Appendix C

The Importance of Riparian Vegetation and Its Functions

By Kibum Sung

Introduction

Riparian vegetation is very important in determining the structure and function of stream ecosystems. Most aquatic organisms, both invertebrates and fish, are directly or indirectly dependent on inputs of terrestrial detritus to the stream for their food. Natural changes in riparian vegetation and the biotic processing of detritus, as well as other factors, determine the kinds and abundance of aquatic invertebrates living in streams, from headwaters to large rivers.

The manner in which riparian systems are managed and protected is commonly related to their value as buffer strips, stream bank stabilizers, and fish and wildlife habitat. These strips of streamside vegetation may be the only habitat remaining for some wildlife species. As riparian vegetation is modified or destroyed by grazing, logging, urbanization, road construction, water development, mining, and recreation, interest in its importance is increasing (Knight and Bottorff, 1984).

The Significance of Riparian Environments

The use of the word "riparian" was a short time ago restricted mainly to academic biological research circles, but as the importance of streamside plant communities has been increasingly recognized and appreciated, the word has entered mainstream use. It is derived from the Latin *ripa*, which means the bank of a stream. A recent attempt to clarify what's meant by riparian states that it "pertains to the banks and other adjacent terrestrial (as opposed to aquatic) environs of freshwater bodies, watercourses, estuaries and surface-emergent aquifers (spring, seeps, oases) whose transported freshwaters provide soil moisture sufficiently in excess of that otherwise available through local precipitation to potentially support the growth of mesic vegetation" (Richard and Kathleen, 1984). Biologists then make references to and distinctions between riparian areas, floodplain wetlands, and aquatic systems, which can be confusing to the uninitiated. Aquatic environments refer to the waters in which plant and animal organisms grow and live.

Because of the abundance of water and vegetation along streams, floodplains and the associated riparian and wetland areas provide habitat for a large and diverse fish and wildlife species. An interagency government report on floodplains states, "No other ecosystem is considered more important to the survival of the nation's fish and wildlife resources" (Interagency Task Force on Floodplain Management, 1989). Inland, midwestern floodplains and wetlands are most noted for waterfowl production and as habitat for migrating birds. The Mississippi River floodplains are major duck and goose resting and feeding grounds during fall and spring migrations. The bottomland forests of the southern rivers are primary wintering grounds for North American waterfowl and important breeding areas for many species. Forested river bottoms in the eastern United States are also important to birds and mammals. In the more arid West, riparian communities are particularly valuable, providing habitat for up to 80 percent of western wildlife species and an essential environment for other wildlife populations in the region.

It is estimated that about 50 percent of the endangered species in the United States require a wetland habitat at some point in their life cycle. The reason that such a large number of birds, mammals, and other vertebrates depend on riparian systems has to do with the diversity of conditions in riparian environments. Riparian areas have flowing water, moist and nutrient-rich soils, relatively high plant productivity, and corridors for migration and travel. Such structural complexity adds to the landscape diversity of the region. There is also an important spatial and temporal dimension to the interactions between land and water. Habitat features change dramatically with only small topographic differences such as the gradient from an open-water stream channel to a dense streamside forest; the duration and timing of flooding can be critical to species types and densities. Such changing dynamic conditions must be allowed to affect these plant and animal communities, or we will lose them. An important effect of the biological productivity of rivers and floodplains has been termed the flood pulse. Not only are floodplains, as a physical feature of a river, important to biological diversity, but also the timing and frequency of seasonal overbank flows and floodplain inundations can profoundly affect ecological systems. When such natural pulsations of water have been changed by channelization, drainage, dams, other influences, plant communities have been found to shift to different species compositions (Riley, 1998).

Important Functions of Riparian Vegetation

- Tree roots, shrub species, vines, and other growth bind the stream bank soil and provide resistance to the erosive forces of the water. This produces deeper channels with banks that are undercut but held together with exposed root systems. These undercut banks, complete with overhanging vegetation, provide important escape cover for fish.

- Riparian vegetation moderates water temperatures, making the stream habitable for fish.
- Most of the stream's biological energy and the base of the food chain for stream life come from the leaves, fruit, cones, and other plant detritus from the riparian vegetation.
- Woody debris that falls into the stream forms pools for fish, creates habitat by causing backwater pools, and provides storage areas for sediment that otherwise might be released into spawning areas.
- Riparian vegetation can slow flood velocities and help deposit and store sediment on the floodplains as opposed to the stream channel downstream. During high flows the vegetation lies against the banks and protects them from accelerated erosion.
- A well-vegetated channel helps store water along the stream corridor during the rainy season for slow release to the stream in drier seasons, which helps maintain the base flows of water for the fish.

Riparian Values

Riparian vegetation plays a role relative to erosion, channel stability, and water quality, and riparian areas have aesthetic, recreational, and resource values more directly related to humans.

