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IMPROVING RIPARIAN BUFFER STRIPS AND CORRIDORS FOR WATER QUALITY AND WILDLIFE

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ABSTRACT: The management and restoration of riparian zones has received considerable attention throughout the United States. Numerous studies have shown that riparian buffer strips of sufficient width protect and improve water quality by intercepting non-point source pollutants. Buffer strips also clearly provide a diversity of other functions, including movement corridors and habitat for a large variety of organisms. However, criteria for determining proper dimensions of buffer strips for most ecological functions are not well established. Although riparian zones are being restored along thousands of streambank miles throughout the country, the ecological benefits of variable buffer strip designs (e.g., width, length, vegetation type, placement within the watershed) have not been adequately recognized. There have been few systematic attempts to establish criteria that mesh water quality width requirements with other riparian functions. Subsequently, management prescriptions (e.g., width recommendations) are frequently based upon anecdotal information with little regard for the full range of effects these decisions may have on other riparian functions. Our objectives are to address the suitability of riparian zones to protect water quality while enhancing biodiversity, and to discuss recent strides in providing improved guidance for corridor and buffer designs based primarily on ecological criteria.
KEY TERMS: Biodiversity; Corridor; Design Criteria; Riparian Zone; Vegetated Buffer Strip; Wildlife

INTRODUCTION

Riparian zones occur as transitional areas between aquatic and upland terrestrial habitats. Although not always well defined (Fischer et al., 2000), they generally can be described as long strips of vegetation adjacent to streams, rivers, lakes, reservoirs, and other inland aquatic systems that affect or are affected by the presence of water. Riparian zones typically comprise a small percentage of the landscape, often less than one percent, yet they frequently harbor a disproportionately high number of wildlife species and perform a disparate number of ecological functions when compared to most upland habitats. Riparian zones have been widely recognized as functionally unique and dynamic ecosystems only within the past 25 years. Even more recently, these areas have become a major focus in the restoration and management of landscapes (Knopf et al., 1988; Naiman et al., 1993).

Unfortunately, many riparian zones in North America do not function properly (e.g., they are degraded to the point that they do not protect water quality or provide the resources needed to make them suitable as wildlife habitat or as movement corridors) (Ohmart 1984, Welsch 1991). This degradation also negatively affects many of the other important functions and values these landscape features provide.

WHAT IS THE DIFFERENCE BETWEEN BUFFER STRIPS AND CORRIDORS?

There is considerable confusion in the literature regarding both wetlands and riparian zones (Fischer et al., 2000). At the heart of this confusion is the proper distinction between vegetated buffer strips and corridors. Riparian zones are often referred to by names that relate to their principal intended or recognized purpose, such as riparian buffer strips (for protection of water quality) or riparian corridors (for wildlife habitat and movement corridors). Understanding the similarities and differences between buffer strips and corridors, and having a clear idea of one's objectives, can have major implications for how one might attempt to manage a riparian ecosystem. These terms are defined as follows:

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" Riparian Buffer Strip. A linear band of permanent vegetation adjacent to an aquatic system primarily intended to maintain or improve water quality by trapping and removing various non-point source pollutants (e.g., contaminants from herbicides and pesticides; nutrients from fertilizers; and sediment from upland soils) from both overland and shallow subsurface flow. Buffer strips occur in a variety of forms, including herbaceous or grassy buffers, grassed waterways, or forested riparian buffer strips. A buffer strip may provide a variety of other functions (see below), including habitat for plants and animals if enough land-area is retained to meet the life-history needs of a particular species, and movement corridors if they provide suitable connections between larger blocks of habitat.

" Riparian Corridor. A strip of vegetation adjacent to an aquatic system that connects two or more larger patches of vegetation (i.e., habitat) and through which an organism will likely move over time. These landscape features are often referred to as conservation corridors, wildlife corridors, and dispersal corridors. Some scientists have suggested that corridors are a critical tool for reconnecting fragmented habitat "islands."

WHY ARE BUFFER STRIPS AND CORRIDORS IMPORTANT?

The management and restoration of riparian corridors and buffer strips is becoming an increasingly important option for improving water quality and conserving wildlife populations. There is solid evidence that providing riparian buffers of sufficient width protects and improves water quality by intercepting non-point source pollutants in surface and shallow subsurface water flow (e.g., Lowrance et al., 1984; Castelle et al., 1994). In the absence of proper buffer strips, there can be a greater requirement for water treatment plants and other expensive restoration techniques.

