

## Changing Values of Riparian Ecosystems

Malchus B. Baker, Jr., Leonard F. DeBano, and Peter F. Ffolliott

---

### Introduction

---

Riparian ecosystems in the Central Arizona Highlands, and throughout the Southwest in general, provided the necessary water for humans, livestock, and agricultural crops during settlement by Europeans in the late 1800s. Other resources available in these moist environments included wildlife and fish, livestock and wildlife forage, and shade. Trees were often used for fuel, poles, and building materials. As human population increased in the early 1950s, demands for increased water supplies often dominated management of riparian ecosystems, which resulted in the destruction of many riparian areas (Horton and Campbell 1974). Within the last 25 yr people have become more aware of the diversity and multiple benefits provided by healthy riparian ecosystems.

This chapter describes changes in research emphasis that reflect changing attitudes of the public about the importance of riparian ecosystems. No one site has been the focus of this research. Instead, investigations were, and continue to be, conducted in response to a wide range of issues. Some important concerns are:

- Flow of water into and through these ecosystems.
- Maintenance of wildlife and fish habitats.
- Vegetative structure, classification, and patterns of plant succession.
- Impacts of grazing by livestock and wildlife.

---

### Riparian Ecosystems

---

The nature of riparian ecosystems and the linkages between them and the upland watershed areas are described to place subsequent discussions into a watershed perspective. Riparian areas are at the interface between terrestrial and aquatic ecosystems. The abruptness and extent of the transitions across these interfaces are generally site-specific. Riparian ecosystems are delineated by soil characteristics and vegetative communities that re-

quire free or unbound water (DeBano and Schmidt 1989). These vegetative communities consist of herbaceous riparian plants (generally species of *Carex*, *Eleocharis*, *Juncus*, and *Scirpus*), which typically produce the characteristic dark-green edge on the sides of stream, and woody species (alder, ash, cottonwood, saltcedar, and willows) that usually reside on the higher alluvial terraces. Riparian systems are ecological sites where soil moisture exceeds the requirement of species present because of water flowing into and through the ecosystems.

Riparian ecosystems in the Central Arizona Highlands furnish habitats for a variety of wildlife species, are grazed by livestock and wildlife, and provide areas for fishing, hiking, bird watching, picnicking, and camping. Maintaining the integrity of these ecosystems requires careful management and, in some cases, protection from overgrazing, excessive tree cutting and recreational use, and other disturbances.

---

### Riparian-Watershed Linkages

---

Erosion and surface runoff are important to the stability of riparian ecosystems and its surrounding hillslopes. A response to a disturbance, such as a vegetative conversion treatment or fire, must be considered within this context (DeBano and Schmidt 1989, DeBano et al. 1996a, Baker et al. 1998). Water flow and sediment movement through a riparian ecosystem is controlled by vegetation, topography, hydrology, and geologic formations within this linked system.

Riparian ecosystems are considered healthy if channel deposition (aggradation by sedimentation) and downcutting (degradation by erosion) is at equilibrium (figure 19). A healthy riparian area maintains a dynamic equilibrium between the streamflow forces producing change and the forces of resistance to change of its vegetative, geomorphic, and structural features (DeBano and Schmidt 1989). This dynamic equilibrium is sufficiently stable so that external disturbances on surrounding hillslopes can often occur without altering the equilibrium. This resistance to change results largely from adjustments among several factors, such as vegetation,

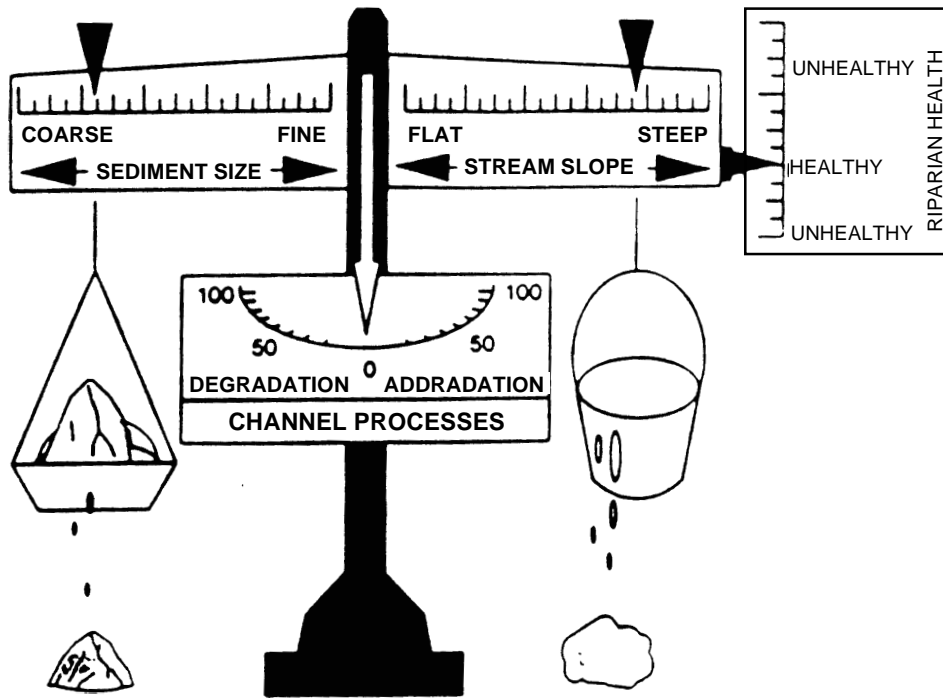


Figure 19. Relationships of a stable stream channel balance (adapted from Rosgen 1980, based on Lane 1955).

channel depth, and stream morphology, which react simultaneously within the riparian system to increases or decreases in flow or sediment from the uplands.

