Abstracts and Speakers
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River & Stream Restorations: Implication for Riparian Wetland Function & Process
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Hydrologic Connectivity Increases Sediment and Nutrient Retention in the Floodplains of Restored Urban Streams

Sara McMillan with Gregory Noe

Restoration of streams and floodplains frequently aims to increase hydrologic connectivity to improve channel stability and enhance water quality through sediment trapping and nutrient retention. While extensive research has been conducted on the capacity for riparian zones to buffer sediment and nutrient loads in natural systems, we know relatively little about the water quality function of floodplains in restored streams. Floodplain biogeochemistry operates on long timescales through the build-up of organic matter in floodplain soils and on shorter timescales via episodic deposition of sediment, associated nutrients and dissolved inorganic and organic nutrients. To understand the effects of flooding on nutrient dynamics in restored urban streams, we monitored five sites to represent a range of channel morphology and vegetation types. In each stream, high and low floodplain sites were established in triplicate to capture variation in floodplain connectivity. We measured rates of nutrient biogeochemistry (N and P mineralization; denitrification), sediment and nutrient loading and stream stage. Flashy hydrology and localized stream hydraulics in these urban sites controlled rates of sediment erosion and deposition. Denitrification was most closely correlated with sedimentation rates, while in situ N and P mineralization rates (measured via 30-day core incubation) were positively correlated with restoration age highlighting the importance of vegetation and soil organic matter. While connectivity seemed to have a positive impact on nutrient retention, high sediment loads in well-connected urban floodplains may limit long-term success as sedimentation may raise floodplain benches and disconnect these systems over time.

Establishing Riparian Restoration Goals and Evaluating Vegetation Futures Using a Plant Trait-Based Modeling Approach

David Merritt

A variety of trait-based approaches to characterizing vegetation have been developed over the past century with great promise of: providing non-taxonomic groupings of plants that are functionally meaningful, better linking plants to physical processes, and facilitating conservation, management, and restoration of ecosystems. Such approaches certainly complement standard gradient analyses through linking traits with the environmental pressures that select for them – the mechanisms driving change. The riparian response guilds framework is among these techniques that use functional groupings of plants in conjunction with hydrologic and hydraulic modeling to project the outcomes of alternative environmental flow prescriptions, effects of climate change, and other hydrologic shifts along rivers. The challenges in such efforts include acquiring or developing meaningful trait profiles for species in a flora, dealing with the fact that many species possess different traits at different life stages, recognizing the inherent plasticity in some traits, and being realistic about what traits selective pressures act upon (often multiple traits). I will examine advancements in riparian response guilds development and provide examples (from several western North American rivers) of how refinements to guild-environment modeling can provide a valuable tool in establishing restoration goals, monitoring restoration projects, and evaluating restoration success.

Achieving Water Quality Goals Through Riparian and Floodplain Management and Restoration
Richard Lowrance with Ken Forshay, Barton Faulkner, Tim Strickland, Dan Jaynes and William Anderson
Restoration and management of riparian systems and floodplains is well established in agriculture as a way to improve stream water quality and habitat and reduce nonpoint source pollution. Programs to establish riparian buffers are successful in many agricultural regions and experimental restorations show water quality benefits. Use of floodplains and riparian zones to manage water quality in non-agricultural settings has been less widespread for both biophysical and socioeconomic reasons including incomplete understanding of complex flow systems, the presence of permitted discharges, competing land uses, cost of land acquisition, and lack of consistent funding. We will discuss the restoration and management of riparian zones and floodplains in both agricultural and non-agricultural settings focusing on removal of N from both nonpoint and point sources. Active management of agricultural riparian zones can include approaches such as growing high-yielding bioenergy crops and diverting tile drain effluent into re-wetted riparian buffers. Approaches in non-ag settings include use of floodplain reconnection, levee set back, indirect discharge of wastewater, and active management of floodplains to enhance denitrification. Active floodplain management by manipulating vegetation, water, or both to enhance denitrification could be combined with innovative wastewater management approaches to achieve multiple goals that would reduce N loading. Successes in agricultural riparian and floodplain buffers have been achieved through a combination of consistent guidance on use of the technology; availability of cost-share incentives for individual land-owners; and the provision of multiple ecosystem services that go beyond water quality improvement. Successful use of riparian and floodplain management in non-agricultural settings may be able to follow a similar model but a key difference will be the importance of community involvement and decision-making in addition to decision-making by individual land owners. Improved tools are needed to help in both community and individual land owner decision making to help achieve these successes.

Contingent Effects: Variation in Annual Flooding Alters Outcomes for Restoration of Phalaris Arundinacea Invaded Forest Floodplains
Carrie Reinhardt Adams with Leah Lee and Meredith Thomsen
Research that identifies common outcomes of restoration actions at multiple sites can rigorously elicit generalizable results and best practices for restoration. Observation of commonalities is complicated by contingent effects, i.e. "year effects" or environmental variation. For instance, predictions of restoration outcomes for riparian wetlands are particularly afflicted by contingent effects related to annual flooding. Efforts to develop a decision tool for restoration of P. arundinacea invaded forest floodplain wetlands included tests of restoration actions on 8 wetlands in the Upper Mississippi River (UMR) floodplain (4 main channel floodplains, 1 main channel island, 3 second channel floodplains). Outcomes of invasive species control were similar across sites, but restoration of the forest floodplain community varied considerably. Recolonization by P. arundinacea, natural tree seedling recruitment, and survival from direct seeding differed with site. Though our study did not directly link restoration success with site-level differences, native plant restoration was greatest in wetlands that were not impacted by untimely flooding which promoted seedling mortality, P. arundinacea dominance, and loss of tree seed from direct seeding and natural seed rain. In a similar UMR floodplain restoration study during years in which growing-season flooding was shorter in duration, tree seedling recruitment from natural seed rain was higher. Sustained adaptive management efforts are one way to incorporate long-term accumulation of knowledge of contingent effects and their implication for decision-making. More immediately, floodplain restoration efforts can account for contingent effects by working across natural elevation gradients within the floodplain,

thereby increasing the likelihood of success within some part of a site in a given annual flooding scenario. Alternatively, applying restoration treatments to discrete locations within invaded sites (ideally establishing "tree islands") could decrease the cost of treatment in a given year, allowing several rounds of treatments for the same cost, thereby hedging our restoration "bet."

