Symposium Abstracts

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Opening Presentation

America's Only "Industrial Strength" River Clean-up Organization

Chad Pregracke

Living Lands & Waters, East Moline, IL, USA

As the founder of America's only "industrial strength" river clean-up organization and the 2013 CNN Hero of the Year, Chad Pregracke, tells a compelling story about growing up on the river and how his river experiences led to his unique vision to clean up the Mississippi River and start an internationally recognized not-for-profit, Living Lands & Waters.

During his hour-long talk, Chad takes the audience out on one of the world's greatest rivers – a journey filled with endless challenges and gripping adventures. His delivery is motivating, captivating, genuine and refreshingly spontaneous. Chad will relate his experience to your organization's mission and vision engaging the audience. Chad's tale embodies the importance of setting goals and illustrates how determination hardwork and persistence pays off.

Featured Speaker Presentations

Keeping 'the ecology' in River Connectivity

Margaret Palmer

National Socio-environmental Synthesis Center, Annapolis, MD, USA

There is a very rich tradition of developing and testing ecological theory among running-water scientists. We know a great deal about how ecological processes and ecosystem structures together support diverse biotic communities and supply many essential ecosystem services to people. Maintaining those services to ensure quality of life for both present and future generations will require stronger connections between people, ecologists, and those who manage river networks. As the level of disconnection between physical segments within river networks increases, it is time to reconnect river management with fundamental principles from ecological science. Rivers are much more than conduits for sediment and water and I see a very positive future for connecting ecology with current practices of river restoration.

Shifting Habitat Mosaic of River Ecosystems

Jack Stanford

Flathead Lake Biological Station, The University of Montana, Polson, MT, USA

In this presentation I will examine river ecosystems in a trophic-dynamic habitat context and as governed by the laws of thermodynamics and evolution. I will present a general typology of floodplain structures or elements as a basis for habitat delineation. I argue that while the elements that define riverine habitats tend to persist in natural river systems (and are constrained or eliminated by human alteration), the distribution of the habitat patches (mosaics) changes spatially over time due to primary drivers, particularly flooding, channel avulsion, cut and fill alluviation (erosion and deposition of fine and coarse sediments), deposition of wood recruitment and regeneration of riparian vegetation. I and others refer to this phenomenon the shifting habitat mosaic (SHM) and I argue that it is a fundamental process attribute of river ecosystems. I will review an array of contemporary theories about river ecosystem structure and function are substantially unified by thinking of river ecosystems as a continuum of 3-dimensional shifting habitat mosaics from headwaters to the ocean. I will provide a number of examples of how the SHM plays out in rivers from different biomes. I focus on the Flathead River in northwestern Montana where the biophysical interactions of the SHM were originally observed and documented. I will compare and contrast the Flathead with a wide array of studies elsewhere, specifically including detailed work on the Kol River in Kamchatka, the Kuskokwim River in Alaska and the Okavango River in Botswana.

An Environmental Report Card for the Mississippi River

William Dennison

University of Maryland Center for Environmental Science, Cambridge, MD, USA

Early in 2013, the University of Maryland with direction from a diverse steering committee facilitated the engagement of more than 600 participants from over 400 organizations, businesses and agencies to help shape America's Watershed Initiative (AWI) Report card for the entire Mississippi River Watershed. Diverse experts and stakeholders came together in workshops, meetings and webinars to identify information about six broad goals and create a report card to support collective action toward sustaining the economic and natural vitality of the river system. The larger Mississippi River basin was divided into the five major sub basins of the Upper Mississippi, Ohio, Missouri, Arkansas/Red and the Lower Mississippi Rivers. Data and information will measure and report on progress against six goals – flood control and risk reduction, recreation, ecosystems, transportation, economies and water supply. Each sub basin meeting was different, but the importance of the rivers and waters to every sector and in each basin was clear. The first AWI report card for the sub basins and the basin as a whole will be released this September. This presentation will cover the process that went into this first report card and provide a seek preview of the final report card.

Engaging the Public in the Future of Rivers Using the Mississippi as a Model

Jerry Enzler

National Mississippi River Museum and Aquarium, Dubuque, IA, USA

How do we engage the public in changing awareness, attitude, and action for the Mississippi River? As founding director of the National Mississippi River Museum & Aquarium, Jerry Enzler has led a talented team of staff, volunteers, and national leaders to create one of the most comprehensive river museums in the nation. An affiliate of the Smithsonian Institution, the Museum & Aquarium tells the story of the 31-state Mississippi River watershed and has served 2.2 million on site visitors in the past 11 years and another 500,000 people through RiverWorks Discovery in 18 states.

The river we have today is as a result of choices humans have made over time. What will the river look like in the future? What are the intended and unintended consequences of choices that are made for the river? Under his leadership the Museum & Aquarium has founded the Great River Road network of 73 Mississippi River Interpretive Centers and has played a major role in the founding coordination of the Mississippi River Network, supported by the McKnight Foundation. With the Coastal America network of Coastal Ecosystem Interpretive Centers, he piloted the effort to place the NOAA/Smithsonian Ocean Today kiosk in major aquariums across the country to reach large audiences nationwide.

Global Rivers Observatory – A People Network for Studying Globally Significant Rivers

Bernhard Peucker-Ehrenbrink

Woods Hole Oceanographic Institution, Woods Hole, MA, USA

The Global Rivers Observatory (GRO) is a global network of people committed to studying globally significant river systems in time series fashion. The goal of this initiative is to observe over the coming decades how river systems adapt to the changing environmental conditions that will influence the biogeochemistry of these systems, and to keep records and environmental archives of those changes. For the past decade we have collaborated with local scientists, educators, students, and citizen scientists to study the Fraser, Yukon, Mackenzie, Ob', Yenisei, Lena, Kolyma, Changjiang, Brahmaputra, Ganges, Congo, Amazon and Mississippi rivers. Local partners sample "their" river ideally at least once a month. Much of the analytical research is carried out at the Woods Hole Oceanographic Institution and the Woods Hole Research Center, but capacity-building slowly enables more and more of the analytical load to be shifted to partner institutions. Starting this year, we have begun to complement sampling by people with automated sensor systems that gather environmental data multiple times per day. The data will be uploaded to a public website. For the future of the GRO we envision a combination of sampling by local partners, observations by automated sensor systems and auto-samplers equipped with adaptive sampling capabilities. The scientific goals of the GRO are supported by the "My River, My Home" outreach program that aims at enticing K-12 students to bring to paper how "their" river system influences their lives. This student art project is permanently exhibited at the Fraser River Discovery Center near Vancouver, Canada.

