Riparian Zones: 1) What Are They and How Do They Work?

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What is a Riparian Zone?

There are many ways of defining riparian zones (or areas), but most definitions include some mention of a transition between terrestrial and aquatic ecosystems. Thus, the riparian zone is the transition between the uplands where there is seldom standing water and the stream, river, or lake where free flowing or standing water should be common. As a transition, riparian zones tend to have characteristics of both upland and aquatic ecosystems. Plants growing in these areas may be completely under water during a portion of the growing season, and yet be exposed to drought stress during certain times of the year. The following factors may influence the nature of a given riparian area: stream size, geology and hydrology of the area, seasonal and yearly climate patterns, elevation, gradient, size of the watershed, upland vegetation, prior land management, and water use patterns. This multitude of factors results in a complex mix of soils and vegetation that may change dramatically over very short distances.

In the western U.S., riparian zones tend to be more productive than other ecosystems, but occupy only a small proportion of the total landscape. Elmore and Beschta (1987) estimated that less than 0.5% of eastern Oregon rangelands were occupied by riparian areas. Even though the amount of land occupied by riparian zones is relatively low, they serve as the focal point for watersheds. Riparian areas must be viewed in the context of the entire landscape and not as separate entities.

Why are Riparian Areas Important?

These narrow riparian strips of land adjoining streams and lakes provide a number of important resource values. Thomas et al. (1979) estimated that about 80% of the terrestrial wildlife species known to occur in southeastern Oregon are either directly dependent on riparian zones or use these areas proportionately more than other habitats. A high proportion of bird species found on rangeland are dependent on riparian habitats for at least part of the year (Kauffman and Krueger 1984). Riparian zones and associated meadows may also provide a good deal of forage for livestock and big game. In northeastern Oregon, Pickford and Reid (1948) suggested that one acre of mountain meadow is equivalent to 10–15 acres of forested range in terms of grazing capacity. In their analysis, mountain meadows comprised 1–2% of the total land area, yet provided nearly 20% of the summer forage used by livestock. That figure will vary depending on the condition of the meadows relative to the uplands, and the system of grazing management.

Riparian zones also influence water quality and the seasonal pattern of waterflow leaving a watershed. Vegetation along streams and lakes may be important in the "filtering" of water before it reaches flowing or standing bodies of water. Lowrance et al. (1984) discussed the ramifications of maintaining healthy riparian zones in watersheds where the upland is farmed. They point out that the riparian zone can reduce the non-point source pollution that might otherwise end up in streams and rivers. A properly functioning floodplain can store water, help with aquifer recharge, and dampen peak spring flows (floods) (Elmore and Beschta 1987). If water is stored during the spring runoff period, and release through the soil back to the stream is relatively slow, then there is potential for improving late season flows. Thus, the "riparian ecosystem" can serve a number of important functions, and is relatively more important than the small area it occupies on the landscape.

Structure and Function of Riparian Zones

Stream ecosystems are generally much more complex than they first appear. Although it is not always apparent, streams are closely linked to the riparian zones that surround them; and even more obscure is the linkage of the stream and riparian zone to the entire watershed, which may include many thousands of acres.

Before any discussion of structure and function of streams and associated riparian zones, a few basic points should be emphasized. First, streams are very dynamic over the course of a year, and from year to year (Heede 1980). We have all probably seen streams at near flood stage in the spring, and just barely a trickle by late summer. Thus, the associated riparian vegetation may have to survive a period of complete inundation, followed by drought stress. In addition, no two streams are exactly alike (Heede 1980), and the variability increases even further when the stream and associated riparian zone are considered together. Rosgen (1985, 1994) proposed a stream classification system for the western United States. The criteria used to separate streams include, gradient, sinuosity, width/depth ratio, channel materials, entrenchment, confinement, and soil/landform features. Although no two streams are exactly alike, there is a need to group streams that behave similarly. The vegetation associated with streams may be even more variable than the streams themselves. Along any given stretch of stream there may be many different plant communities. Kauffman et al. (1985) identified 60 plant communities along a stretch of northeastern Oregon stream less than 2 miles long. Youngblood et al. (1985), Kovalchik (1987) and Hanson et al. (1995) have developed community type classifications to help group the various types of riparian plant communities within the areas studied. From the above discussion, one can see that riparian zones vary considerably, and thus the subsequent discussion of structure and function must be rather general.