Short-term increases in surface runoff from disturbances on upland areas can increase streamflow volume and velocity, which causes changes in channel erosion and deposition downstream (figure 19). In a healthy riparian area, oscillations in the system produce little change in its dynamic equilibrium. Equilibrium can easily be reestablished when the resiliency of the system is not severely stressed by the disturbance. When degradational or aggradational forces overwhelm this dynamic equilibrium, riparian health can be adversely affected. Usually degradational processes (causing channel downcutting) result in unhealthy riparian conditions more rapidly than do aggradational processes (causing sediment deposition). The sensitivity of the equilibrium to aggradation and degradation processes are indicated by the riparian health scale in figure 19.

Fire is a common disturbance in riparian ecosystems and the surrounding hillslopes. Fire can burn either the upland watershed or both the riparian and upland areas. Fire rarely occurs only in a riparian ecosystem unless a controlled burn is prescribed to do so. When only the upland watershed area is burned, the riparian ecosystem acts as a buffer between the burned hillslopes and stream. However, when both the upland and riparian areas are severely burned, devastating results can occur. Of most significance, the buffering effect of the riparian ecosystem is lost, leading to a disruption of the dynamic equilibrium (DeBano and Neary 1996).

## Changing Research Emphasis

A major goal of flood plain management through the mid 1960s was control or elimination of riparian vegetation for water salvage and flood control. By the late 1960s, pressure by environmental groups and the general public to preserve and develop riparian ecosystems for wildlife habitats, recreation, and aesthetic values largely halted these water salvage programs. As a consequence, holistic, ecosystem-based riparian management has prevailed throughout the Central Arizona Highlands since the mid 1970s.

### Early Emphasis

Removal of riparian trees and shrubs (phreatophytes) in stream channels, floodplains, and terraces to reduce transpiration characterized riparian management from the early 1950s through the mid 1970s. A phreatophyte is a plant with a root system that obtains water either directly from groundwater or from the capillary fringe above the water table. The potential for water-yield improvement by converting phreatophytes to low water-using plants was considered for a number of reasons. The high transpiration rate of plants in arid or semi-arid environments with roots extended into the groundwater or capillary fringe above the water table was a major

reason for conversion. The rapid invasion of the introduced saltcedar, a high water-using phreatophyte that forms dense, impenetrable thickets, created further interest. Managers believed that phreatophytes were low in economic value and, more importantly, were water-wasters (Horton 1960). Therefore, their eradication was stressed as a major management goal.

## Water-Yield Improvement

To determine the potential for water-yield improvement by manipulating riparian vegetation, early experiments were conducted on Sycamore Creek, the Whitespar Watersheds, and the North Fork of Workman Creek. These experiments involved water-budget analyses and paired-watershed studies.

Thomsen and Schumann (1968) conducted a water-budget study on the lower 10 miles of Sycamore Creek where riparian vegetation covered about 1,400 acres of stream channel and floodplain. The study was designed to estimate possible changes in the water yield through removal of riparian vegetation. Water losses were estimated to average 81,500 acre-ft annually or about 1.1 acre-ft per acre. Since transpiration by vegetation was thought responsible for much of this loss, it was determined that a large percentage of water would be saved by eradication of the riparian vegetation (Horton and Campbell 1974).

A primary reason for gaging the Whitespar watersheds near Prescott was to determine the streamflow response when channel-side chaparral shrubs were converted to a grass-forb cover (Ingebo 1972, Hibbert et al. 1974, DeBano et al. this publication). For the 4 years following the herbicide treatment, annual streamflow increased an average of 0.61 inch or about 30% when compared to the untreated control watershed. This increase of streamflow averaged 4 inches from the treated area (15% of the watershed). Over 75% of the increase came during the December through April major flow period.

All of the Arizona alder and bigtooth maple adjacent to springs, seeps, and streams on the North Fork of Workman Creek were cut in 1952, and their stumps were poisoned with an herbicide to prevent resprouting. The effect of removing these broad-leaved trees on subsequent streamflow was insignificant, even during the growing season when the greatest rate of transpiration would occur. It was hypothesized that the number of trees removed and the area affected by this treatment were too small to cause a significant change (Rich and Thompson 1974, Gottfried et al., Chapter 2 of this publication).

While the results from these and similar experiments on effect of riparian vegetation removal on water regimes were inconclusive, relatively large-scale operational eradication programs continued into the 1970s (Horton and

Campbell 1974). Riparian plants, particularly woody phreatophytes, were removed from within stream channels, on floodplains, and terraces by mechanical, chemical, or a combination of mechanical-chemical means. Following initial conversion, the treated areas were usually subjected to mechanical or chemical maintenance programs to suppress invasion by high water-using plants.