Rivers, Human Conflict, and Water Security

Charles Vörösmarty

Environmental CrossRoads Initiative, City University of Ne York, New York, NY, USA

Fresh water is widely regarded as a fundamental, if not the single most important, natural resource upon which the future of humankind will rest. It underpins countless benefits to society and is pivotal to the success of the food and energy sectors, industry and commerce, and an expanding urban populace. Water is unsubstitutable in the context of maintaining aquatic habitat and biodiversity and the so-called ecosystem services that nature provides. Water is also the ultimate “connector”, uniting the dynamics of the Earth system with human society and human enterprise.

A recent and growing body of evidence points to a pandemic array of threats confronting much of the fresh water resource base that sustains society, placed into jeopardy through neglect and inaction. Today we can observe a globally significant yet collectively unorganized approach toward managing this situation. We find that impairment accumulates with rising wealth but is then routinely reduced by costly, after-the-fact technological fixes. This strategy of treating symptoms rather than underlying causes is practiced widely across rich countries that can afford such a remedy, but it leaves poor nations and much of the world's aquatic life forms under high risk. The seeds of this modern impair-then-repair mentality for water management were planted deep within human history. Yet, the wisdom of our “water traditions” may be ill-suited to an increasingly crowded world aiming for continued economic growth, yet having to live under some of this development’s most important downside consequences--growing pressure on its natural resources and accelerated climate change.

Exploring the nature of human-water interactions today, how we got here, and where we are going is one subject of this talk. The talk will examine the evolution of human-water systems using a long-term historical perspective, which is essential to understanding the full dimensionality of contemporary and future global water crises. Legacies abound, with water problems connecting many generations of humans. The situation in 2015 did not materialize spontaneously and is but one point in an historical continuum. Studying how present-day conditions arose and are connected to the history of human-water relations is the key to understanding the future. It is also important to recognize that when it comes to the world’s water, what happens in Las Vegas no longer stays there, so to speak, reflecting the fact that water problems are highly transportable, and connect different parts of the world, such as when rivers translocate agricultural pollution downstream to create coastal dead zones or when water-polluting rich countries outsource their environmental problems to places with weaker environmental regulation. The talk will conclude by presenting the impair-then-repair management paradigm as a testable, global-scale hypothesis with the aim of stimulating systematic study of not only the impairment process but also the search for potentially innovative solutions. Achieving these objectives will require uniting and then co-balancing perspectives from both the natural sciences and the humanities.

Luncheon Speaker Presentations

The Mississippi River Cities & Towns Initiative

Tim Kabat

The City of La Crosse, La Crosse, WI, USA

The Mississippi River Cities & Towns Initiative is an effort of 68 mayors along the Mississippi River from Bemidji, MN to New Orleans, LA. We are an association stretching across ten states whose membership includes some of America's largest cities and smallest towns. Shaped by one of the most important rivers in the world, our cities are the laboratories of sustainable economies must achieve – growth with a neutral or beneficial impact on our natural resources and ecological services.

MRCTI is led by two co-chairs, Mayor Roy Buol of Dubuque, IA and Mayor AC Wharton of Memphis, TN. They are supported by an executive committee of ten mayors – one from each state that touches the waterway. Our membership is a strong cohort of elected officials that find more in common than different regarding our shared challenges living next to the waterway. MRCTI is the ONLY association of elected officials centered on the Mississippi River's entire length. This uniqueness brings value that we as mayors can leverage with more torque than most others, but we can't do it alone. MRCTI has galvanized our ability to be elected entrepreneurs innovating advanced conservation policy and performance in the public sphere for America's Great Waterway.

This discussion will focus on the strategies employed to bring local governments together around the sustainability of a major river - most specifically, how mayors are brought into a collective chorus for 2500 miles of waterway through ten states.

Commercial Navigation Infrastructure Priorities in the USA for the Next 25 Years

Paul Rohde

Waterways Council, Inc., Washington, DC, USA

US rivers have been used for commercial navigation for the last 150 plus years. As the vessels became larger and drafted more water the main river channel was modified to create predictable and reliable channels for the deeper vessels. Waterborne transportation built river communities by moving people and materials across the vast country, and eventually it became the most effective method of moving bulk commodities such agricultural products, coal, steel, petroleum and other products that were moved in a raw or bulk form. Today over 60% of US grain and many other commodities are exported via the 12,000 miles of the inland waterway system. However, over sixty percent of the water borne transportation infrastructure in the USA exceeds the design life by as much a quarter century, and that number will jump to seventy-eight percent by the end of the decade. Commercial operators are faced with planned and unplanned lock closures due to infrastructure repair and maintenance which makes it difficult to predict reliability of bulk commodity movement on the nation's river systems due to these potential delays. Understanding these issues, commercial navigation leaders have come together with the US Army Corps of Engineers to define what waterborne infrastructure is a priority for renovation, reconstruction, or other appropriate replacement, to provide a functioning waterway system into the future. This presentation will go into the factors that had to be considered to determine where limited infrastructure dollars should be spent first and why.

Swimming Upstream - Why are River Issues a Tough Sell?

Reggie McLeod

Big River Magazine, Winona, MN

During more than 30 years writing about river issues and organizations, McLeod has recognized a variety of characteristics that are unique to rivers and that make it difficult and expensive to communicate information about river issues to politicians as well as the general public. These barriers to communications are physical, cultural and political.

His presentation explores the sources of these problems and some of the ways they are being overcome. Some of the solutions involve recognizing these impediments, but some of the impediments are so ingrained in our assumptions about rivers that they may require changing the ways people think about rivers, water and the world.