Shading

The shading effect of riparian vegetation provides significant temperature moderating effects to adjacent watercourses. This cooling effect can determine the suitability of streams for important gamefish species such as trout and salmon (Collings and Myrick 1966; Brown and Kygier 1967; Meehan 1970; Brown, Swank, and Rothacher, 1971). Greene (1950), Gray and Edington (1969), and others have demonstrated that lack of, or removal of, shading along streams can increase water temperature by 6.5 ~ 10 º C (11.7 ~18 º F). Shading also can significantly diminish daily temperature variations in streams, which has important ecological effects (Baltz and Noyle, 1984).

Erosion

Riparian vegetation protects watercourse bank from erosion through reduction of water velocity, soil binding by root masses, and the presence of ground litter, which impedes the rate of surface runoff (U.S Army Crops of Engineers, 1978; Lines, Jr., Carlson, and Corthell, 1979). It promotes deposition of silt as new soil during periods of flood, without which key riparian species such as willows and cottonwoods could not reproduce. It also provides important substrates for aquatic insects, and escape and resting cover for many fish species.

Organic Input

The dead organic matter or detritus (leaves, twigs, branches), and to a lesser extent live invertebrates, from riparian vegetation are important sources of nutrients, especially to headwater streams. Up to 99 percent of the annual energy input, the food base for entire aquatic communities, comes from streamside vegetation in these situations, especially where there is a dense forest canopy.

Aquatic Insects

When thinking about fish and their habitats, we have tended in the past to follow in our minds the sequence: big fish eat little fish; little fish eat aquatic insects, and aquatic insects somehow make out in their watery world.

Little fish do indeed eat aquatic insects, but aquatic insects feed to a large degree-especially those in smaller streams and headwaters—on a harvest of materials provided by the riparian vegetation. Furthermore, the aquatic insects directly depend on riparian vegetation for summer resting sites, for places to transform themselves from larval to adult forms, and for breeding sites. In reality many, perhaps most, aquatic insects are amphibious, spending parts of their life cycles in water and part on, in, and around riparian vegetation.

Corridor

Linear riparian systems, which their shade, food supplies, cover, and water, can become important corridors for the migratory and dispersal movements of wildlife. In some parts of the country, elk and deer consistently use riparian zones as migration corridors between summer and winter ranges. Riparian corridors provide important migratory and dispersal routes for highly mobile species such as birds, bats and other mammals, and even for some reptiles, amphibians, and insects. This phenomenon may have special significance in the Central

Valley of California where linear riparian systems traverse the north-south length of the valley, a distance of 450miles. Many species of land birds use riparian corridors as they are sometimes the only available woodland environment through which the birds may traverse a geographic region while on migrating flights. In the riparian zone they find food and cover which may be unavailable in adjacent uplands but a few feet away.

The Water Quality Connection to Riparian Woodlands

Inland and coastal marshes have received a lot of attention as the wetland systems with the capacity to absorb and act as natural treatment "plants" for polluted, nutrient-laden waters from urban runoff and runoff from agricultural areas. In the late 1970s researchers began to explore the potential of riparian systems to contribute to water quality—and to determine whether impacted riparian systems contribute to the degrading of water quality.

Researchers found that riparian areas are environments that trap sediment. From there they discovered that large amounts of phosphorus (greater than 85 percent) and nitrogen (greater than 70 percent) in surface runoff measured from agricultural areas is attached to sediment. Wendall Gilliam of North Carolina State University and other researchers concluded that a riparian system is the best ecological system for removing sediment—and therefore for removing pollution-causing nutrients from water. They found that 80 percent of the sediment produced by an agricultural watershed was dropped in a stream's riparian zone and that the finer sediments ended up downstream in the swamps and wetlands. They also found that riparian areas are better at reducing phosphorus, while swamps and other nonriparian wetlands are typically high in phosphorus and have the ability to actually contribute it to the environment as opposed to using or absorbing it. They concluded that riparian vegetation is just as effective a filter in urban areas as in agricultural areas and that riparian buffer areas as narrow as 20 feet are valuable in contributing to water quality. Research has not only corroborated those findings in other locations in the country but has also determined that trees and shrubs are more effective in removing nutrients—in particular, nitrates—than grassed waterways.

The development and clearing of riparian areas not only represents a loss of the water treatment capabilities of those areas but also may turn such damaged environments into sources of nonpoint pollution. Because those areas have served as sinks for sediment and nutrients, they can export the sediment that has been deposited over many years through disturbance and erosion back into the watershed.