An understanding of the hydrologic or water cycle for an area will aid in visualizing how riparian areas work and what sets them apart from the uplands. A simplified version of a hydrologic cycle is presented in Figure 1. In much of the western U.S., snowmelt supplies the majority of the moisture for riparian zones and streams (e.g., Swanston 1991). Vegetation in the uplands can influence the manner in which water reaches the riparian zone. Cheng (1989) studied a watershed in interior British Columbia in which 30% of the acreage had been clear-cut after a pine beetle infestation. He found that total annual streamflow, monthly average streamflow (March to November), and annual peak streamflows all increased as a result of clear-cutting. Conversely, the expansion of juniper on western rangelands may have a negative impact on streamflows if juniper uses more water than the sagebrush—grass vegetation that existed prior to juniper encroachment (Miller et al. 1989). However, not all portions of a watershed contribute equally to runoff and streamflows. For discussion of the variable source area concept, readers should refer to Branson et al. (1981) or Satterlund and Adams (1992).

Given the variety of conditions that can occur along streams, it is not surprising that a wide range of plant species are common to riparian zones. In his classification guide for central Oregon, Kovalchik (1987) included 234 different plants in his list of common riparian species. Sedges and rushes often dominate the herbaceous (or non-woody) species, and willows often dominate in the woody plant category.

There are a number of characteristics that make these species well-adapted to riparian areas. The willows and sedges tend to have many growing points, and thus can produce numerous stems. Anyone who has walked through a willow thicket can appreciate how dense the growth can be. Many of the herbaceous species have rhizomes (underground stems) and thus form a dense mat that helps hold the streambanks together during high water flows. In addition to the rhizomes, some of the wetter riparian communities have a very high density of roots. In a Nebraska sedge community, Manning et al. (1989) measured the highest root length density (length of root per unit volume of soil) recorded in any ecosystem. There were over 113 feet of roots in a 1 inch cube of soil. Actually the top 4 inches were almost all roots and virtually no soil. In addition to having many roots, the roots of these plants have special tissues to allow oxygen penetration when they are submerged. Aerenchyma tissue allows oxygen to move from the aboveground stem into roots to satisfy the oxygen demand created by root respiration. The ability to transport oxygen to roots may influence where a species can survive within a riparian zone. Near the stream a species may have to survive in flooded soil during most or all of the growing season, whereas, at the upland/riparian boundary flooding may occur for only a brief period in the spring. In addition, plants growing in wetlands will have to deal with natural toxins that are generated in waterlogged soil.

Riparian plants must be adapted to the nutrient conditions of the soil in which they are growing. The amount of nitrogen coming into the riparian zone from the uplands depends on the nature of the uplands and the primary land use. Lowrance et al. (1984) demonstrated that riparian zones can reduce pesticide and fertilizer movement into streams associated with intensive upland farming. Plants take up nutrients, and a good deal is lost when nitrate and ammonium is converted to gaseous nitrogen by soil mi-

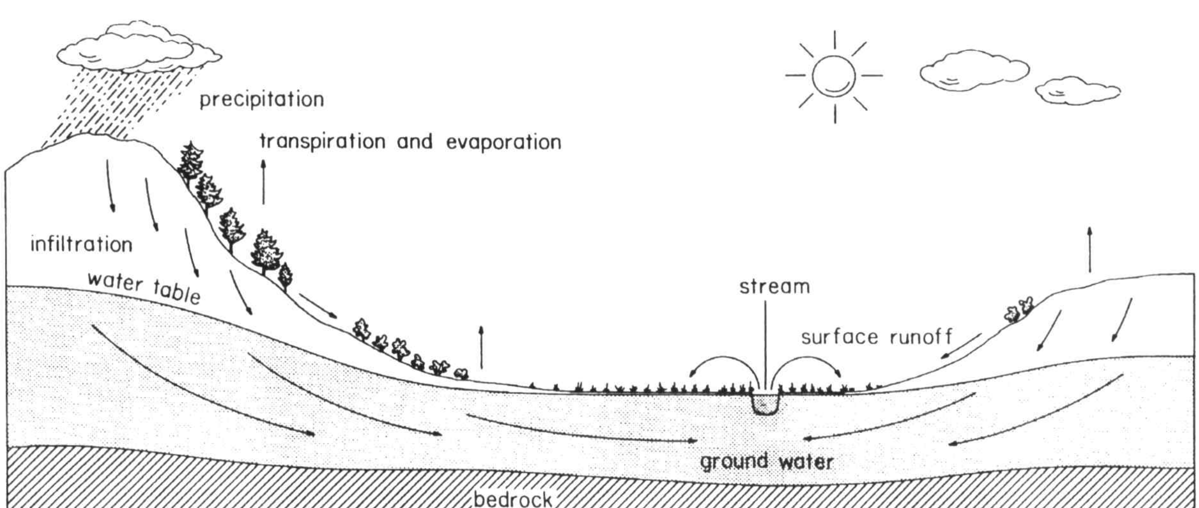

Fig. 1. *Generalized schematic of a hydrologic cycle. The riparian zone associated with the stream is influenced by ground water level and flooding from the stream.*

croorganisms. This process is called denitrification and occurs at high rates in soils prone to periodic flooding (Patrick and Reddy 1976). In the western U.S., many of our riparian areas do not receive large yearly inputs of nutrients from the uplands, and there is still a loss of nitrogen to denitrification. Thus, many riparian plants grow under relatively nutrient-limiting conditions.