## Current Research Emphasis

Continual pressure by environmental groups and the general public to preserve and develop riparian ecosystems for wildlife habitats, recreation, and aesthetic values resulted in altering the riparian management emphasis in the Central Arizona Highlands and throughout the Southwest by the mid 1970s. Interest in the condition, role, and sustainability of riparian ecosystems had increased greatly. Because water-yield improvement was not the primary focus of management, eradication of riparian vegetation ceased. Environmental groups and the general public had become increasingly concerned about maintaining the integrity of riparian ecosystems for multiple values.

Concern for the declining health of riparian ecosystems, initially expressed by the scientific community, had expanded to a broad spectrum of interest groups including land and water resource managers, educators, recreation managers, legislators, and environmentalists (Shaw and Finch 1996). These groups were seeking information and a better understanding of the dynamics, functions, uses, and the restoration of riparian ecosystems. A series of symposia has reflected this growing interest and the often conflicting uses and desired future conditions of riparian ecosystems (Johnson and Jones 1977, Johnson and McCormick 1979, Johnson et al. 1985, Tellman et al. 1993, and Shaw and Finch 1996).

---

## Current Research Program

---

The sustainability of riparian ecological systems in Southwestern forests and woodlands is being investigated by scientists with the USDA Forest Service, Rocky Mountain Research Station, Flagstaff, Arizona. The purpose of this project is to create, develop, and apply knowledge on fluvial, geomorphological, and ecological system functions, processes, and dynamics needed to sustain diverse and healthy riparian ecosystems in the Central Arizona highlands and elsewhere in the arid Southwest.

## Goals

Goals of this research program include:

- Determination of specific interrelationships among hydrologic, geomorphic, and biotic processes that affect fish habitat, riparian vegetation, channel dynamics, and instream flow regimes.
- Development of predictive models to determine the effect of watershed-scale activities, such as prescribed fire, grazing, and vegetation management, on the functioning and quality of riparian ecological systems.
- Determination of factors that influence populations and habitats of threatened, endangered, and sensitive fish, and other fish, plants, and biota inhabiting Southwestern riparian ecosystems.

## Results

Results from earlier studies conducted on riparian ecosystems have been previously reported in a status-of-knowledge paper (Horton and Campbell 1974). Results of the current research program show that:

- Although there is a public perception that riparian areas are fragile, current information indicates that riparian systems are often resilient. Today, many riparian areas are at risk because of various stresses, such as overgrazing by livestock and wildlife, drought, and flooding, which have caused the system to lose its dynamic equilibrium. However, once these stresses are relieved, many riparian systems can regain their equilibrium within a few years because of resilient, native, herbaceous, riparian plants such as *Carex*, *Eleocharis*, *Juncus*, and *Scirpus* (Medina 1996; Medina et al 1996).
- Instream structures, channelization, bank modification, and rip-rap can be used to provide flood control, irrigation development, and wetland conversion. Many restoration projects using these methodologies, however, have resulted in further site degradation and reduction in the functioning condition of the affected streams (Baker and Medina 1997).
- The importance of the interactions between the riparian vegetation and channel systems must be

recognized as integral factors in maintaining ecosystem productivity (Medina et al. 1997). Channel systems are continually adjusting to varying flows and sediment loads, a process that is incompatible with placement of fixed structures. Riparian vegetation on flood plains allows the stream to function properly and helps provides resiliency to withstand a variety of environmental conditions.

- Often, restoration of a degrading channel system only requires exclusion of grazing (ideally, both domestic animals and wildlife) for a few years and occasionally reestablishment of riffle bars (Medina 1996). Removal of the grazing stress allows the riparian plants to regain vigor and restores their functioning ability to detain flood flows, reduce water energy and bank erosion, and to trap sediments and nutrients in the water (figure 20). The riffle bars slow down the water velocities, reduce or terminate downcutting of the channel, and provide fish spawning habitat.

---

## Implications

Research efforts in the riparian ecosystems and changing attitudes of the general public have had major effects on how riparian areas are currently viewed and managed. Riparian ecosystems are now considered important habitats for wildlife species and important grazing areas for livestock and wildlife, while providing opportunities for fishing, hiking, bird watching, picnicking, and camping. Maintaining the integrity of these fragile systems requires careful management and, in some cases, protecting them from overgrazing, excessive tree cutting, recreational use, and other disturbances.

Currently, research emphasis is on assessment of the condition of our riparian resources and on restoration of areas that are not functioning properly. Although millions of dollars have been spent during the last century for riparian restoration and fish habitat improvement, riparian areas have been and are still disappearing, while others remain in a degraded condition (Baker and Medina 1996). Current research, however, provides hope that with little effort and money, many degraded but resilient systems can be restored using inexpensive materials and equipment and changes in grazing strategies.



Figure 20. Section of Boggy Creek in eastern Arizona, immediately following exclosure with an elk proof fence in 1992 (*above*), and some location in October 1996 (*below*).