Effects of Riparian Vegetation Removal

Riparian vegetation is very important in determining the structure and function of stream ecosystems. Most aquatic organisms, both invertebrates and fish, are directly or indirectly dependent on inputs of terrestrial detritus to the stream for their food. Natural changes in riparian vegetation and the biotic processing of detritus, as well as other factors, determine the kinds and abundance of aquatic invertebrates living in streams, from headwaters to large rivers. Removal of riparian vegetation will significantly affect stream organisms by: 1) decreasing detrital (food) inputs; 2) increasing the potential for primary production in aquatic plants; 3) increasing summer water temperatures; 4) changing water quality and quantity; and 5) decreasing terrestrial habitat for adult insects. (See Fig. 1)

Decrease of Detrital Input

Riparian vegetation often supplies large amounts of organic matter (energy) to the stream, forming a dependable food base for stream invertebrates year after year. Many of these animals have complex structures, behaviors, and life cycle events which are specially adapted for using different kinds and sizes of detritus as food. Decrease of detritus will cause decreased populations of these species, although instream populations may still be maintained some at lower densities.

Effect on Primary Production

Riparian vegetation is a major control on light intensities reaching algae and macrophytes in headwater streams, and therefore on the level of primary production that can occur. Shade removal has been demonstrated to increase primary production and cause algae mats in small streams both in the field (Granoth, 1979) and in the laboratory (McIntire and Phinney, 1965). For example, vegetation removal along a small stream in Kansas changed it from heterotrophy to autotrophy (Gelroth and Marzolf, 1978). Also, in laboratory streams exposed to two different light levels, the stream receiving twice as much light had twice the gross plant production (Brockesen et al. 1968). If nutrients or other factors are not limiting, increased illumination due to shade removal will increase primary production and the food resources used by scrapers.

