Riparian Management along Headwater Streams in Coastal British Columbia

Dr. John S. Richardson

Riparian management originated largely to protect fish habitat and water quality, but now considers other environmental values, including riparian and wildlife. More than three decades of study of clearcutting to the streamside have tracked biological, chemical, and physical effects (e.g., temperature alterations, increased turbidity, loss of pool habitat, reduction of organic matter inputs, increased algal biomass). Nevertheless, management practices around streams of the Pacific Northwest and elsewhere vary greatly, and can depend on land ownership. Few studies have looked at any particular configurations of riparian reserves, including around small, or headwater, streams (Gomi *et al.* 2002; Moore and Richardson 2003). Studies on larger streams with riparian reserves are even rarer.

The commonly used buffer width of 30 m comes primarily from the Pacific Northwest (PNW) in consideration of the sources of large woody debris forming salmonid habitat within streams (FEMAT 1993). The focus on stream salmonids has often been said to protect other stream-associated species, but this assertion remains untested. Widths other than 30 m may be needed to meet certain objectives. Riparian reserve widths from 60 to over 100 m may be needed if the objectives were to maintain pre-logging densities of some wildlife in the buffer strips (e.g., Darveau *et al.* 1995; Vesely and McComb 2002). However, the fate of small streams that lack substantial populations of salmonids—but that may supply organic matter and invertebrates to downstream, a source of clean water, and habitat for other species—has rarely been considered. Most jurisdictions in the PNW stratify stream protection based on fish presence and domestic water use regardless of stream size. Only Oregon and British Columbia have management systems that are further stratified by size. Regardless, the level of protection from a 30-m reserve, 10-m reserve, or partial harvesting (various versions of variable retention) is unknown.

In this study, the project team tested the effectiveness of different widths of riparian reserves along small streams, within a full ecosystem approach. Here, I present some of the biological results to date.

View upstream of South Creek at the Malcom Knapp Research Forest showing the 30-m riparian reserve.

John Richardson

The Riparian Management Experiment at Malcolm Knapp Research Forest (MKRF)

At the MKRF, near Maple Ridge, B.C., we used a replicated (*n* = 3 or 4), BACI (before-after control-impact to control for site-to-site differences) experiment to evaluate the effectiveness of riparian reserves. We assigned 13 small streams to one of four treatments: controls, 30-m reserves, 10-m reserves, and clearcuts. Before logging in late 1998, we studied the initial conditions of all the streams and riparian areas for at least 1.5 years to control for stream-to-stream variation, which can otherwise confound even well-replicated studies. We have measured many aspects of the stream and riparian ecosystems (Figure 1) for 5 years post-treatment. The average bankfull width across the streams was

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2.0 m, average annual discharge was 5–32 L/s, and average depths were 9–20 cm. In each of these small watersheds (11.5–46.8 ha), about 25% of the trees were removed (Kiffney *et al.* 2000). A buffer of the same width was left on both sides of the stream. The treatment affected from 250 to 600 m of stream length. The forests were originally logged in the early part of the 1900s and stands grew from a 1931 wildfire, such that all stands were "thrifty" when we began this study. The forest is in the Coastal Western Hemlock (CWHdm1) biogeoclimatic zone.

Results to Date

Stream food webs

Light at the stream surface increased as buffer width narrowed. Water temperatures were also elevated above controls at the logged sites. The 30-m reserves showed up to fourfold increases in algal biomass relative to controls (in some seasons), and even higher amounts of algae with 10-m buffers or clearcut (Kiffney *et al.*, in press). With narrower reserves, the mix shifted to filamentous algal forms, which contributed to larger amounts of inorganic particles in the algal mat. The densities of midge larvae increased with increased amounts of algae. Mayfly and caddisfly numbers were inversely related to the amounts of inorganic matter on the experimental tiles, perhaps because these particles interfere with their feeding. The benthic community shifted to more generalist species (i.e., broader range of habitat tolerances) with decreasing amounts of streamside protection and shade.

Organic matter from riparian vegetation is a primary source of energy to stream food webs. Litter input rates were maintained from 10- and 30-m riparian reserves at levels similar to controls. Not surprisingly, the input rates to clearcut streams declined to about 10% of the inputs to streams with some forest cover. The amount of large particles of organic matter exported to downstream reaches from streams with clearcuts and 10-m buffers declined to about 25% of the export from control and 30-m buffer streams (Kiffney *et al.* 2000). Concentrations of dissolved organic matter (leached from leaf litter), which is derived primarily from groundwater, did not decline, although qualitative changes could accompany changes in forest canopy (McArthur and Richardson 2002).