The Dynamic Nature of Riparian Zones

To assess the impacts of human activities on riparian zones, we must first recognize that these areas are dynamic and prone to change. Streams tend to meander back and forth across meadows with the pathway changing over time. Many streams leave oxbows (where the meander completes a loop and gets cut off from the stream) as evidence of the former pathways (see Figure 2). We can find cases where a stream has abandoned a channel to form a new one. Anyone who has dug soil cores in riparian areas can appreciate how dynamic these systems can be. Gravel layers that at one time were part of the stream channel can be found at surprising distances from the present stream channel.

Riparian systems may undergo long-term cycles that further confuse our interpretations of change. Masters et al. (1991) suggest that the drying of the huge Pleistocene lakes, and consequent lowering of base-levels, has resulted in widespread downcutting of streams in the Great Basin. During the Pleistocene (the last ice-age) the climate was cooler and moister than it is currently, and there were many large lakes scattered across the Great Basin. As the climate dried many of the lakes disappeared completely, and the point at which streams emptied into either lakes or playas (dry lake beds) became lower in elevation, thus, the stage may have been set for adjustments in stream structure. However, it is difficult to assess the actual extent to which downcutting might be influenced by changes in climate relative to changes in land management. There are numerous examples where improved land management has reversed the downcutting process, which suggests present management can be the overriding factor.

Although we have relatively little information on long term changes (over thousands of years) in western riparian areas, Bettis and Thompson (1985) described cycles of gully erosion and subsequent refilling in western Iowa. These researchers took soil cores along streams and gullies and used radiocarbon dating of organic debris to put together a picture of how these sites developed. "More than one-hundred such radiocarbon dates indicate that the six major alluvial fills in western Iowa valleys represent synchronized episodes of gully cutting and filling during the last 12,000 years throughout the region". The authors of this study point out that a better understanding of gully formation in their region of the country will help land managers in making realistic decisions on land use. Ecosystems are dynamic and will change over time, and riparian systems are probably more dynamic than the associated uplands. The dynamic nature of riparian zones represents a major challenge to land managers, who must make decisions about a system that is constantly changing.

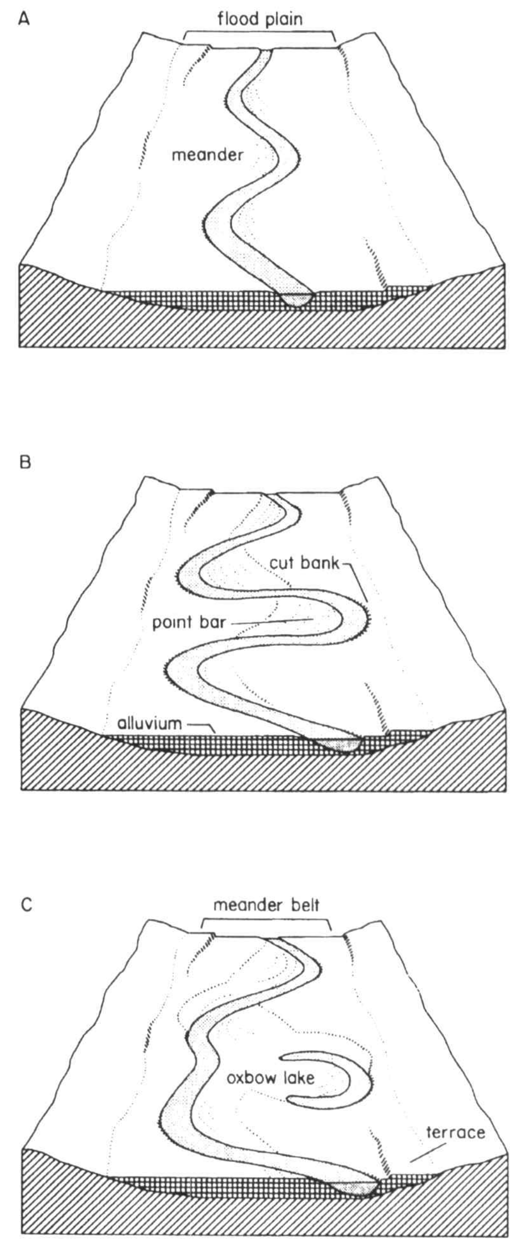

Fig. 2. *Stream systems are naturally dynamic. Meanders (A) move by cutting the outside bank and building a point bar (B). In some cases an oxbow is formed when the channel cuts across a meander (C).*

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