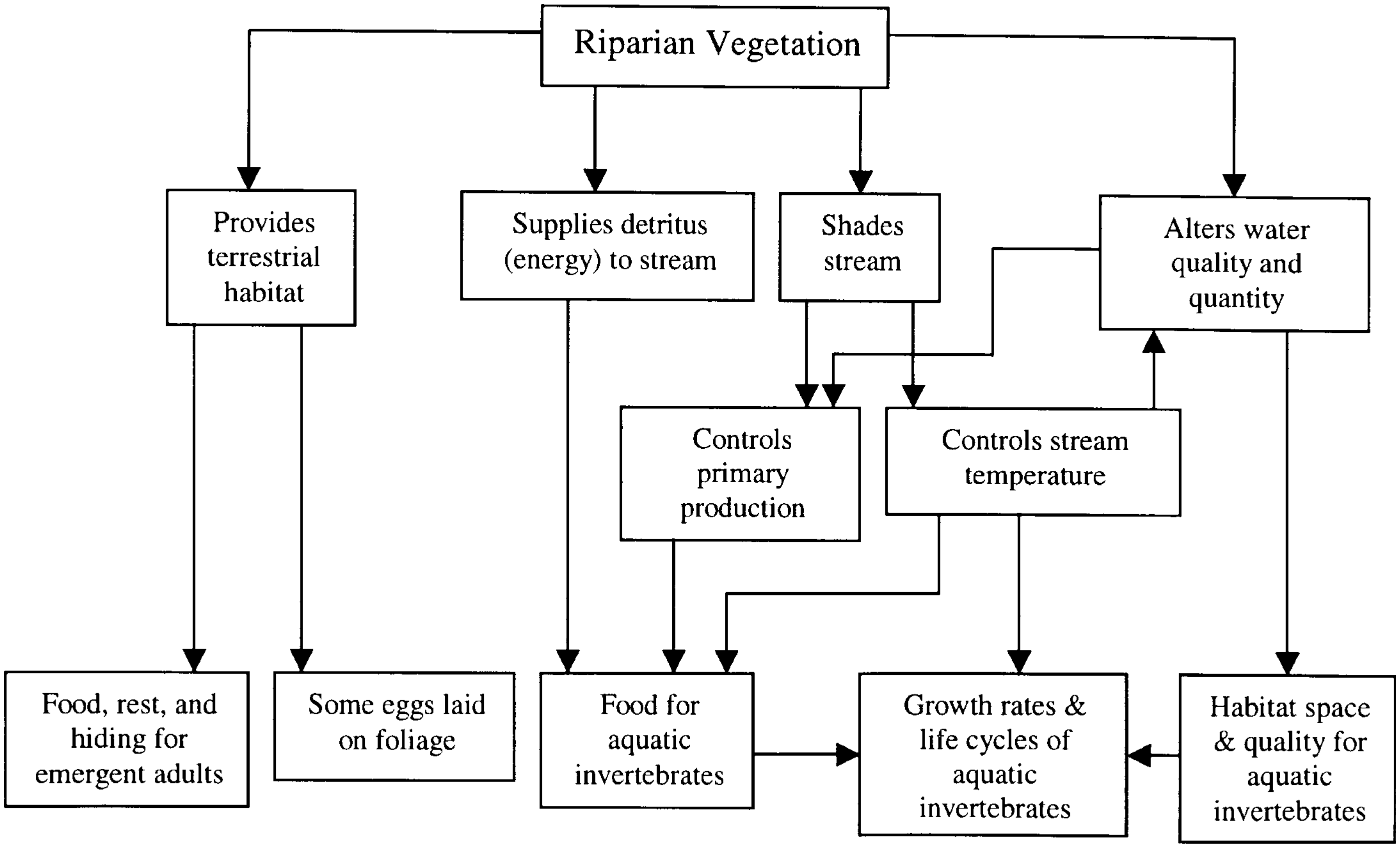

Figure 1. Relationships Between Riparian Vegetation and Stream Components (Knight and Bottorff 1984)

Effect on Stream Temperature

Shade from riparian vegetation moderates stream temperatures, often preventing excessive summer temperatures that may be lethal to invertebrates or fish. Water temperature affects numerous important stream functions, such as processing rates of organic matter, chemical reactions and concentrations, metabolic rates of stream invertebrates, and cues for life cycle events. Because of these complex interactions it is very difficult to assess the ultimate effects of shade removal and water temperature changes on stream animals. Stream invertebrates have different tolerances for water temperature variations, but most species in headwater streams are narrowly adapted for cool temperatures and may use dormant strategies to survive natural warm periods (Hynes, 1970).

Water Quality and Quantity Alterations

Riparian vegetation affects water quality not only by moderating water temperature and influencing chemical reactions, but also by contributing dissolved organic matter (DOM) and nutrients to the stream. Riparian vegetation also protects streambanks from excessive erosion, minimizing the input of fine sediments which can fill the numerous cracks, crevices, narrow channels, and openings that ramify through the upper substrate layers that form the invertebrate habitat of normal headwater streams. Removal of riparian vegetation may increase the annual amount of stream runoff, increase peak discharges after rainstorms, and change the timing of peak flows. Change in runoff quantity will cause the stream channel to readjust its velocity patterns, channel dimensions, frequency of pools and riffles, and substrate composition, all of which are important for the amount and quality of invertebrate habitat.

Loss of Terrestrial Habitat

Most aquatic insects emerge into terrestrial ecosystems as adults with wings for dispersing and searching for mates. Riparian vegetation is an important habitat used by these adult insects for feeding, resting, and hiding. Use of this foliage is heavy in spring and somewhat less in summer and autumn. Some use occurs even in winter. Without this vegetation, predation by birds, terrestrial insects, and mammals would undoubtedly be much greater. Some insect adults lay eggs on riparian vegetation overhanging the stream so that upon hatching the young larvae will drop back into the stream for the aquatic life stage.

Conclusion

The impacts on vegetation determine the effects on wildlife, which can include a full range of amphibians and reptiles, nongame and game birds, small mammals, and large mammals. These animals lose reproductive habitat and food sources, cover from predators, and mobility, as well as nesting, perching, and roosting sites.

There has been a shift in thinking by many professionals to the conclusion that the natural features of streams such as riparian vegetation, pools, riffles, meanders, and floodplains contribute positively to the stability of channels and that those features should, at minimum, be contained in stream modification projects because of the important functions they perform.

References

Briggs, Mark K., *Riparian Ecosystem Recovery in Arid Land: Strategies and References.* The University of Arizona Press, Tucson, 1996.

Interagency Task Force on Floodplain Management. *A Status Report on the Nation's Floodplain Management Activity.* L. R. Johnston Associates, 1989.

Karr, James R. and Ellen W. Chu, *Restoring Life in Running Waters: Better Biological Monitoring*. Island Press, Washington D.C., 1999.

Knight, Allen W. and Richard L. Bortorff. *The Importance of Riparian Vegetation to Stream Ecosystems.* Pages 160-167, University of California Press, Berkeley, 1984.

Malanson, George P., *Riparian Landscape*. Cambridge University Press, 1993.

Mount, Jeffery F., *California Rivers and Streams: The Conflict Between Fluvial Process and Land Use*. University of California Press, 1995.

Odum, Eugene P., *Ecology: A Bridge Between Science and Society.* Sinauer Associates, Inc., Massachusetts, 1997.

Riley, Ann L., *Restoring Streams in Cities: A Guide for Planners, Policymakers, and Citizens*. Island Press, Washington D.C., 1998.

Warner, Richard E. and Kathleen M. Hendrix, *Riparian Resources of the Central Valley and California Desert*. California Department of Fish and Game, 1985.

Warner, Richard E. and Kathleen M. Hendrix, *California Riparian Systems.* University of California Press, Berkeley, 1984.