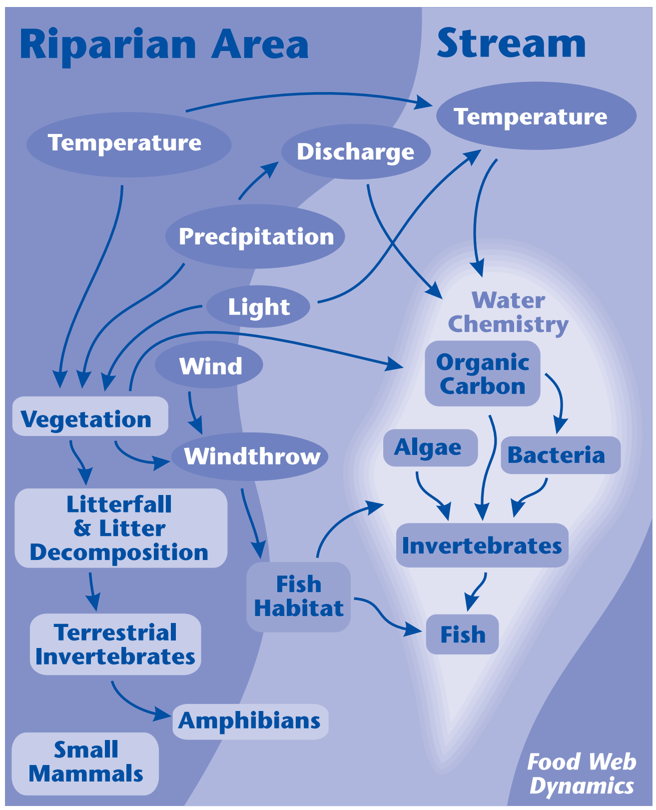

Figure 1. Elements of the riparian management experiment at UBC's Malcolm Knapp Research Forest, Maple Ridge, B.C.

Small mammals, amphibians, and invertebrates

We live-trapped amphibians and small mammals at 8 of our sites (controls, 30-m buffers, and clearcuts). For small mammals, species richness was significantly lower in clearcuts than in controls and buffers (Cockle and Richardson 2003). Small mammals varied in their response, with decreases in forest specialists such as red-backed voles and dusky shrews, and increases in creeping voles. Significantly more deer mice and creeping voles were infested with bot flies at clearcut sites than at buffer sites; no animals were infested at any of the control sites. Such infestations are likely not favourable to these animals. Riparian reserves appear to reduce, but not eliminate, the short-term impacts of clearcutting on small mammal communities.

Amphibians did not significantly decline in abundance immediately after logging, but growth rates were lower in clearcut sites relative to controls (Maxcy and Richardson, in review). Most species' abundances changed little 1-year post-harvest in the buffer and clearcut treatments. However, the relative abundance of red-backed salamanders increased on clearcut sites compared with controls. Shifts in distribution and increased parallel movement for the aquatic-breeding salamanders in the buffer treatments suggest these buffers may be acting as corridors for movement. Riparian buffers of 30 m appear to effectively mitigate the effects of forest harvesting for many of the forest amphibians and small mammals. In the longer term, lower densities on the clearcut sites have persisted from years 2 to 4 post-harvesting, but all species still occur at the sites.

We used pitfall traps at fixed distances from the riparian edge for 21 sites to determine how the ground invertebrates (e.g., beetles, spiders, millipedes, centipedes) responded to our treatments. The shifts in the invertebrate community were complex, but the assemblages changed in response to clearcutting, and the buffer sites were intermediate in their responses.

Results are still being worked up on the many studies within the bigger project. Eventually, we will combine the various measurements and process-based studies into an ecosystem model to understand some of the causal relations.

What Is the Future of Riparian Management?

It might be naïve to expect no change following forest harvesting in headwater basins, even with 30-m reserves. We need to ask how much change, and at what scale, is unacceptable or will not recover in a "reasonable" time frame. Even two- to fivefold increases in algae biomass may only persist until the regenerating stand produces enough shade to reduce algal production. To date, no studies have followed the recovery trajectories of biological communities within riparian reserves for more than a few years after harvesting. With further observations, we will be able to evaluate how long it takes to recover to baseline conditions for each of the attributes. The recovery of these systems may not be along the pathways or at rates expected. Moreover, recovery in second rotations may differ from old-growth forests (Richardson *et al.* 2002). Finally, we need to develop means for evaluating cumulative effects downstream, which have defied simple application in most places.

Other approaches to managing riparian forests besides fixed-width buffers need to be evaluated. Other jurisdictions are considering moving towards partial harvest regimes for riparian areas, often with little study. With this in mind, in 2002 we began testing partial harvest within riparian areas of three small streams at MKRF. In each of the new sites, 50% of basal area of trees within the riparian area will be removed, controlling for the same amount of total removal per watershed (~25%). We are using the same three control streams as before.

Reserving riparian areas around small streams remains contentious, and further losses of harvestable land base will be resisted. One option would be reallocation of the "allotment" available for riparian protection to include smaller streams at the expense of larger streams that already receive lots of light radiation. Solutions beyond narrow, linear strips of trees are preferable.

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For further information, contact:

John S. Richardson
Department of Forest Sciences
3041 – 2424 Main Mall
University of British Columbia
Vancouver, BC V6T 1Z4
E-mail : john.richardson@ubc.ca

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Further information on this project and others is available at:

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