Platform Presentations

(001) The Impact Of Lock And Dam On The Sedimentation Patterns In Navigable Rivers And Their Ecosystems

Misganaw Demissie and Nani Bhowmik

Illinois State Water Survey, University of Illinois

The construction of locks and dams to facilitate navigation within large rivers, changes the natural hydraulics of rivers significantly. The creation of a navigation pool to maintain desirable water level for navigation, results in higher low water levels and lower velocities along the pool. A combination of these hydraulic changes results in increased sedimentation rates in the pool, especially outside of the navigation channel. In the Upper Mississippi River navigation system, the navigation channel is generally maintened for navigation purposes at a minimum depth of 2.7 m and a minimum width of 90 m. The navigation channel is kept at the required depth and width through the process of resuspension and lateral movement of sediment from the navigation channel due to tow traffic and maintenance dreding as needed. The long-term outcome of this process is the gradual shrinking of the deeper parts of the pool resulting in a narrow navigation channel in the middle of the pool with extensive mud flats and marsh areas on both sides of the channel. This geomorphic change overtime alters the types of habitaits available and as a result the ecosystem.

The impact of this process is clearly illustrated by what has happened in Peoria Pool along the Illinois River over the last one hundred years. Peoria Pool is part of the Illinois Waterway that enables navigation from Lake Michigan to the Mississippi river. The Illinois Waterway consists of seven lock & dams creating eight pools from the Mississippi River to Lake Michigan. Peoria Pool is one of the three pools in the Lower part of the Illinois River. The sedimentation pattern in Peoria Pool is well documented through several sedimentation surveys over time and illustrates the gradual geomorphic changes that takes place in a pool. After intially getting deeper after the construction of the Lock & Dam at Peoria, the pool has been gradually filling with sediment and getting shallower. However, the navigation channel is still maintained at desired depth and width, while the rest of the pool is getting shallower. Some of the shallow areas of the pool are now supporting the growth of vegetation and thus accelerating the transformation of the pool into a system of a navigation channel surrounded by a vast shallow flat areas and wetlands on both sides.

(002) Divesting of River Infrastructure at Scale Results in Larger Positive Conservation Outcomes

Robert Sinkler

The Nature Conservancy

The traditional project by project approach of divestiture, removal or modification of obsolete, unneeded or outdated water infrastructure often has limited ecological and conservation benefit from a regional or watershed perspective. The science-based outcomes and lessons learned from four large scale projects illustrate the benefits of tackling conservation projects at scale.

1. The Nature Conservancy worked with partners to reconnect 25 square miles of former floodplain forest at Mollicy Farms back to Louisiana's Ouachita River, a tributary in the Mississippi River Basin. The $4.5 million restoration project removed portions of the 17-mile-long, 30-foot-tall, 30(+)-year old levee. Believed to be the largest floodplain reconnection project in the Mississippi River Basin and one of the largest in the United States, the project helped alleviate flooding downstream, improve water quality (reduce both nutrients and sediments) and restore valuable fish and wildlife habitat.

2. Working with partners, The Nature Conservancy Launched the Atchafalaya River Basin Initiative to protect and restore more than 5,000 acres of America's great swamp forest in the Bayou Sorrel region of the Atchafalaya River Basin, and at the same time help rebuild coastal Louisiana. According to NASA, land losses are widely distributed across the 300 kilometer (200 mile) wide coastal plain of Louisiana. But, the Atchafalaya River delta is the notable exception where new land is now forming. The slow-moving Atchafalaya River is building wetlands during major floods. While the Mississippi River delta is still experiencing land loss. Several diversion projects in planning now, based on lessons learned in the Atchafalaya River basin would attempt to recreate the Mississippi's original land-building sediment deposition cycles before construction of the elaborate man-made levee system that exists today.

3. The Nature Conservancy in partnership with others developed the Mississippi River Side Channel Rehabilitation and Conservation Project with the aim of restoring twenty-three remaining side channels on the Middle River including ten that had closed completely. The plan included both restoring the channels themselves and acquiring land for restoration adjacent to the channels. The additional land acquisitions enabled reforestation of the banks of the channels, some of which were farmed clear up to their edges; reestablishment of the ridge and swale bottomland topography, where water flowing through the channels naturally eroded or deposited sediment on the banks; regaining of cut bank habitat, places where fish could rest and nest; and, public access to the side channels for recreation and education. Today, lessons learned from this efforts are currently being incorporated at an even larger scale in the in the 5-state Lower Mississippi River Basin.

4. The restoration of the Penobscot River was an innovative, unprecedented effort to remove two dams and build a state-of-the-art fish bypass around a third. As a result, hundreds of miles of habitat along the Penobscot and its tributaries were re-opened for sea-run fish, with tremendous benefits to biological and human communities along the river. 100 years ago, the series of hydropower dams built on the

river blocked salmon migration and their annual appearance nearly sputtered out. Today the salmon are back and due to wise planning, the river is producing more renewable hydropower than ever before.

All four of these large projects (flood plain restoration, swamp restoration, removal of navigation infrastructure, and dam removal) demonstrate the clear science-based benefit of tackling water infrastructure at watershed scale.

(003) Letting Go: Lock Closure, Levels of Service And Asian Carp in The Twin Cities

John Anfinson

National Park Service

In the 2014 Water Resources Reform and Development Act, Congress directed the Corps of Engineers to close the Upper St. Anthony Falls Lock on or before June 10, 2015. The Act did not specify a reason, but most assume the threat to Minnesota's lakes and rivers represented by Asian carp lay behind the decision. Economic factors also played a role. This lock and the two below it had never really succeeded in making Minneapolis the head of navigation, and Minneapolis accepted this reality.

Once the Upper St. Anthony Falls Lock closes, the Lower St. Anthony Falls Lock and Lock No. 1, which lie downstream, will become superfluous to commercial towboat navigation. There are no terminals for barges to load or unload above Lock No. 1. Any towboat going through No. 1 must go through Upper St. Anthony, and that will no longer be possible after June 10. A few tour boat companies and recreational craft will be the only traffic that remains. Some are already pushing for the closure and possible removal of the two locks and dams below St. Anthony Falls.