Healthy riparian buffer strips are also widely recognized for their ability to perform a variety of functions other than water quality. These functions include stabilizing stream channels; providing erosion control by regulating sediment storage, transport, and distribution; providing organic matter (e.g., leaves and large woody debris) that is critical for aquatic organisms; serving as nutrient sinks for the surrounding watershed; providing water temperature control through shading; reducing flood peaks; and serving as key recharge points for renewing groundwater supplies (DeBano and Schmidt 1989; O'Laughlin and Belt 1995). Buffer strips also provide habitat for a large variety of plant and animal species. Their role as movement corridors for wildlife is not quite as clear, but they have become a popular tool in efforts to mitigate fragmentation by increasing connectivity of isolated habitat patches and conserving biodiversity (Rosenberg et al., 1997). They have been proposed, and in some cases proven, to be landscape components that promote faunal movement, enhance gene flow, and provide habitats for animals either outright or during disturbance in adjacent habitats (e.g., clearcut in upland). However, some scientists suggest that corridors are being used too frequently and at the expense of purchasing and conserving larger blocks of unfragmented habitat.

Riparian buffer strips in urban areas, often called greenbelts or greenways, are protected open spaces usually along stream valleys and rivers that are managed for conservation, recreation, and non-motorized transportation. They provide numerous social benefits and are a focus of many community enhancement programs. Greenways can provide a community trail system for outdoor recreation activities, such as hiking, jogging, bicycling, rollerblading, horseback riding, cross-country skiing, or walking. Greenways can also stimulate the economy by providing an array of economic and quality-of-life benefits.

WHAT ARE THE GENERAL DESIGN CONSIDERATIONS?

Many land managers throughout the country are in need of improved design criteria when planning for riparian zone restoration and management, and they need information on how various land uses influence riparian vegetation, fauna, and water quality. Although the value of riparian buffer strips is increasingly being recognized, there is presently limited information available to make sound management decisions for enhancing some of the functions that riparian zones can provide (Fischer et al., 1999). Criteria for determining proper dimensions of buffer strips for some functions is not well established and recommended designs are highly variable. Economic, legal and political considerations often take precedence over ecological factors, and most existing criteria address reduction or elimination of nonpoint source pollutants. Because of the lack of information relating riparian zone characteristics to other specific functions, management prescriptions (e.g., width recommendations) are frequently based upon either water quality considerations or anecdotal information. There is little regard for the full range of effects these decisions may be having on habitat, flood conveyance and storage, recreation, aesthetics and other riparian functions listed above.

Although riparian buffer strips are being planted along thousands of streambank miles throughout the country, the benefits of variable buffer strip designs (e.g., width, length, type of vegetation, placement within the watershed) are effectively unrecognized. There have been few systematic attempts to establish criteria that mesh water quality width requirements with conservation and wildlife values, specifically, the ability of these buffer strips to function as habitat or as corridors for wildlife dispersal between habitats in highly fragmented landscapes. Even less information is available relating riparian vegetation characteristics to other functions such as sediment transport and bank stability conditions of streams. Also, physical and biotic processes that occur in riparian zones are strongly influenced by activities in the surrounding landscape. Thus, the maintenance of riparian ecosystem functions requires a much broader (i.e., watershed-based) approach to restoration and management than has usually been taken in the past (Kauffman et a. 2000).

Unfortunately, there is no one-size-fits-all design for an ideal riparian buffer strip. First and foremost, the primary objectives of a buffer strip should be determined. Various objectives might include protection of water quality, streambank stabilization, downstream flood attenuation, or provision of wildlife habitat or movement corridors. In general, the ability of buffer strips to meet specific objectives is a function of their position within the watershed, the composition and density of vegetation species present, buffer width and length, and slope. Some benefits can be obtained for buffers as narrow as a few meters while others require hundreds of meters.

Placement within Watersheds

The spatial placement of buffer strips within a watershed can have profound effects on water quality. Although buffer strips are important along all river and stream reaches, those in headwater streams (i.e., those adjacent to first, second, and third order systems) often have much greater influences on overall water quality within a watershed than those buffers occurring in downstream reaches. Downstream buffer strips have proportionally less impact on polluted water already in the stream. Even the best buffer strips along larger rivers and streams cannot significantly improve water that has been degraded by improper buffer practices higher in the watershed. However, buffer strips along larger systems tend to be longer and wider than those along smaller systems, thus potentially providing better wildlife habitat and movement corridors (Lock and Naiman 1998).

