

INTRODUCTION TO THE FEATURED COLLECTION ON RIPARIAN ECOSYSTEMS & BUFFERS¹

Paul M. Mayer, Albert H. Todd, Judith A. Okay, and Kathleen A. Dwire²

Mayer, Paul M., Albert H. Todd, Judith A. Okay, and Kathleen A. Dwire, 2010. Introduction to the Featured Collection on Riparian Ecosystems & Buffers. *Journal of the American Water Resources Association* (JAWRA) 46(2):207-210. DOI: 10.1111/j.1752-1688.2010.00425.x

Riparian ecosystems, located at the interface of terrestrial and aquatic systems, are often given special attention by scientists for their high biodiversity and biological activity (Naiman *et al.*, 1993; Naiman and Decamps, 1997) and significant role in nutrient and energy flux (McClain *et al.*, 2003). Riparian ecosystems are known to buffer environmental impacts and contribute to the maintenance of water quality (Lowrance *et al.*, 1997). For example, riparian zones can intercept, filter, and process anthropogenic nitrogen inputs (Lowrance *et al.*, 1984; Peterjohn and Correll, 1984; Mayer *et al.*, 2007), attenuate phosphorus (Hoffmann *et al.*, 2009), capture sediments (Liu *et al.*, 2008), reduce urban noise (Harris, 1985), and moderate stream temperature (Wilkerson *et al.*, 2006), functions that are especially important in the face of global climate change and continued land use development. Their position in the landscape and linear pathways create critical corridors for animal migration and movement (Hagar, 1999). Thus, riparian areas provide critical ecosystem services that support society and economies (Millennium Ecosystem Assessment, 2005) and are, therefore, essential to human health and well-being. In many regions such as urban and suburban centers, riparian areas remain the last

intact ecosystems to provide parks and green space (Groffman *et al.*, 2003). Ultimately, riparian ecosystems are immeasurably valuable. The continual loss of riparian zones represents a loss of ecosystem services (Sweeney *et al.*, 2004). The proliferation of management initiatives for riparian buffers demonstrates a need for sound, quantitative science on riparian ecosystem function and the results of conservation and restoration actions. The contents of this special issue are intended to help inform management decisions that support the values and services riparian ecosystems provide.

The 10 papers in this collection were solicited from research scientists and others who participated in the American Water Resources Association summer specialty conference titled "Riparian Ecosystems & Buffers: Working at the Water's Edge," held in Virginia Beach, Virginia, June 30-July 2, 2008. The approximately 330 conference attendees participated in an interdisciplinary forum with over 120 speakers in 36 technical sessions. Keynote speakers included Brian Richter of the Nature Conservancy, James Karr of the University of Washington, Bernard Sweeney of the Stroud Water Research Center, and Emily Bernhardt of Duke University who spoke on issues

¹Featured Collection Introduction. © 2010 American Water Resources Association. No claim to original U.S. government works. DOI: 10.1111/j.1752-1688.2010.00425.x.

²Respectively, Ecologist, U.S. Environmental Protection Agency, Ground Water and Ecosystems Restoration Division, 919 Kerr Research Drive, Ada, Oklahoma 74820; Conference Chairperson, Assistant Director for Ecosystem Services & Markets, USDA Forest Service, 1400 Independence Avenue, SW, Washington, DC 20250; Riparian Ecologist, Chesapeake Bay Program, Northeastern Area, 410 Severn Avenue, Annapolis, Maryland 21403; and Research Riparian Ecologist, USDA Forest Service, Rocky Mountain Research Station, 240 West Prospect, Fort Collins, Colorado 80526-2098 (E-Mail/Mayer: mayer.paul@epa.gov).

ranging from the importance of buffers to water supplies and people, the evolution of riparian science, the significance of biological communities to the maintenance of water quality, and the effectiveness of river restoration, respectively. Closing remarks by Mark Walbridge of the United States (U.S.) Agricultural Research Service and W. Tayloe Murphy, former Virginia State Senator and Secretary of Environment, highlighted future research and sociopolitical challenges to conservation and stewardship of riparian areas, respectively. A predecessor to this meeting was the May 2008 issue of *Water Resources IMPACT* which was dedicated entirely to the topic of riparian ecosystems and buffers and to the complex interrelated issues of riparian ecosystem science, policy, restoration, and management.