For the first time in over 100 years, residents of Minneapolis and St. Paul have the opportunity to reconsider what the Mississippi River between the to cities will become. This presentation looks at the forces behind why Congress closed the Upper St. Anthony Falls Lock and at the issues that will influence the decision on what to do Lower St. Anthony Falls and Lock and Dam No. 1.

Key Words: Locks, Dams, Closure, Navigation, Levels of Service, Asian Carp

(004) Levee Setbacks and Removal in The Yakima Basin Rationale and Examples

Joel Freudenthal

Yakima County Surface Water Management Division

Yakima County has an aggressive program to reconfigure levee systems and other infrastructure on the main stem Yakima and Naches Rivers in Yakima basin in order to reduce risk and increase habitat. The presentation will share the rationale behind ongoing and future levee reconfiguration projects, and discuss one large project in particular.

The rationale discussion will consist of a discussion of the theoretical effects of infrastructure on channel form and process through the use of Lane's Balance, the Shields Equation, position in the drainage network, and one and two dimensional sediment transport modeling. The project discussion will examine the progress to date of reconfiguration of the eight mile Federal Project levee in the Selah Gap to Union Gap Reach of the Yakima River and associated floodplain restoration actions. This project is in its 10th year, has already reconfigured a major bridge, over 2 miles of federal and county levees, a regional trail system, and the Regional Wastewater Treatment Plant outfall to the river. In Cooperation with the Corps of Engineers, the County is hoping to complete the project under the Section 1135 Ecosystem Restoration Authority. The final levee setbacks will open up 2000 acres of high value habitat floodplain in the urbanized mainstem reach considered the most critical to basin salmon recovery.

The geomorphic concepts and hydraulic processes that drive infrastructure stability, public safety, water conveyance efficiency and habitat for salmonids will be discussed in relation to the projects. Having predictive power regarding how the riverine/infrastructure system will behave in the future under existing or modified configurations, across all of the affected resource values, provides strong reasons for infrastructure reconfiguration or removal.

(005) Restoration and Reconnection of Functional Floodplain at The Nature Conservancy's Emiquon and Merwin Preserves Along the Illinois River

K. Douglas Blodgett

The Nature Conservancy, Lewistown IL

In naturally functioning large-floodplain river ecosystems, the dynamic connection between the river and its floodplain contributes to key ecological processes and habitats that sustain phenomenal natural productivity and diversity. Along the Illinois River in Illinois, that natural productivity was dramatically reduced nearly a century ago when floodplains were isolated from the river by levees (or earthen berms), drained, and converted to intensive agriculture. The Nature Conservancy is working to reestablish functional floodplain as one critically important measure for restoring the ecological health of this formerly productive large-floodplain river ecosystem. Starting in 1999 and 2007 respectively, restoration began at the Conservancy's 500-hectare Spunky Bottoms and 2700-hectare Emiquon Preserves. By most accounts, the restorations have been quite successful to date, attracting and abundance and diversity of wildlife and people. However with the levees intact, many key ecological processes associated with connectivity remained constrained if not eliminated. Plans were being developed to construct managed connections between the river and the restored floodplains to reestablish some of these ecological processes when the record flood of 2013 on the Illinois River overtopped the levees at both sites. Subsequently the levee at Spunky Bottoms failed, although the one at Emiquon remained intact. With partners, intensive monitoring and research is evaluating the effects of those unplanned and unmanaged connections. Results are contributing to a better understanding of floodplain structure and function and will provide guidance for long-term management of these as well as other floodplains. Results of this research will be presented in this and subsequent presentations, as will future plans for managing connectivity.

(006) Changes in the Pelagic Bacterial Community in Two Illinois River Floodplain Lakes Under Restoration

Maria Lemke[1], Michael J. Lemke[2], John Beaver[3], and Collin Hinz[4]

[1]The Nature Conservancy, [2]University of Illinois at Springfield, [3]BSA Environmental Services, Inc., [4]Illinois Natural History Survey, University of Illinois Champaign-Urbana, Urbana, Illinois.

The Illinois River was separated from much of its floodplain by levees in 1919 as floodplain areas were converted into farmland. Systems were installed to drain the land that consisted of underground pipes to transport water from fields into a series of drainage ditches and excess water was pumped into the Illinois River. Pumps were turned off at two Nature Conservancy preserve sites in 1998 (Merwin) and 2007 (Emiquon) and these historic backwater lake habitats were reinundated over the following years. In April 2013, water levels reached historical flood heights that breached and overflowed levees that otherwise had separated backwater habitats from the Illinois River for almost 100 years. Emiquon Preserve had water overtop levees for six days, but the levee was not breached during the flood. Levee failure at Merwin Preserve resulted in an unmanaged connection between the backwater floodplain and the Illinois River. Zooplankton were collected from each of these floodplain lakes during different periods of restoration and during the year following the 2013 flood as part of a larger study to record the response of floodplain-river ecosystems to different levels of flood disturbance. Our objectives were to quantify zooplankton community composition, biomass and secondary production (1) among pre- and post-restoration communities in Thompson Lake at Emiquon, and (2) between Emiquon and Merwin in response to the 2013 flood event. Definite shifts in community composition and biomass occurred during the restoration of Thompson Lake at Emiquon. Mean biomass was initially low in pre-restoration communities that were dominated by small-bodied zooplankton (*Diaphanosoma*, *Sida*, nauplii, and rotifers) but increased early on during the restoration as larger-bodied microcrustaceans became much more abundant (*Daphnia* spp., *Acanthocyclops robustus*, *Leptodiaptomus siciloides*). A subsequent shift to a community that was once again dominated by small species (*Bosmina*, *Chydorus*) occurred as planktivorous fishes became more abundant. Merwin Preserve zooplankton communities were likely highly influenced by the response of algal production to river water inputs of nutrients and turbidity to the backwater system through the unmanaged connection with the Illinois River during the 2013 flood. In contrast, comparisons of biomass and density patterns in Thompson Lake in 2013 to previous years (2008-09, 2011-12) indicate that the flooding had a minimal effect on the zooplankton community structure at Emiquon.

