The Watershed-Riparian Connection: A Recent Concern?

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Abstract.—Management impacts on a watershed can cause a variety of complex responses by the encompassed riparian-stream system. Information about these responses will help land managers select practices that provide the riparian area with the best chance for future health and stability. Since we now recognize that people have been impacting riparian areas for a long time through their actions on the surrounding watersheds, it is appropriate that we apply our knowledge of history to guide our actions in the direction of stabilized watersheds and healthy riparian areas.

Introduction

There have been some over simplifications, and some connections have been overlooked, in discussions about riparian areas. Land managers and the public often fail to recognize the importance of the links between channel response and impacts caused by natural or human-caused events in the surrounding watershed (Baker and others 1998).

The Problem

Human-induced disturbances brought about by land-use activities on the surrounding watersheds probably have a greater potential for introducing enduring changes to the structure and function of riparian-stream systems than human-caused disturbances within the riparian systems (FISRWG 1998). Although much has been written about the many values of riparian areas and how various intensive uses have degraded these areas, only relatively recently have publications described how upland watershed practices have affected riparian areas (DeBano and Schmidt 1989a).

Maintenance of historic riparian physical and biological conditions requires maintenance of appropriate, preferably historic, instream flow and sediment conditions (Rieman and Clayton 1997, Rinne 1996). Stream flows can be greatly reduced by pumping aquifers or diverting flow for irrigation purposes, or the flows can be increased due to vegetation change, soil loss, or road conditions. Although increased flow, particularly peak flow, can be very damaging to riparian areas, in situations where upland management is focused on or contributes to water-yield increases, riparian systems have expanded (DeBano et al. 1984, DeBano and Schmidt 1990, Rinne 1995). The primary focus of this paper is the conditions of disturbed watersheds that create increased flood flows and sediment loads.

Erosional Processes

Riparian areas should be managed within the context of the entire watershed. A balance exists between health, diversity, and productivity of riparian communities and the watershed conditions where they are contained (DeBano and Schmidt 1989b, McGurrin and Forsgren 1997). All tributary effects accumulate to influence riparian health and stability. Upland watersheds in satisfactory condition absorb storm energies, provide stormflow regulation through the soil mantle, and contribute stability to the entire watershed. In contrast, watersheds that have experienced past abuse often have developed channel systems, including gully networks, throughout the watershed in response to the increased surface flows. These gully networks cause rapid, concentrated surface runoff with increased peak flows and sediment loads (DeBano and Schmidt 1989b). Channelized flow from intermittent and low-order streams is a primary sediment source in mountainous regions where large amounts of material can move long distances into streams. In general, small streams are more affected by hillslope activities than larger streams and, as adjacent slopes become steeper, the likelihood of disturbance from in-stream effects increases (Lee et al. 1997, Megahan and Ketcheson 1996).

Channels are formed, maintained, and altered by the water and sediment they carry. A stream constructs and maintains its channel size to enable most sediment to be carried during short periods when the flow is near bankfull (FISRWG 1998, Leopold 1994, Whiting et al. 1999). If riparian systems are in dynamic equilibrium, the volumes

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of incoming sediment equal the volumes of exiting sediment. Normally, under such conditions there are few rapid changes in stream meander cutting, growth of point bars, or erosion of channel beds. Characteristics of channel profile, stream morphology, and vegetation mutually adjust to accommodate prevalent conditions (DeBano et al. 1996, Heede 1980).

Erosion is a temporally discontinuous process that transports sediment from a source area through a channel system with intermittent periods of storage (Wolman 1977). Most of the sediment is transported in riparian systems during major streamflow events (DeBano et al. 1996). Sediment is often deposited in a channel until a sufficiently large peak-flow event occurs that moves it further downstream. Sediment can be stored in a channel for years making it difficult to interpret the sediment generating process on the surrounding hillslopes (DeBano et al. 1996, Heede et al. 1988). The bedload component of total sediment varies greatly from area to area, but it always plays an important role in channel structure and function. The unsteady movement of sediment involving aggradation and degradation is important in maintaining the stability of downstream riparian systems (DeBano and others 1996).

Decreased Plant Cover

Vegetation regulates sediment by slowing streamflow and dissipating energy so that water infiltrates into the soil. Increased infiltration prevents excessive erosion, maintains the physical stability of the landscape, and provides moisture to the streambanks to maintain riparian vegetation (DeBano et al. 1996). Conversely, disturbing vegetation cover accelerates erosion and increases sediment yield. Vegetation and topography interact to stabilize and store sediment within intermittent drainage systems and in small headwater basins.. Periodically, these sites are flushed by floods that remove some or most of the material. A period of relative stability results in colluvium accumulation (Lee et al. 1997).

