



**Biodiversity**  
Management Concepts  
in Landscape Ecology

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March 1998

*“... the ecological processes of riparian habitats must be sustained to maintain landscape-level biodiversity ...”*

## Riparian Areas: Providing Landscape Habitat Diversity PART 5 of 7<sup>1</sup>

### Introduction

Riparian areas represent less than 10% of the provincial land base, but are often considered the most dynamic of all landscape features. Natural disturbances and fluvial processes continually work together in these areas to create distinctive ecosystems that are crucial for biological habitat diversity. Because of their usually abundant supplies of water and nutrients, most riparian sites are highly productive for timber. Riparian ecosystems also exert a great influence over animal and plant life, and many wildlife species depend on riparian areas in some way for food, water, security, rest, travel, and reproduction.

However, because riparian areas usually occupy the lowest topographic positions in landscapes and have natural connections throughout the watershed, they are particularly sensitive. Many of the known negative effects of historical land-use practices on forested riparian areas resulted from a focus on the individual stand or stream reach. Resource managers now realize that a larger landscape perspective and longer timeframes are necessary when planning land-use activities in riparian zones.

The Forest Practices Code acknowledges the importance of landscape

ecology concepts by enabling district managers to designate planning areas called landscape units, each with specific landscape unit objectives. The *Biodiversity Guidebook* (B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks 1995a), a component of the Code, recommends procedures to maintain biodiversity at both the landscape and the stand level. These procedures, which use principles of ecosystem management tempered by social considerations, recognize that the ecological processes of riparian habitats must be sustained to maintain landscape-level biodiversity.

This extension note is the fifth in a series designed to raise awareness of landscape ecology concepts and to provide background for the ecologically based forest management approach recommended in the *Biodiversity Guidebook*. The focus here is on riparian areas.<sup>2</sup> We first define and describe riparian areas. We then discuss several ecological principles underlying the common structural and functional characteristics of riparian areas and review their implications for biodiversity. We also briefly examine some of the functions of healthy riparian areas

- 1 January 2000. Policy direction for biodiversity is now represented by the Landscape Unit Planning Guide. This Extension Note should be regarded as technical background only.
- 2 For those wanting a more in-depth understanding about riparian areas, refer to Voller's chapter in *Conservation Biology for Forested Landscapes* (Voller and Harrison 1998).

and cumulative harmful effects of poor management at the landscape level. We conclude by suggesting how these concepts can be applied in landscape-level planning for biodiversity.

### Riparian Areas: Definition

“Riparian” is derived from the Latin word *ripa*, which means bank or shore. Riparian areas are therefore considered as the strips next to streams and lakes that develop and support a typically rich and diverse flood-tolerant vegetation. While not all riparian areas are endowed with distinctive vegetation, these ecosystems are nevertheless important because of their proximity to water.

Landscape ecologists define riparian strips in forested landscapes as “corridors” because they differ substantially from the surrounding upland matrix on both sides. Because of their linear character, these corridors provide important connections throughout the forested landscape by joining upper elevations and mid-slopes with valley bottoms.<sup>3</sup>

Riparian areas represent a dynamic interface, or “ecotone,” between water- and land-based ecosystems, where components of both ecosystems interact. Natural disturbance events (e.g., flooding, erosion, and sedimentation) are regular phenomena in these areas, causing fluctuations in the associated mosaic of successional vegetation communities and in fish and wildlife populations. Indeed, the character of a riparian corridor can change continually along its length, reflecting the soil moisture and nutrient conditions, vegetation, or geomorphology of the adjacent upland area (Gregory and Ashkenas 1990). However, while riparian areas are greatly affected by the nature of the adjacent upland regions,

they in turn can also strongly control how the entire watershed functions. Therefore, the general condition of riparian areas can have significant and wide-ranging economic and environmental consequences.