(007) Zooplankton Dynamics in Restored Floodplain Lakes of The Nature Conservancy's Emiquon and Merwin Preserves Along the Illinois River

Michael J. Lemke[1], Keenan Dungey[1], Felipe Velho[3], Maya Scott[2], Doyn Kellerhals[1], Angela Kent[2] and Luzia Rodrigues[3]

[1]University of Illinois Springfield, Springfield, IL, USA; [2]University of Illinois Champaign-Urbana, Champaign-Urbana, IL, USA; [3]University of Maringa, Brazil

There is growing societal interest in restoring rivers and floodplains to re-establish ecosystem services, including reduced flood damage, nutrient processing and supporting fisheries and wildlife. Beyond reducing flood damages, The April 2013 record flood on the Illinois River created two different floodplain management scenarios at separate floodplain sites under restoration: 1) a minor, levee overtopping at the Emiquon Preserve and 2) levee failure flood disturbance at the Merwin Preserve; both areas sites of ecological restoration. Early restoration of Thompson Lake on the Emiquon Preserve, Lewistown, IL after decades of agriculture, represents an altered natural ecosystem going through rapid stages of change in structure and function, whereas Long Lake at the Merwin Preserve has been under restoration for about two decades. Because bacterial communities serve as a responsive indicator of biotic change, a time series study was designed to measure and relate water quality characteristics through the Emiquon restoration effort over five years, and the 2013 flood event at both sites. Lake water was sampled weekly (n=3) and physical (e.g., light, temperature) and chemical (TN, TP, pH) parameters were measured. ARISA community fingerprinting characterized bacterial community composition. In 2008, Thompson Lake had remarkable water clarity with Secchi disk readings reaching the bottom (~200 cm) that decreased in depth after 2010-2011). A measured increase in SRP was likely triggered by low dissolved oxygen (late June, 2008) near the lake bottom and, coupled with low dissolved nitrogen concentrations, led to an extensive cyanobacterial bloom of the heterocystous cyanobacteria, *Aphanizomenon flosaque* that dominated in 2008-09. Microbial community change was directional with time throughout 2008-12. The 2013 flood caused a temporary increase in nitrate (3 mg/L) due to river water introduced to Emiquon that appeared to trigger nearly a twofold increase in chlorophyll concentration, but only a slight and temporary change in the bacterial community. At Merwin SRP levels in late June 2013 were above historic averages, perhaps in response to decreasing water levels due to the open connection to the river; denitrification potential showed a drastic decrease from previous measurements. Long Lake at Merwin preserve was impacted by river connection and drastic flooding with measurable effects to the lake ecosystem. At Emiquon, analysis of Thompson Lake data indicates that the lake has gone through two phases of pre-flooding change, an early, transitional and late phase of change; the 2013 flooding did little to disturb this second lake stable state.

(008) Alternative Dynamic Regime Theory: Large Scale Community Shifts in a Newly Restored Lake Across Multiple Community Levels

Logan Benedict [1, 2], Mike J. Lemke[2], Felipe Velho[3], Luzia Cleide Rodrigues[3], Keenan Dungey[2], Andrew Casper[4], and T.D. VanMiddlesworth[4].

[1] UIS Therkildsen Field Station at Emiquon, Lewistown, IL, USA; [2] University of Illinois Springfield, Springfield, IL, USA; [3] University of Maringa, Maringa, Brazil; [4] Illinois Natural History Survey, University of Illinois Champaign-Urbana, Urbana, IL, USA

Alternative dynamic regime theory of shallow lakes is characterized by shifts between turbid algae-dominated and clear aquatic vegetation-dominated states. Shallow lakes undergoing ecological restoration have yet to be explored in this theory. Even less exploration has gone to understanding multiple community-level shifts. This research investigates the first five years of multiple aquatic community data from Thompson Lake at The Nature Conservancy's Emiquon Preserve, Lewistown, IL; a lake undergoing restoration. In 2008, Thompson Lake's clear water was low in nitrogen and high in SRP leading to an extensive cyanobacteria (*Aphanizomenon flosaque*) bloom and shifting to turbid water in 2010-2012. This decrease Secchi depth corresponds to shifts in phytoplankton, zooplankton, aquatic vegetation, and fish compositions, with gizzard shad showing 145% population growth. A comparison of these communities with five years of reference data from the same period in a non-restored lake (Lake Mendota, WI) provides support for regime shifts in Thompson Lake. Three stages of community structuring have been categorized: early restoration, transition stage, and late restoration. This research uses a more inclusive multiple community approach to describing shallow lakes undergoing restoration.

(009) Hydrophysical Modeling of Mussel Habitat in Large Rivers

Steve Zigler and Teresa Newton

U.S. Geological Survey - Upper Midwest Environmental Sciences Center

Large floodplain rivers are fundamentally different from smaller systems in their lateral complexity and hydrology. However, conditions that constitute habitat for freshwater mussels in large rivers are poorly understood, greatly limiting our understanding of the conditions that promote high quality mussel assemblages. Over the past 10 years, we have modeled the abundance and distribution of mussels in the Upper Mississippi River (UMR) using physical and hydraulic variables. Analyses of data from small (0.4 km) to large (38 km) spatial scales indicated that computed hydraulic variables (e.g., shear stress, boundary Reynolds) were more predictive than variables measured in the field (e.g., depth, velocity). Discharge-specific models suggested that episodic events such as droughts and floods were more important in structuring mussel distributions than conditions during average flows. Models also indicated distributions of adult mussels were considerably more predictable than juvenile mussels, suggesting that distribution of juvenile mussels was less dependent on hydrophysical features than adult mussels with some areas potentially functioning as population sinks. Geospatial models have consistently predicted few mussels in poorly connected backwater areas and the navigation channel, whereas main channel border areas with high geomorphic complexity and small side channels were typically favorable to mussels. Overall, studies indicated spatial distribution of mussels in large rivers is determined by a complex interaction of biotic and abiotic factors acting at various spatial scales. Our research suggests that the interaction of geomorphology and discharge produces a template of hydrophysical conditions in the UMR that could be manipulated by managers to create quality mussel habitat to benefit restoration activities.

