?**

Answer: It is more than a band aid – getting the stock out of the water is a big advance. Furthermore, restoring forested habitat conditions of shade and litter input to pastoral streams is hugely beneficial for native fauna. Riparian fencing is part of a package of things needed to develop water-sensitive agricultural systems that have a strong focus on efficient use of resources and controlling contaminants at source.

l. **What length of protected stream is needed before improvements in water quality and stream quality to occur, and what length of unprotected areas downstream will cause these improvements to be lost?**

Answer: It depends on the management goals and the system characteristics. For stream temperature control this is well understood and has been modelled. Small (shallow) streams cool down or heat up quickly when they enter or leave an area of good riparian shade (at about 1 °C / 100 m of shaded stream in summer for first order streams (modelled depth 20 cm) and slightly over 1 °C / km for third order streams (see Fig. 42 in Rutherford et al. 1999). Larger (deeper) streams take longer to heat and cool. Effects on nutrients depend on the inputs to the reach buffered relative to those from upstream. This has been modelled in the paper of Parkyn et al. (2005).

m. **Is there an optimal level of light that maintains instream functions of nutrient attenuation, whilst allowing riparian attenuation of nutrients and other stream benefits through riparian vegetation development?**

Answer: It is likely that there is no such overall optimum lighting level. Instead different values will probably need to be traded off, or compromised, in relation to site-specific priorities. For example, protecting cool stream temperatures in NZ streams will often require maintaining lighting at <30% of open lighting (Rutherford et al. 1999), whereas instream nutrient attenuation declines once lighting drops below 60-80% of open lighting (Matheson, Quinn and Martin in review).

2.2 Vegetation change

a. **If we ask landowners to remove willows and plant with natives, is it reasonable to expect that stream bank erosion and changes in stream morphology will be minimal?**

Answer: Willows have denser, stronger and deeper root systems than natives studied to date. Whether replacement results in erosion will depend on the severity of the erosive forces at a place and things like bank height relative to the rooting depth of trees used to replace willows. If willows are to be replaced, it seems sensible that it should be done progressively (maybe over a decade), thinning out the willows as the new plants establish. In situations with moderate erosion problems, natives may be better long-term bank protectors, despite their lower rooting strength, because they are less at risk to disease-devastation (e.g., current problem with willow saw-fly infestation), and provide intrinsic biodiversity benefits.

b. **Could changing the existing vegetation type induce dramatic changes as the river returns to a more natural system? For example, in terms of pasture loss, a landowner with a steep banked 5m wide stream may not be so keen if he thought he might end up with a 10m wide stream with sloping sides.**

Answer: This depends on the stream power – often the existing vegetation is ineffective at preventing channel widening and incision during big events and does not contribute to downstream flood control. Channel widening may occur in pasture that develops very high levels of light reduction under shade (e.g., lighting = <10% of open). Many managed buffers will often be more open, so this may not be such a big issue.

c. **Clearing willows when riparian fencing - are you doing more harm than good?**

Answer: It depends on how it is done. First rule should be "do no long-term harm". Guidelines are available:
http://www.dpiw.tas.gov.au/inter.nsf/Attachments/JMUY-4YY8LE/$FILE/rivercareguide2000.PDF.

2.3 Hill country

a. **In hill country Class VI and VII land, how effective is riparian planting in trapping sediment and nutrient stripping?**

Answer: Smith's (1989) Scotsman's valley study showed grass filter strips can be very effective in hill country (probably Class V-VI site) if surface runoff is an important flow pathway. Flow convergence zones in such catchments provide challenges and opportunities for targeted interception and management as "in channel" wetlands. To address this we are currently working on contour filter strips placed out in the paddocks that are periodically grazed.

b. **In hill country what method can you propose to reduce the channeling for water through planted/fenced riparian margins after a heavy rain event?**

Answer: Extend buffers into preferential source areas and/or create flow obstructions that slow and spread flow, preventing channelisation, and/or create buffers in paddocks before water is channelised. Link water management to soil conservation as an integrated system.

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