### Riparian Areas and Biodiversity: Ecological Principles

Biologically, riparian areas are valuable ecosystems in any forested landscape. Because of their high productivity and their inherent connections with the rest of the watershed, riparian areas provide a crucial source of habitat diversity at the landscape level. The following ecological principles explain some of the common structural and functional characteristics of riparian areas and their importance for biological diversity.<sup>4</sup>

#### 1. Riparian areas contain a wide diversity of plant species.

Riparian areas are usually transition zones between different types of structurally complex vegetation communities. This complexity exists because of the moisture gradient (the progression from higher to lower moisture conditions) associated with these areas. The proximity of water increases the yield of plant biomass and provides the proper environment for plant species unable to grow in drier conditions. Flood-tolerant plants, including mosses, sedges, and willows, occupy positions close to the water’s edge. Behind these species, a series of different understorey (herbaceous plants and shrubs) and overstorey (deciduous and coniferous trees) canopy layers progressively develop toward the upland boundary ( Figure 1).

**Implications for biodiversity** Many animal species are attracted to riparian areas by the assortment of plant

<sup>3</sup> Part 3 of this Extension Note series (Spatial Patterns) contains more information about the matrix/patch/corridor model, and corridors are discussed more fully in Part 4 (Connectivity).

<sup>4</sup> This description of ecological processes focuses on a hypothetical riparian environment. Such processes will be of greater or lesser importance in riparian areas, depending on the area’s biogeoclimatic classification.

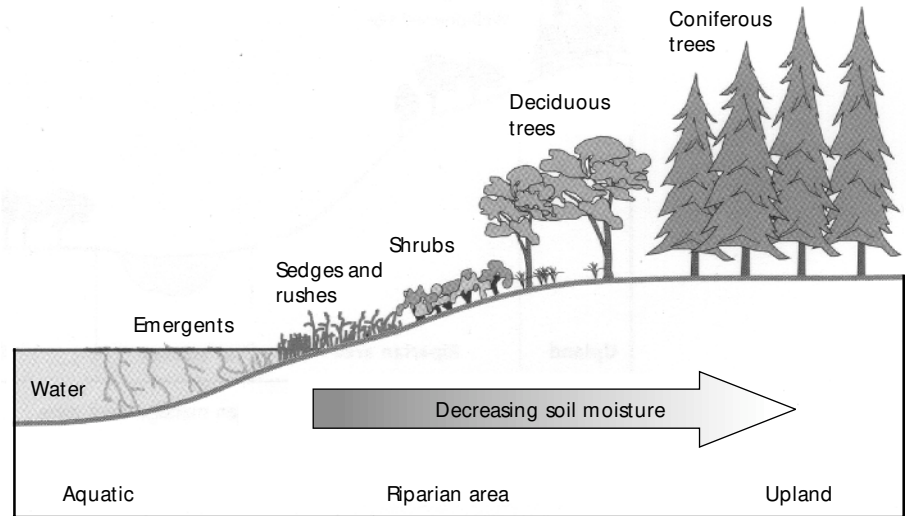


FIGURE 1 *Illustration of the moisture gradient in a typical riparian ecosystem (from Stevens et al. 1995:2).*

species in the multi-layered canopy and understory. This structure is characteristic of transitional edge habitats.

Riparian vegetation provides:

- excellent food resources (e.g., water plants, herbaceous plants and shrubs producing berries and seeds, and leafy forage) for a wide range of species (e.g., invertebrates, fish, large and small mammals, and birds);
- dense thickets for cover and shelter (e.g., deer hide in thick bushes; rodents make secure passageways, or “runs,” in the undergrowth); and
- habitats for the perching, nesting, and resting of aquatic and terrestrial bird species (e.g., snags provide perches and cavities for nesting; shoreline vegetation provides nesting and refuge sites for waterfowl).

## 2. Riparian vegetation influences the local aquatic and terrestrial environment.

A distinctive microclimate is created for both terrestrial and aquatic ecosystems in riparian areas. Riparian vegetation shields the underlying soil from wind and sunlight. This keeps soil temperatures cooler in summer, which decreases moisture losses and maintains the air temperature at lower levels. Because of

these moister soil conditions, the spread of ground fires is retarded. As a result, the plant communities in riparian areas can be older than those in neighbouring uplands where there is a more recent history of fire.

In winter, riparian vegetation may protect the zone against severe weather and reduce heat losses. In summer, overhanging vegetation that shades standing or flowing water helps to regulate the amount of light reaching the water’s surface and, therefore, the water’s temperature. For instance, in smaller streams, incoming radiation may be reduced up to 85% by canopy closure (Wilzbach 1989).