The papers in this special issue of *JAWRA* are a culmination of the 2008 conference presentations and associated discussions and are intended to advance our understanding of the structure and function of riparian ecosystems. This issue incorporates select papers from the summer conference in one of four overlapping categories: (1) riparian ecosystems as corridors, (2) nutrient processing at the landscape scale, (3) riparian buffer function, and (4) modeling and monitoring techniques.

RIPARIAN ECOSYSTEMS AS CORRIDORS

In the first paper, Opperman *et al.* (2010) explains that riverine floodplains have high ecological value, but that most have been severely altered and remain vulnerable to future development. Floodplain conservation efforts frequently face scientific, technical, and socioeconomic challenges. The authors propose a conceptual model that integrates the components of an ecologically functional floodplain, then present case studies from three rivers in California's Central Valley to illustrate the application of the model. Through definition of critical floodplain elements and processes, the authors provide an ecological framework that can inform political, social, and economic discussions regarding floodplain restoration and conservation.

A primary strategy for restoring watershed-scale ecological processes is the protection of river corridors and their associated ecosystem functions. Therefore, successful river corridor management requires an understanding of how fluvial processes have been modified by channel management activities and land use change. Kline and Cahoon (2010) describe a method being used in Vermont for developing river corridor protection and restoration plans based on

stream geomorphic assessment data. The authors found that three quarters of stream reaches evaluated in Vermont were undergoing channel evolution processes, lacked access to floodplains during floods, and, consequently, provided limited ecological services. Therefore, protection and restoration of river corridors by the Vermont Agency of Natural Resources relies on a strategy of reconnecting floodplains and reestablishing critical fluvial processes.

NUTRIENT PROCESSING AT THE LANDSCAPE SCALE

Watson *et al.* (2010) evaluated the important relationship of watershed land use to the structure of riparian zones and the subsequent ability of riparian ecosystems to function as nitrogen sinks. Riparian sites in New England in agricultural, suburban, and forested watersheds provided the authors with a diverse set of conditions for quantification of groundwater denitrification, water table dynamics, and distribution of soil organic material. Their findings highlight the significant differences and variability of denitrification rates and water table dynamics where irrigated agriculture and suburban development replace forested conditions.

Speiran (2010) addresses the issue of groundwater flow and its impact on water quality in riparian forests. Recently, there has been increasing awareness of the role of groundwater in riparian ecosystems. Understanding how nutrients and energy are processed in the groundwater is key to quantify nutrient reduction in riparian buffers. Speiran presents results from field studies and groundwater flow models of hypothetical aquifer systems that demonstrate how groundwater flow paths influence nitrogen flux beneath riparian corridors. Physical and geological attributes of the riparian zone dictate groundwater discharge, recharge, and evapotranspiration. In turn, these hydrological processes influence subsurface biogeochemical processes such as nitrogen transformations.

Dosskey *et al.* (2010) offer a review of research literature and characterize the processes and variability of riparian vegetation effects on streamwater quality. The authors describe the role that riparian vegetation has in protecting streams from pollutants through direct uptake and other functions such as the provision of organic matter to soils and channels. Riparian vegetation has multiple benefits for stream ecosystems; however, nutrient reduction by vegetation has not been clearly defined. The lack of consistent results between studies of various riparian vegetative

covers implies that species variability and site conditions are more important than gross vegetation types. Their analysis suggests that water quality improvement depends on the type of pollutant, the processes that act on it, site conditions, and the extent of pollutant attenuation. From a management perspective, having information to guide riparian restoration is essential to successful project implementation.

Vidon *et al.* (2010) present an ambitious review of the literature on the “hot” subject of hot moments and hot spots in riparian zones. These terms refer to the spatial and temporal variability of pollutant removal in riparian zones due to the heterogeneity of biogeochemical and hydrological processes regulating contaminant movement. Understanding the mechanisms of this heterogeneity is critical in developing effective means of employing riparian zones as buffers for attenuating pollutants such as phosphorus, nitrogen, pesticides, and mercury.

RIPARIAN BUFFER FUNCTION

Newbold *et al.* (2010) provide a detailed look at the water quality and hydrologic conditions of a stream and reforested riparian area in Pennsylvania over the 15-year period of vegetation establishment and growth. Long-term case studies of this kind are rare and this information provides a valuable look at the dynamics of nutrient processing over time in a field example.