Keywords: freshwater mussel, Upper Mississippi River, ecohydraulics, habitat restoration

(011) Environmental Flows for Mussels and Other Sedentary Taxa: Identifying Persistent Habitat Using Historical Hydraulic Conditions

Kelly Maloney[1], Jeffrey Cole[1], and Colin Talbert[2]

[1] US Geological Survey, Northern Appalachian Research Branch, Leetown Science Center; [2] U.S. Geological Survey, Fort Collins Science Center

Sedentary taxa (e.g., freshwater mussels) and life stages (e.g., fish redds) and sessile taxa have limited or no mobility. This inability to move quickly when hydrologic conditions become harsh necessitates examining environmental flow needs for these taxa over an extended period of time. Here, we examined historical hydraulic conditions that constrict mussel densities in a reach of the Delaware River near Callicoon, NY, USA. A detailed mussel survey was conducted for this reach where density of mussels (mainly *Elliptio complanata*) was quantified for over 1000 quadrats. Hydraulic variables (depth, velocity, shear stress, Froude, Reynolds) for each quadrat were calculated on a daily basis for 10 years prior to the survey through the use of 2-D hydrodynamic modeling and USGS gage data. Preliminary results showed quadrats with a high *E*. *complanata* density had higher long-term mean depths, intermediate shear stress levels, and low temporal variation in many hydraulic variables. Hydraulic conditions on or near the survey date showed little relation to density. However, hydraulic conditions on possible constricting events (storms and low flows) showed strong relations to mussel density. Results such as these highlight the importance of past conditions on riverine species distributions, particularly for those of limited or no mobility. They will also help in understanding how alterations to the flow regime, for example through reservoir releases, water withdrawals or climate change, affect riverine populations. Future research efforts will be aimed at identifying the characteristics of the constricting dates and the hydraulic variables driving these constrictions as well as testing findings in other reaches to evaluate the generality of our results.

(012) Assessing the Effects of Land-use, Climate Change, and Extreme Events On Physical Habitat in Rivers

Joseph Daraio

Rowan University

The physical habitat of mollusks and other benthic macroinvertebrates is directly linked to hydrologic response of a watershed and local scale river hydraulics, hence the need for ecohydraulics research, or the integration of ecology and hydraulics. A key to our understanding how hydrology and hydraulics influence benthic organisms lies in a better understanding of interactions of a wide range of processes over a wide range of spatial and temporal scales. The effects of natural and anthropogenic changes to river, stream, landscape, and climate processes interact across scales, and in ways not fully understood, to affect hydrologic, hydraulic, and temperature responses of river systems. Our knowledge of river ecosystem's structure, functions, and processes requires a greater understanding of potential impacts and linkages between the natural and built environment. This includes interactions between stream flow, flooding, water supply, water infrastructure, and the subsequent responses of channel morphology, water quality (chemistry and temperature), physical habitat, and benthic communities. Much work has been done and continues to be done on the potential impacts of land-use and climate change on hydrologic response and stream flow in river systems. As we are gaining a better understanding of potential changes in stream flow, more work is required to answer the question, how do the hydraulics of a river reach change with changes in flow regime (hydrologic response) due to climate and land-use change? Additionally, it is understood that frequent flood events can have significant impacts on channel morphology and river ecosystems (i.e. the flood-pulse concept), and less frequent extreme events impact river systems, including channel morphology, riparian habitats, and, most likely, benthic communities. Changes in precipitation regimes as a result of climate change are likely to impact these vital processes. For example, there is high confidence that heavy precipitation will increase in Eastern US, but it is not clear how changes in frequency and magnitude of extreme events will impact flooding in combination with changes in land-use and other aspects of the built environment, such as storm water infrastructure. I have been developing a modeling framework that uses multi-model ensemble simulations to assess and forecast the potential impacts across a range of spatial and temporal scales of such changes to hydrologic and instream response. I have taken this approach to assess the potential impacts of climate and land-use change on stream temperature, and the implications for mussel communities through mid-century in the upper Tar River basin in North Carolina. Additionally, I have been assessing potential climate change impacts on stream flow in watersheds in New Jersey, and I have been working to incorporate projections of changes in frequency and intensity of extreme precipitation with hydrologic models. These hydrologic models can be linked with hydraulic models of river reaches with sufficient biological data to obtain a better understanding of these interactions.

(013) Quantifying Flooding Regime and Channel Migration in Floodplain Forests to Guide River Restoration

Christian Marks[1], Keith Nislow[1], Francis Magilligan[2], and Erik Martin[3],

[1] USDA Forest Service, Northern Research Station; [2] Dartmouth College; [3] The Nature Conservancy

Determining the flooding regime needed to support distinctive floodplain forests is essential for effective river conservation under the ubiquitous human alteration of river flows characteristic of the Anthropocene Era. At over 100 sites throughout the Connecticut River basin, the largest river system in New England, we characterized species composition, lateral channel migration rates in the recent past, historic land cover, valley and channel morphology, and hydrologic regime to define conditions promoting distinct floodplain forest assemblages. Species assemblages were dominated by floodplain-associated trees on surfaces experiencing flood durations between 4.5 and 91 days/year, which were generally well below the stage of the two-year recurrence interval flood, a widely-used benchmark for floodplain restoration. These tree species rarely occurred on surfaces that flooded less than 1 day/year. By contrast abundance of most woody invasive species decreased with flooding. Such flood-prone surfaces were jointly determined by characteristics of the hydrograph (high discharges of long duration) and topography (low gradient and reduced valley constraint), resulting in increased availability of floodplain habitat with increasing watershed area and/or decreasing stream gradient. Downstream mainstem reaches provided the most floodplain habitat, largely associated with low-energy features such as back swamps and point bars, and were dominated by silver maple (*Acer saccharinum*). Likewise distinct pioneer species were associated with point bar habitats on large rivers with high channel mobility. However, we were able to identify a number of suitable sites in the upper part of the basin and in large tributaries, often associated with in-channel islands and bars and frequently dominated by sycamore (*Platanus occidentalis*) and flood disturbance-dependent species. Our results imply that restoring flows by modifying dam operations to benefit floodplain forests on existing surfaces need not conflict with flood protection in some regional settings. A full assemblage of floodplain species including pioneers requires not just regular flooding but also bar formation and growth associated with lateral channel migration. These results underscore the need to understand how flow, geomorphology, and species traits interact to produce characteristic patterns of floodplain vegetation, and that these interactions should form the basis of effective river restoration and conservation.