**Implications for biodiversity** Shaded headwater streams contribute cool water to riparian areas further downstream (Stevens et al. 1995). This is important because, if water is cooler, levels of dissolved oxygen are higher and organic wastes can be broken down more readily. Water temperature and the amount of available light also determine whether the aquatic ecosystem is dominated by primary production or decomposition activities. This in turn controls the type of aquatic invertebrates present and, therefore, the type of prey available for the fish community.

Because fish and amphibians are

cold-blooded, air and water temperature controls their body heat and metabolic processes. Amphibian eggs and larvae and some species of juvenile fish are consequently very sensitive to the changes in water temperature brought about by vegetation removal.

At Carnation Creek on western Vancouver Island, water temperatures increased by 1–5°C after the removal of 41% of the forest cover including streamside vegetation in a clearcutting trial. This long-term study was initiated in 1970 and continues to examine the effects of forestry activities on riparian areas. In creek areas affected by logging and the related decrease in shade, the egg-to-fry survival rate of coho salmon has decreased, as has the number of spawning adults (Hartman and Scrivener 1990).

Decreasing the amount of streamside vegetation will therefore increase summer water temperatures, which could:

- kill salmon and other fish species if temperatures exceed tolerance levels (over 22°C for some species);
- increase susceptibility to disease;
- increase competition from warm-water fish; and
- change the fish species and age composition in streams (Voller 1998).

### **3. Root systems provide bank stability and help reduce erosion and siltation.**

The root systems of herbaceous plants and shrubs can stabilize lake, river, and stream banks by binding together soil, rock, and organic material, which reduces erosion and prevents sediment from entering the water system. This is particularly important in streams with relatively unstable banks and variable channels that can potentially transport sediment and cloudy water further downstream.

Tree roots withstand flood conditions more effectively than do shrubs and are therefore necessary for long-term bank stability (Gregory and

Ashkenas 1990). Undisturbed forests adjacent to riparian areas can also prevent or reduce the effects of debris avalanches, debris torrents, and debris jams.

**Implications for biodiversity** Sediment, both suspended and deposited, can interfere drastically with the life cycles of many aquatic creatures. For example, fish embryos may smother if silt settles on incubating eggs. Sediment deposits may hinder the emergence of young fish hatching from buried eggs. Cloudy, sediment-choked streams:

- clog fish gills;
- reduce the transmission of sunlight and therefore the growth of water-based vegetation; and
- imperil some amphibians, such as the endangered Pacific giant salamander and tailed frog.

### **4. Riparian zones are an extremely important source of woody debris.**

Streamside vegetation may become unstable during windstorms or when stream banks are undercut during periodic flooding. Large pieces of organic debris (trees, large branches, and roots) can fall into streams and create important habitats such as pools and protected backwater areas. By providing channel structure, this debris determines how water flows through the watershed.

Large organic debris plays the following important structural roles:

- creates and maintains stream structures, such as islands, pools, gravel bars, riffles, and side channels;
- dissipates the energy of flowing water, which slows currents, drops gravel, and traps other sediment; and
- helps re-establish structures in streams after floods, debris torrents, or landslides.

**Implications for biodiversity** Maintaining the natural abundance and distribution of large organic debris in riparian areas:

- enriches riparian soil as it decays,

**Dysfunction in landscape: “cumulative effects” and riparian areas**

Riparian areas have important and positive connections with the rest of the watershed that make them valuable elements in the landscape. However, these connections can be detrimental if management disturbances at the headwaters are allowed to disrupt the continuity of the riparian ecosystems further downstream.