Throughout the agricultural region of the American Midwest, riparian conservation buffers are recommended to reduce nonpoint source pollution of adjacent streams. Knight *et al.* (2010) compare the buffering capacity of narrow, naturally occurring riparian forests with and without planted grass filters in three northeast Missouri watersheds. They document the fate of concentrated flow paths (CFPs) that originated in crop fields – then served as conduits for runoff and sediment – through different buffer types. They found that wider remnant forests with adjacent grass buffers dispersed or buffered the CRPs, while narrower remnant forests were frequently breached, and suggest ways to potentially enhance the effectiveness of natural remnant forests.

MODELING AND MONITORING TECHNIQUES

The ability of buffers to moderate stream temperature through shading is important for maintaining

spawning habitat for fish and for reducing nuisance algal growth. DeWalle (2010) presents an elegant model of light attenuation in riparian buffers, basing his analysis on how buffer height, width, and light transmission through vegetation can ultimately reduce solar radiation reaching streams.

Claggett *et al.* (2010) discuss the state-of-the art in remote sensing of riparian forest cover. Obtaining accurate estimates of canopy cover is a key first step in managing forested riparian ecosystems. The monumental task of making such estimates on a regional basis is dependent upon calculating cover from satellite and aerial imagery. These authors used a stratified random sampling approach to increase spatial resolution and improve estimates of forest cover change over time. Their approach represents a means of verifying small and meaningful changes in forest cover that will be critical for assessing riparian buffer restoration goals regionally.

ACKNOWLEDGMENTS

We thank the authors for their contributions to this collection and we are grateful to the anonymous reviewers for their diligent efforts to provide constructive input to improve the articles. The views expressed in this Introduction or elsewhere in the collection are those of the individual authors and do not necessarily reflect the views and policies of the U.S. Environmental Protection Agency.

LITERATURE CITED

- Claggett, P.R., J.A. Okay, and S.V. Stehman, 2010. Monitoring Regional Riparian Forest Cover Change Using Stratified Sampling and Multi-resolution Imagery. *Journal of the American Water Resources Association* 46(2), doi: 10.1111/j.1752-1688.2010.00424.x
- DeWalle, D.R., 2010. Modeling Stream Shade: Riparian Buffer Height and Density as Important as Buffer Width. *Journal of the American Water Resources Association* 46(2), doi: 10.1111/j.1752-1688.2010.00423.x
- Dosskey, M.G., P. Vidon, N.P. Gurwick, C.J. Allan, T.P. Duval, and R. Lowrance, 2010. The Role of Riparian Vegetation in Protecting and Improving Chemical Water Quality in Streams. *Journal of the American Water Resources Association* 46(2), doi: 10.1111/j.1752-1688.2010.00419.x
- Groffman, P.M., D.J. Bain, L.E. Band, K.T. Belt, G.S. Brush, J.M. Grove, R.V. Pouyat, I.C. Yesilonis, and W.C. Zipperer, 2003. Down by the Riverside: Urban Riparian Ecology. *Frontiers in Ecology and the Environment* 6:315-321.
- Hagar, J.C., 1999. Influence of Riparian Buffer Width on Bird Assemblages in Western Oregon. *Journal of Wildlife Management* 63:484-496.
- Harris, R.A., 1985. Vegetative Barriers: An Alternative Highway Noise Abatement Measure. *Noise Control Engineering Journal* 27:4-8.
- Hoffmann, C.C., C. Kjaergaard, J. Uusi-Kämpä, H.C. Bruun Hansen, and B. Kronvang, 2009. Phosphorus Retention in Riparian Buffers: Review of Their Efficiency. *Journal Environmental Quality* 38:1942-1955.