Geographical Information Systems (GIS) can aid in determining where the most benefit can be accrued from placing buffers on a landscape. Knowledge of soils and the valley-floor types provides important information regarding types of channels and riparian processes likely to be present in a given area (Hemstrom 1989). Because interactions between aquatic, riparian, and terrestrial ecosystems are a function of valley-floor morphology, digitized GIS data on valley-floor morphology aids in delineation of specific areas where erosion potential is high (e.g., where streams flow through alluvial deposits) or low (e.g., through bedrock). Thus, critical areas for buffer strips can be identified before significant impacts occur.

How Wide and How Long?

Most of the focus on buffer design is the needed width, but the vegetation assemblage, layout, slope of adjacent lands, and length are also key design parameters. Buffer width, as defined herein, is measured beginning at the top of the bank or level of bankfull discharge. Buffer strip width recommendations typically are either of fixed-width or a variable width nature. Fixed width buffer strip recommendations tend to be made based on a single parameter or function. They are easier to enforce and administer by regulatory agencies but often fail to provide for many ecological functions (Castelle et al., 1994). Variable width buffer strips are generally based on a variety of functions and usually account for site-specific conditions by having widths adjusted along the length of the strip depending on adjacent land use, stream and site conditions (e.g., vegetation, topography, hydrology), and fish and wildlife considerations (Castelle et al., 1994). Protection of water quality is often the most common consideration during buffer strip design recommendations. Although many buffer strip width recommendations tend to be arbitrary or based on anecdotal information, the scientific literature is replete with recommendations for maintaining or improving water quality in a variety of different settings (e.g., various soil types and different slopes). Most buffer strip width recommendations for improving or protecting water quality tend to be between 10 and 30m (Table 1).

Wildlife habitat and movement corridors in riparian zones are also an important consideration when determining widths. Appropriate designs for species conservation depends on several factors, including type of stream and taxon of concern (Spackman and Hughes 1995). Recommended widths for ecological concerns in buffer strips typically are much wider than those recommended for water quality concerns (Fischer 1999; Fischer et al., 1999), often exceeding 100m in width (Table 1). These recommendations usually apply to either side of the channel in larger river systems and to total width along smaller streams where the canopy is continuous across the channel. Management for long, continuous buffer strips rather than fragments of greater width should also be an important consideration. Continuous buffers are more effective at moderating stream temperatures, reducing gaps in protection from non-point source pollution, and providing better habitat and movement corridors for wildlife.

CONCLUSIONS

The ability of a riparian zone to provide various functions depends on such factors as width; length; degree of fragmentation; and type, density, and structure of vegetation present. Objectives may also be constrained by land ownership, existing or potential riparian vegetation, soils, slope, or past land-uses both within the riparian zone and in uplands throughout the watershed. At a minimum, buffer strip widths of 15m or wider should be promoted for providing a range of multiple objectives including water quality. However, much greater widths (i.e., >100m) usually are needed to ensure values related to wildlife habitat and use as migration corridors. If only a narrow buffer strip is possible, it should at least be wide enough to sustain a forest or shrub community that will adequately stabilize the streambank from erosion. Recommended widths in this report are intended to provide a starting point for land managers to make decisions regarding design of buffer strips in their own area. Proper widths for various objectives may vary significantly by region and depend on a variety of ecological and physical factors.

TABLE 1. Summary of recommended widths of vegetated buffer strips for various functions.

Function	Recommended Width	Authors
Improve or protect water quality	≥15m	Woodard and Rock (1995)
	≥25m	Young et al. (1980)
	≥30m	Lynch et al. (1985)
	≥9m	Dillaha et al. (1989)
	≥18m	Nichols et al. (1998)
	≥10m	Corley et al. (1999)
	≥4m	Doyle et al. (1977)
	≥19m	Shisler et al. (1987)
Reptile/Amphibian habitat	100-1000m	Burbrink et al. (1998)
	>30m	Rudolph and Dickson (1990)
	≥165m	Semlitsch (1998)
	>135m	Buhlmann (1998)
Bird habitat	≥60m	Darveau et al. (1995)
	≥100m	Hodges and Krementz (1996)
	≥100m	Mitchell (1996)
	≥100m	Triquet et al. (1990)
	≥150m	Spackman and Hughes (1995)
	≥500m	Kilgo et al. (1998)
	≥100m	Keller et al. (1993)
	≥150m	Vander Haegen and deGraaf (1996)
	>40m	Hagar (1999)
	50-1600m	Richardson and Miller (1997)
	≥50m	Whitaker and Montevecchi (1999)
Mammal habitat	≥50m	Dickson (1989)
Maintain plant diversity	≥30m	Spackman and Hughes (1995)
Maintain an unaltered microclimatic gradient	≥45m	Brosofske et al. (1997)

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