(014) Progress in River Restoration Over Three Decades

Geoff Petts

University of Westminster, London, UK

Following centuries of river 'regulation' through controls on floods, channel dynamics and flow regimes below dams, over the past three decades river scientists have addressed measures to 'restore' or 're-naturalize' river channels to enhance ecological values and, most recently, ecosystem services. This paper reviews the progress of river restoration by analysing papers published in Regulated Rivers/River Research and Applications. It highlights the changing themes of river restoration and explores the tensions arising from ambitions to re-naturalize riverine corridors in highly-developed and developing catchments. It then considers the challenges of advancing river restoration programmes in a context of uncertain climate futures.

(015) Impacts of a Large Flood Event On Cottonwood Forests Along the Regulated Missouri River, USA

Mark Dixon[1], Christopher Boever[1], Victoria Danzeisen[1], Christopher Merkord[2], Michael Scott[3], W. Carter Johnson[2], and Terrence Malloy[4]

[1] University of South Dakota; [2] South Dakota State University; [3] Utah State University; [4] Benedictine College

Decades of flow regulation have impacted floodplain forests along the Missouri River, contributing to declines in plains cottonwood (*Populus deltoides*) recruitment, a predominance of older forest age classes, and increases in invasive woody (e.g., *Juniperus virginiana* and *Elaeagnus angustifolia*) and herbaceous plant species. Record runoff in 2011 led to the highest discharge in 59 years, with flood durations of up to 3 months. We assessed the impacts of this "large infrequent disturbance" on the riparian landscape by evaluating pre- (2006-2009) to post-flood (2012-2014) changes in riparian vegetation structure and composition, land cover, and cottonwood recruitment along six study segments spanning 1090 river km. Overall shrub/sapling live stem density declined across all study segments and most age classes, while declines in tree density were weaker and more variable. Declines in both were highest in the youngest stands (i.e., those that established after the 1997 high water event). Delayed effects of the flood on tree mortality were not apparent beyond year one (2012) and some species (*P. deltoides* and *E. angustifolia*) showed evidence of partial recovery via re-sprouting in subsequent years. In terms of land cover, sandbar area increased dramatically and area of young forests declined across segments. Post-flood cottonwood recruitment was widespread, but occurred primarily in 2012 and at low sandbar positions within the active channel on most segments. On the Fort Peck segment in Montana, however, receding flood levels in June-July 2011 provided opportunities for recruitment at overbank positions as well, where saplings may be less vulnerable to removal by future flows. Geomorphic legacies of long-term flow regulation, operational constraints, and conflicting management goals limited the restorative effects of the 2011 flood and are likely to limit future cottonwood forest regeneration along the regulated Missouri River.

(016) Stakeholder-Led Science: Engaging Floodplain Conservation Land Managers to Identify and Meet Science Needs

Garth Lindner[1], Kristen Bouska[1], Robert Jacobson[2], and Craig Paukert[2]

[1] University of Missouri; [2] US Geological Survey

Long-term changes in climate, land uses, and water uses present new challenges to managing conservation lands in large-river floodplains. Scientific information can guide management, but the process is often done in isolation and thus scientific endeavors often fail to match management needs. Our first objective has been to collaborate with managers to identify science needs and information gaps for long-term management of floodplain conservation lands. We surveyed managers of floodplain conservation lands along the Upper and Middle Mississippi River and Lower Missouri River to evaluate management priority, management intensity, and available scientific information for management objectives and conservation targets. Approximately 80% of the 155 identified floodplain conservation lands were represented by the 55 survey respondents. Across the study area, objectives identified as medium-high priority, but having limited information available to manage, included invasive species, native, non-game species, threatened and endangered species, bottomland forests, and relations with neighboring landowners. Similarly, conservation targets of medium-high priority, but having limited information available to manage, included shore birds, marsh birds, song birds, reptiles, and terrestrial invasive species. We also asked managers to rank major constraints limiting the acquisition or use of scientific information, including importance of information to management decision, quality of scientific information sources, and capacity to conduct and/or fund management-related research. A follow-up workshop and survey in March of 2015 focused on clarifying science needs and tools to inform long-term management decisions under non-stationary conditions. At the conclusion of the workshop, we will have a list of prioritized biological endpoints and environmental variables identified as science needs and more information on the spatial and temporal scales for which those metrics are needed We will use this information to document the existing state of science through assessment of available data, scenario forecasts, and simulation tools for large-river floodplain environments and then develop hydrodynamic and biotic models matched to identified management needs. Focusing on the prioritized list of science needs, we will evaluate which needs can be addressed given available datasets and develop models and tools using those data. Our results will be delivered to managers so they can make better informed decisions on how to manage their floodplain lands in a changing landscape and climate.