Some studies have shown logging roads and clear-cutting can have the cumulative effect of increasing peak streamflows over those experienced in forested areas without roads or logging (Franklin 1992). Downstream effects can be magnified when abnormally high stream flows (due to rapid rainfall runoff) occur simultaneously with snow-melt. During these dramatic rain-on-snow flood events, major landslides, debris torrents, and dam-break floods can be triggered, affecting aquatic environments. Steep stream reaches can be scoured and simplified; lower gradient reaches buried in debris and sediment; and plant, wildlife, and fish spawning habitat can be damaged.

supplying a long-term source of nitrogen and other essential nutrients to organisms;

- increases aquatic habitat diversity;
- creates rearing habitat (protected gravel beds) for salmonid fishes;
- provides critical habitat for the reproduction of reptiles and amphibians, such as the tailed frog and Pacific giant salamander; and
- supports a diverse assemblage of saprophytic fungi and wood-boring insects.

**5. Riparian vegetation provides important nutritional inputs for aquatic ecosystems.**

Organic litter, such as leaves, needles, twigs, mosses, and lichens, falling from overhanging riparian vegetation, forms an important foundation in the aquatic food chain. This litter decomposes or becomes a primary food source for aquatic invertebrates, which in turn nourishes fish and a host of other organisms in the riparian zone. In small- to medium-sized streams, for example, it is likely that 70–80% of the food energy required by aquatic populations is supplied by leaf litter (Hollingsworth 1988).

**Implications for biodiversity** Removing vegetation in riparian areas eliminates an important source of food for both aquatic and terrestrial organisms. For example, trials conducted for the Carnation Creek study showed that harvesting limited a stream’s ability to retain leaf litter and also reduced the amount of leaf litter available to 27% of pre-logging levels. Deciduous leaf litter from unlogged tributaries was unable to compensate for the loss of leaf litter in the main channel (Hartman and Scrivener 1990).

**6. Riparian vegetation helps maintain water quality.**

Storm water runoff, which may contain fertilizer residue, herbicides, pesticides, and other pollutants, can introduce chemicals to riparian areas,

and reduce water quality. The root systems and microbes associated with riparian vegetation act as a natural filter, trapping chemical elements from fertilizers (nitrogen and phosphorus) and breaking them down into usable nutrients (Stevens et al. 1995). Vegetated riparian areas may therefore store, cleanse, and slowly release water and nutrients.

**Implications for biodiversity** Clean water is essential for most living organisms. Adult amphibians, such as salamanders and frogs, absorb the chemicals through their skin along with water (Stevens et al. 1995), while fish may take up contaminants through their gills during respiration.

When riparian vegetation is removed, the ability of the riparian zone to filter deleterious substances and to store water and nutrients is impeded (Bird and Rapport 1986).

- Excess nitrogen, in the form of urea and ammonia from livestock wastes, dissolves in water and may cause fish kills.
- Phosphate fertilizers can also cause fish mortality by producing algal blooms, which deplete dissolved oxygen levels in the water.
- Herbicides and pesticides can threaten all life stages of fish and amphibians.

**Riparian Area Habitat Diversity: Landscape-level Concepts**

Riparian corridors are important for preserving biodiversity at the landscape level (Harris 1984). In British Columbia, 59% of rare, threatened, and endangered species have all or part of their habitat needs met by riparian areas (Stevens et al. 1995) (Figure 2). Part of the attraction is the proximity to free-flowing or standing water. However, the greater diversity of plant species in these areas also provides a wider range of habitat conditions and niches for wildlife.

In addition to containing diverse habitats for direct use, riparian corri-

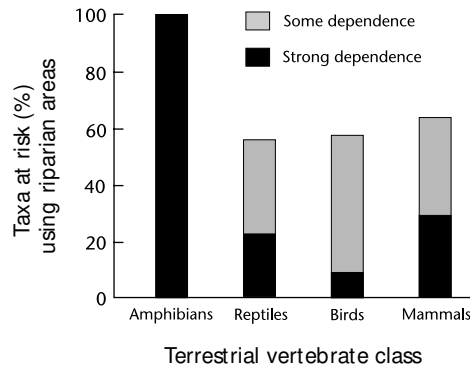


FIGURE 2 *Percentage of species at risk that use riparian areas and proportion of users that show a strong or some dependence on these ecosystems (from Stevens et al. 1995:9).*

dors also function as important linkages that enable movements or flows to take place throughout the forested landscape. For instance, within their channels, creeks, streams, and rivers distribute water, soil, gravel, woody debris, nutrients, and genetic material (e.g., plant seeds, spores, and waterborne organisms) to downstream areas of the watershed. When their adjacent floodplain or upland habitats are also considered, riparian areas can link several otherwise isolated forest patches containing different wildlife habitats. In this way, riparian corridors become natural routes for various travelling or migrating animal species. If their original habitat is disturbed by natural or human agents, or if it deteriorates because of population pressures, forest-dwelling mammals may then use these corridors to disperse to new territory (Stevens et al. 1995).