Under conditions of dynamic watershed equilibrium and minimum on-site disturbance, the riparian vegetation remains vigorous but does not encroach into the active mean annual flood channel (DeBano et al. 1996). When sufficiently large changes in erosion and deposition occur, the riparian area may lose equilibrium as it is no longer able to quickly adjust to change. The area may remain in a state of disequilibrium for long periods of time. Without the stabilizing influence of a rhizomatous, heavily-rooted riparian plant community, greater bank erosion and vertical or lateral channel instability can occur (Medina 1996). Channel incision can intercept and drain existing floodplain water tables, desiccating the site with the accompanying loss of the riparian plant community. Alternatively, when excessive deposition takes place and the aggrading channel becomes braided and shallow with rapidly shifting bank and channel erosion, the wetland vegetation may be overwhelmed (Baker et al. 1998).

For most streams, streambank and channel stability is one the most important attributes of a properly functioning riparian system. Adapted wetland plants are important in sustaining desirable functional processes, particularly those of channel stability (Medina 1996). If flood flows and sediment loads from partially denuded uplands continually impact the wetland plant communities through changed hydrologic regimes, incised channels, debris flows, etc., a long-term unstable riparian system will result (Clary et al. 1996).

Increased Plant Cover

Traditional Western United States land uses (e.g., grazing, logging, mining) are normally mentioned when landscape degradation associated with decreases in vegetation density and cover is considered. However, the indirect affects of various forestland management practices that have increased plant cover are also of great concern. Selective and extensive timber harvest, fire suppression, and grazing practices have significantly altered forest structure and fuel loads. Forests that were once mosaics of species, ages, and patterns have been simplified. Many are now dominated by higher-density, middle-aged stands (often referred to as the “forest health problem”) which are more vulnerable to pest infestations and fire. The more homogeneous, interconnected vegetation patterns and the increased fuel loadings are thought to increase landscape vulnerability to high-intensity stand-replacing wildfire events (Rieman and Clayton 1997, Rieman et al. 1997). Fires originating in the surrounding landscapes can affect riparian areas directly and indirectly. Direct effects include stream heating and changes in water chemistry. Indirect effects include changes in hydrologic regime, erosion, debris flows, woody debris loading, and reductions in riparian vegetation and cover (Rieman et al. 1997).

Fire and the associated hydrologic effects have been characterized as pulsed disturbances, while effects caused by permanent road networks are considered as chronic or press disturbances. Many aquatic organisms, including native salmonids, may be adapted to pulsed disturbances (Rieman and Clayton 1997). Characteristics that allow populations to persist with disturbance may well depend upon large, well-connected, spatially complex habitats that can be lost through chronic effects of management. Attempts to reduce the cover of currently over-dense forest stands by conventional roading and timber harvest may cause chronic delivery of fine sediment into riparian-aquatic systems resulting in more long-term damage to those systems than that caused by extreme wildfires (Rieman and Clayton 1997).

Conclusions

Major watershed disturbances affect the quality and quantity of streamflow, bank storage, channel stability, and vegetation in the riparian zone (Baker et al. 1998).

Many widespread uses of watersheds, such as agriculture, extensive unmanaged livestock grazing, forest clearing, other forestry practices, and mining, coupled with roads and trail construction and maintenance, have some common effects that conflict with the hydrologic and geomorphic functions of riparian-stream systems. To various degrees, these activities reduce vegetation cover, compact soils, and decrease infiltration. Such disturbances result in productivity loss, reduced soil porosity, reduced soil infiltration, increased surface runoff, increased flood peaks, increased sheet, rill, gully, and bank erosion, unstable stream channels, and impaired habitat (DeBano and Schmidt 1989b, Eldridge 1995, Frasier et al. 1995, Johnson 1995, Krueper 1996). Increased channel sedimentation reduces channel capacity, increases width / depth ratios, and induces bank erosion and other instabilities. Alternatively, excessive water reaching a stream system **without** additional sediment loading, as often occurs with water diversions, can erode the channel bottoms, thus incising the channel (FISRWG 1998).

Is this Something New?