- Kline, M. and B. Cahoon, 2010. Protecting River Corridors in Vermont. *Journal of the American Water Resources Association* 46(2), doi: 10.1111/j.1752-1688.2010.00417.x
- Knight, K.W., R.C. Schultz, C.M. Mabry, and T.M. Isenhardt, 2010. Ability of Remnant Riparian Forests, With and Without Grass Filters, to Buffer Concentrated Surface Runoff. *Journal of the American Water Resources Association* 46(2), doi: 10.1111/j.1752-1688.2010.00422.x
- Liu, X., X. Zhang, and M. Zhang, 2008. Major Factors Influencing the Efficacy of Vegetated Buffers on Sediment Trapping: A Review and Analysis. *Journal of Environmental Quality* 37:1667-1674.
- Lowrance, R., L.S. Altier, J.D. Newbold, R.R. Schnabel, P.M. Groffman, J.M. Denver, D.L. Correll, J.W. Gilliam, J.L. Robinson, R.B. Brinsfield, K.W. Staver, W. Lucas, and A.H. Todd, 1997. Water Quality Functions of Riparian Forest Buffers in Chesapeake Bay Watersheds. *Environmental Management* 21:687-712.
- Lowrance, R., R. Todd, J. Fail, Jr., O. Hendrickson, Jr., Ralph Leonard, and Loris Asmussen, 1984. Riparian Forests as Nutrient Filters in Agricultural Watersheds. *BioScience* 34:374-377.
- Mayer, P.M., S.K. Reynolds, M.D. McCutchen, and T.J. Canfield, 2007. Meta-Analysis of Nitrogen Removal in Riparian Buffers. *Journal of Environmental Quality* 36:1172-1180.
- McClain, M.E., E.W. Boyer, C.L. Dent, S.E. Gergel, N.B. Grimm, P.M. Groffman, S.C. Hart, J.W. Harvey, C.A. Johnston, E. Mayorga, W.H. McDowell, and G. Pinay, 2003. Biogeochemical Hot Spots and Hot Moments at the Interface of Terrestrial and Aquatic Ecosystems. *Ecosystems* 6:301-312.
- Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-Being: Synthesis*. Island Press, Washington, D.C.
- Naiman, R.J. and H. Decamps, 1997. The Ecology of Interfaces: Riparian Zones. *Annual Review of Ecology and Systematics* 28:621-658.
- Naiman, R.J., H. Decamps, and M. Pollock, 1993. The Role of Riparian Corridors in Maintaining Regional Biodiversity. *Ecological Applications* 3:209-212.
- Newbold, J.D., S. Herbert, B.W. Sweeney, P. Kiry, and S.J. Alberts, 2010. Water Quality Functions of a 15-Year-Old Riparian Forest Buffer System. *Journal of the American Water Resources Association* 46(2), doi: 10.1111/j.1752-1688.2010.00421.x
- Opperman, J.J., R. Luster, B.A. McKenney, M. Roberts, and A.W. Meadows, 2010. Ecologically Functional Floodplains: Connectivity, Flow Regime, and Scale. *Journal of the American Water Resources Association* 46(2), doi: 10.1111/j.1752-1688.2010.00426.x
- Peterjohn, W.T. and D.L. Correll, 1984. Nutrient Dynamics in an Agricultural Watershed: Observations on the Role of a Riparian Forest. *Ecology* 65:1466-1475.
- Speiran, G.K. 2010. Effects of Groundwater-Flow Paths on Nitrate Concentrations Across Two Riparian Forest Corridors. *Journal of the American Water Resources Association* 46(2), doi: 10.1111/j.1752-1688.2010.00427.x
- Sweeney, B.W., T.L. Bott, J.K. Jackson, L.A. Kaplan, J.D. Newbold, L.J. Standley, W.C. Hession, and R.J. Horwitz, 2004. Riparian Deforestation, Stream Narrowing, and Loss of Stream Ecosystem Services. *Proceedings of the National Academy of Sciences* 101(39):14132-14137.
- Vidon, P., C. Allan, D. Burns, T.P. Duval, N. Gurwick, S. Inamdar, R. Lowrance, J. Okay, D. Scott, and S. Sebestyen, 2010. Hot Spots and Hot Moments in Riparian Zones: Potential for Improved Water Quality Management. *Journal of the American Water Resources Association* 46(2), doi: 10.1111/j.1752-1688.2010.00420.x
- Watson, T.K., D.Q. Kellogg, K. Addy, A.J. Gold, M.H. Stolt, S.W. Donohue, and P.M. Groffman, 2010. Groundwater Denitrification Capacity of Riparian Zones in Suburban and Agricultural Watersheds. *Journal of the American Water Resources Association* 46(2), doi: 10.1111/j.1752-1688.2010.00418.x
- Wilkerson, E., J.M. Hagan, D. Siegel, and A.A. Whitman, 2006. The Effectiveness of Different Buffer Widths for Protecting Headwater Stream Temperatures in Maine. *Forest Science* 52:221-231.