Riparian ecosystems and undisturbed riparian populations can also function as reservoirs of genetic material. Because they are so biologically productive, these areas help to maintain a “storehouse” for genetic diversity. For example, when adjacent areas are disturbed by fire, logging, or floods, animal species can use connective riparian corridors to colonize or repopulate the disturbed areas. Intact

vegetation in adjacent riparian areas also acts as a seed source to revegetate severely disturbed upland or stream-side areas (Bunnell et al. 1995).

### Applying the Concepts: Managing Riparian Areas to Protect Habitat Diversity

The principles of ecosystem management provide a solid conceptual framework for:

- identifying riparian management objectives;
- evaluating current land-use practices; and
- developing future resource alternatives (Gregory et al. 1991).

For example, one of ecosystem management’s central tenets is that deviating from the natural range of an ecosystem’s historical variability can increase the potential for unforeseen consequences. Therefore, if biodiversity is to be maintained in riparian zones, planning efforts should recognize the ecosystem’s historic structure and functions, and its connections with the rest of the landscape.

The Forest Practices Code requires that Riparian Management Areas (RMAs) be designated along both sides of streams and around lakes and wetlands (B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks 1995b). These management areas, because of their linear nature and ecological linkages across forest landscapes, are often pivotal elements of the Forest Ecosystem Networks (FENs) outlined in the *Biodiversity Guidebook* (B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks 1995a).

As a buffer against upslope activities, RMAs are intended to preserve the diversity and productivity of fish, wildlife, and riparian ecosystems. These areas can fulfill several functions, such as:

- serve as a trap, or sink, to decrease

**Watershed analysis: some key historical questions**

The watershed's historical range of variability (the variations in ecosystem conditions and processes over a period of time) provides an important reference point for riparian area planning. Some key questions (Regional Interagency Executive Committee 1995) to ask about historic watershed conditions include:

1. What erosion processes occurred and where did they take place? (e.g., consider surface erosion and mass wasting)
2. What were the characteristics of the historic hydrologic regime? (e.g., consider total discharge, peak and minimum flows, sources of cold water seepage and ground-water recharge)
3. What plant communities and seral stages were present? What determined their composition and pattern? (e.g., consider natural disturbance regimes)
4. How were stream channels structured and how was sediment transported and deposited in the watershed?
5. How would the watershed's water quality be characterized in the past?
6. What species and habitats were historically present; how were they distributed and how abundant were they?
7. What were the major historical human uses in the watershed, including aboriginal and other cultural uses?

the rate at which upslope sediment, nutrient, or other chemical runoff enters and contaminates the water body;

- regulate flows of surface or subsurface water by diffusing it and reducing its velocity;
- maintain bank stability and limit erosion potential;
- control water temperature by supplying shade;
- provide vegetation debris and terrestrial invertebrates as a food source for aquatic organisms;
- supply coarse woody debris for stream channel stability; and
- provide habitat for a diverse array of animal and plant species (Voller 1998).

The optimal width of riparian management areas will depend on the riparian classification and the nature of the surrounding watershed. As a coarse-filter approach, watershed analysis helps to identify past and present riparian ecosystem elements. It also organizes this information so that the direct, indirect, and cumulative effects of management actions can be estimated and their consequences understood before these activities take place (Regional

Interagency Executive Committee 1995). This sort of analysis is important because it shifts our focus from species and sites to the ecosystems and landscapes that support them.

Because of the dynamic nature of riparian ecosystems, managers are often faced with limited knowledge about their historic processes and conditions. Therefore, decision-making must often occur within an atmosphere of uncertainty. In these cases, managers should refine their plans by adopting a flexible, adaptive management approach that allows for feedback and adjustment as new information becomes available.

*Text by Susan Bannerman*

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