Novel Stream and Wetland Restoration Approaches to Enhance Ecological Services in Riparian Wetlands in an Urban Watershed

Curtis Richardson with Neal Flanagan, Mengchi Ho and Scott Winton

It is well known that both natural and restored wetland riparian zones can provide ecosystem services like flood control, sediment retention, nutrient storage and removal, erosion control, carbon storage, and wildlife habitat. However, research has indicated that not all riparian wetlands provide these services; especially restored riparian ecosystems that are not properly integrated into hydrologic stream configurations; resulting in reduced ecosystem services in the watershed. Therefore, successfully restoring a diversity of wetlands systems, which are functionally equivalent to their natural counterparts, requires a more complex approach than simply adding vegetation and a water supply. While substantial efforts are being made to revitalize the natural ecosystem functions of streams and degraded riparian ecosystems many are unsuccessful due to a lack of understanding of the complexities of these systems and their interactions on the landscape. In this study we assess the cumulative effect of restoring increased portions of streams with a diversity of adjacent wetlands in an urban/forested watershed with the specific goal of quantifying improvements in ecological services. The multi-phased restoration of Sandy Creek in Durham, North Carolina used natural stream design principles, and reference reaches as templates to connect and re-contour adjacent wetlands and incorporated the concepts of anabranching, and low head berms to distribute water onto the floodplains or into treatment wetlands. These innovative approaches resulted in enhanced floodplain riparian hydrology, which in turn reduced downstream water pulses and stream erosion. Most importantly we found vastly increased sediment retention, improved water quality for nutrients (N and P) and reduced coliform bacteria leaving the watershed prior to release into streams entering Jordan reservoir. The increased connectivity between riparian and stream habitats resulted in a tripling of macroinvertebrate, plant, and bird species, greatly reduced downstream pollution of N and P by over 40% and removed 489 Mt of sediment annually.

Principles, Paradigms, and Needed Restoration of River/Floodplain Wetland Exchanges

William Mitsch

Ecologists have developed two different ways of describing flowing water systems. The river continuum system clearly is related to the general differences in ecology along streams and rivers, going longitudinally along the river itself. The concepts were developed mostly in low-order streams in the United States and little attention was initially paid to lateral connections or floodplains. The flood pulse concept, based on research done in the Amazon River and its tributaries, features the importance of seasonal patterns of stream flow and the importance of lateral exchange between the river and its riparian ecosystems, some of which are unique to large river systems. A recent report by the U.S. EPA (2015) on connectivity of streams and wetlands attempted to summarize the important exchanges between rivers and their floodplain ecosystems. A history of 40 years of studies of the exchanges between natural, restored, and created riparian ecosystems with their adjacent rivers in Midwestern USA, Florida and several other rivers in the world will be presented with an emphasis on how we may need a new paradigm of ecohydrology and ecological engineering of floodplains, given dramatic downstream pollution problems that need to be solved and given the changes caused by humans on rivers that make exchanges between rivers and floodplains more problematic.

Measuring and Predicting P Inputs and Release from Restored Floodplains: Pocomoke River, Maryland

Gregory Noe with JV Loperfido, Mario Martin-Alciati, Jaimie Gillespie, Edward Schenk and Cliff Hupp

The restoration of floodplains is often recommended as a management tool to improve water quality in watersheds, but the great uncertainty of pollutant trapping and release rates following hydrologic reconnection of floodplain and river is limiting implementation. We are measuring rates of phosphorus (P) and sediment inputs and release from floodplain soils in restored (before and after notches are created in levees), unrestored, and natural floodplains along the Pocomoke River, Maryland. Most of the streams and rivers in the Pocomoke watershed were channelized in the 1940's, resulting in hydrologic disconnection between channel and the still forested floodplain by a spoil levee. Inputs of P are being measured as sedimentation and phosphate inputs to the floodplain soil surface, and phosphate outputs are being measured as release from the soil surface. Potential phosphate release, pre- and post-restoration, is being estimated using experimental flooding of soil cores in the laboratory in conjunction with P fractionation and metal geochemistry. Results from the experimental flooding of soil cores (pre-restoration) indicate substantially greater potential for phosphate release following floodplain restoration along the larger main stem river, but not tributaries. Phosphate release following experimental flooding was highly predictable by soil total Al (-) and NH_4Cl (+) and NaOH (-) extractable fractions of phosphate (stepwise regression: $R^2=0.81$), and dissolved organic P release was moderately well predicted by soil total Al (-)($R^2=0.38$). At most 0.5% of soil total P was lost from soils during experimental flooding. Further, phosphate release rates were small from the natural floodplain, suggesting that phosphate release from soils is both small and short-lived following floodplain restoration. Prior measurements of P sedimentation rates on floodplains in the study watershed suggest that inputs of P are likely to exceed loss of P following restoration. Finally, the predictability of phosphate release from soils using a relatively simple soil measurement (total Al) suggests a restoration screening tool to identify sites for restoration with the lowest potential for phosphate release.