Riparian zone problems from management activities on the surrounding landscapes are a recent concern that is related to modern societies–right? Wrong. European settlers came to a continent in which ecosystems had been changing for thousands of years in response to American Indian populations. These indigenous populations had been increasing in numbers, and their society was becoming more complex and required significant amounts of resources (Jennings 1993, Periman 1999, Tainter and Tainter 1996). As agricultural-based communities developed in Southwestern river valleys, settlements of up to 2,000 to 3,000 rooms were built. Land was cleared for agriculture, and wood for construction, cooking, heating, and other uses that was available within transporting distance would have been consumed within a short time (Tainter and Tainter 1996). It has been estimated that a prehistory settlement of 1,000 people would have cleared a 3.5 mile radius of trees around a village within one generation (Spoerl and Ravesloot 1995). Landscape impacts from deliberate setting of fires would have been extensive and undoubtedly greatly affected the herbaceous and woody plant composition of the time (Spoerl and Ravesloot 1995).

The floodplains in some areas were greatly modified as American Indian canal systems and other water control structures were developed and used (Spoerl and Ravesloot 1995). Such systems were often highly vulnerable to extreme climatic events. Periods of erosion and channel entrenchment correlate with periods of prehistoric human modifications of the floodplain (Spoerl and Ravesloot 1995). Another prehistoric feature was the cobble-mulch gardens of the Anasazi. Cobble-mulch gardens and associated water harvesting features covered vast areas along specific drainages, in some cases covering 50% of the total terrace area. In these areas, less water would have reached riparian areas, thus affecting riparian vegetation and hydrological dynamics. Water harvesting features can persist and affect ecosystems for hundreds of years after abandonment (Periman 1996).

Such situations were not limited to a few localized circumstances in North America (Periman 1999). The region of ancient Mesopotamia and surrounding locality may have contributed more to the advancement of complex societies than any other equivalent area. The chief resources were fertile valley lands and the waters of the Tigris and the Euphrates rivers. This area, largely contained within the current country of Iraq, supported thriving populations for several thousand years through the use of irrigated agriculture. Over the centuries, over-irrigation resulted in soil salinization (Adams 1981), and sediment from rivers filled and blocked the irrigations systems (Carter and Dale 1974). Much of the sediment came from uplands that had been denuded by deforestation and overgrazing. Thus, human activities on the uplands and the lowlands contributed to the degradation of the lowlands. Today, much of the central floodplain of the ancient Euphrates River is beyond the bounds of cultivation and supports only a fraction of the earlier human population levels (Adams 1981, Carter and Dale 1974). Records suggest that similar experiences have occurred around the world. Much of the problem has been the eroding watersheds that are depleted of productive soils, and the degraded, sediment choked waterways (Carter and Dale 1974). It has been stated that "civilized man has marched across the face of the earth and left a desert in his footprints." Perhaps this is a slight exaggeration (Carter and Dale 1974). The internal collapse of complex societies often initiated abandonment of landscapes (Tainter 1988).

Desertification and other forms of land degradation are occurring globally. Soil erosion is proceeding at rates in excess of natural soil development (Brooks and Ffolliott 1995). The resulting accelerated rates of sediment and debris flows reduce upland productivity, impact riparian areas, clog stream channels, and fill reservoirs. Planners should strive to link costs and benefits between watershed and riparian areas. Pouring money into degraded stream systems that are continuously disturbed by surrounding land-use activities is futile and raises false hopes of improved aquatic conditions (McGurrin and Forsgren 1997). Correcting or mitigating the fundamental causes of degradation, whether it be road construction, timber harvest, mining, or overgrazing, will facilitate the natural recovery of eroding hillsides and streambanks (Wood et al. 1997). Considering a watershed perspective would help planners justify expending funds to protect or improve conditions in one portion of a watershed to benefit activities in another portion of a watershed. For example, siltation of reservoirs costs the U.S. economy about $6 billion annually, yet the value of forests and rangelands in preventing erosion is rarely considered in the analysis of wildland worth (Dobrowolski and Thurow 1995). "It remains a great irony that U.S. residents are more attuned to the decline of distant tropical rain forests than they are to the loss of natural resources in our own backyard" (Tilt and Williams 1997).

Conclusions

1. Riparian areas exist within the context of the surrounding watershed.
2. Unstable uplands produce a continuously unstable riparian area.
3. Begin restorative efforts at the watershed divide and work towards the riparian area. "Band Aid" approaches are not recommended (Dobrowolski 1995).
4. Conduct all management knowing that uplands and riparian areas are linked physically, biologically, socially, and economically.
5. Planning tools can provide predictive capability that contributes to your understanding of the effect of watershed actions upon the riparian-stream system below (Bettinger et al. 1998).
6. Break some rules and learn from what we already know! Remember, "Every time history repeats itself, the price goes up" (quoted by Tainter 1988).

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