Keywords: Floodplain management; climate change; hydrologic modeling; biotic modeling

(017) Longitudinal Dam Interactions Control Channel Morphology: The Impacts of the Garrison and Oahe Dams on the Upper Missouri River

Katie Skalak[1], Adam Benthem[1], Edward Schenk[1], Cliff Hupp[1], Joel Galloway[2], Rochelle Nustad[2], and Gregg Wiche[2]

[1] U.S. Geological Survey National Research Program; [2] U.S. Geological Survey ND Water Science Center

Although the downstream impacts of dams on channel morphology and the upstream effects of dams on reservoir sedimentation are well documented, these effects were generally studied in isolation, with relatively little attention paid to their potential interaction along a river corridor. We examine the morphological and sedimentological changes in the Upper Missouri River, between the Garrison Dam in ND (operational in 1953) and Oahe Dam in SD (operational in 1959) (the Garrison Dam segment). Through historical aerial photography, stream gage data, and cross sectional surveys, we demonstrate that the influence of the upstream dam is still a major control of river dynamics when the backwater effects of the downstream reservoir begin. We propose a conceptual model of how interacting dams could affect river morphology, resulting in distinct and recognizable geomorphic sequences that we term “Inter-Dam Sequence”. Based on previous research on the geomorphic adjustment and recovery of sediment loads downstream from large dams, we define a distance criterion for dam interaction. We use this criterion to demonstrate that there are more than 400 reaches on large rivers in the United States that could be geomorphically controlled by dam interactions, similar to the Garrison Dam segment.

(018) Black Swan, Brown River: How a Levee Failure Transformed Floodplain Restoration and Management in California's Central Valley

Joshua H. Viers[1], Alexander K. Fremier[2], Alison A. Whipple[3], Carson A. Jeffres[3], and Andrew L. Nichols[3]

[1] School of Engineering, University of California, Merced, CA; [2] Washington State University; [3] Center for Watershed Sciences, University of California, Davis, CA

Transformative events shaping human histories, perceptions, and modalities can be considered to be of the Black Swan variety. Black Swans, in this context, are unanticipated events with significant impact, yet in hindsight appear perfectly predictable (sensu Taleb). Flood events and ensuing social-ecological transformations are an archetype Black Swan. In this paper, we illustrate how a Black Swan event transformed not only a riverine floodplain, but also initiated a paradigm shift in thinking and approach to riverine floodplain restoration. In 1986, a relatively routine levee failure along the banks of the Cosumnes River (USA) led to the establishment of an "accidental" forest. The forest was not the surprise, rather it was the shift in thinking. In retrospect, of course, it was perfectly predictable. Following the levee failure, floodplain restoration approaches now focus on initiating hydroecological processes, rather than on mimicking biological composition and pattern. Subsequently, the social-ecological transformation has led to a scientific focus on ecological effects of hydrological process, including intentional levee breaching and promotion of flooded floodplains. We explore the role of Black Swans at the interface of ecosystem disturbance and human reaction within this emergent paradigm with a new focus on the use of setback levees and levee breaching to promote process-based restoration of Central Valley floodplains for multiple social-ecological benefits.

Keywords: Black Swan; social-ecological transformation; resilience; hydroecological process; riparian; floodplain; ecological restoration; levee failure; levee removal; set-back levee

(019) The Visible Benefits and Hidden Costs of Levee Infrastructure

Nicholas Pinter

Southern Illinois University

Despite widespread calls and political mandates to consider non-structural solutions, levees and other structural flood-control systems are the primary tool for managing flood risk in the US. Levee protection is a mixed blessing, safeguarding floodplain infrastructure but creating a broad range of adverse impacts.

US floodplains are lined by up to 161,000 km of levees, and "Levees … have prevented inundation of major communities [and] helped avert billions of dollars in damages" (National Research Council, 2013). But many US levees are in questionable repair. According to recent inspection data, just 1.7% of levee miles nationwide were rated "Acceptable." Many researchers and floodplain managers recognize that flood-risk assessment must include the possibility of inundation behind levees. Put most starkly, "There are two kinds of levees … [t]hose that have failed and those that will fail" (Martindale and Osman, 2010). In addition to this "residual risk" of failure, levees cause higher water-surface elevations (levee "surcharge") because of the loss of storage volume and conveyance of flow on the floodplain. The US Government Accountability Office concluded "[t]hat levees increase flood levels is subject to little disagreement," but surcharge magnitudes often are disputed. Both empirical studies and hydraulic modeling document that levees along Midwestern US rivers have caused large surcharges, in some cases exceeding legal limits. One modeling study documented that surcharges and residual risk, combined, can lead to increased long-term flood risk, even for structures behind and "protected" by large and certified levees.

Levee surcharges drive a "hydrologic spiral" in which new and higher levees result in higher floods, which in turn drive demand for more and higher levees. Rejection of this hydrologic spiral in The Netherlands drove their new "Room for the River" flood-management strategy. However political pressure for new and larger levees remains strong in the US.

Other potential negative levee impacts include (1) increased scour potential and (2) floodplain ecosystem effects. Two-dimensional hydraulic modeling of a reach of the Mississippi River, with and without levees present, documented up to 20% increases in flow velocities and significantly increased scour within the channel. On the floodplain, levee failures are associated with intense local scour near the failure site; in contrast, inundation of un-leveed floodplains is gradual and typically does not cause extensive erosional damage. Finally, and importantly, natural floodplains are some of the richest and most diverse habitats on earth and owe this diversity to their hydrological connectivity to the river channel. Large levee systems sever this connectivity and thus significantly degrade floodplain and channel habitats and reduce the ecosystem services provided by river corridors.

In summary, levee protection is neither a universal positive nor an inevitable negative. In areas of concentrated population and infrastructure, structural flood protection is a compelling social and economic benefit. In other areas, some levee projects are driven by local political pressure without full accounting of the balance between benefits and negative impacts. In all cases, the full range of levee

benefits and costs need to be rigorously and quantitatively assessed, and non-structural alternatives considered where appropriate.

(021) Sediment Connectivity, Fluvial Geomorphology, and Long-Term Mining-Lead Storage In Big River, Old Lead Belt, Missouri

Robert Pavlowsky

Missouri State University

Sediment connectivity is inversely related to alluvial deposition rate and storage capacity in a river system. Understanding connectivity and the balance between storage and transport is important to manage problems caused by excessive and/or contaminated sediment loads. A storage-focused approach can help to predict the geography and persistence of ecological risks posed by sediment problems including physical habitat disturbance or contaminant toxicity. Big River (2,500 km2) drains the Ozarks Plateaus of southeast Missouri. It has been affected by two sources of legacy sediment inputs: (i) watershed-scale settlement and land-clearing from 1870 to 1920 and (ii) tailings releases by the Old Lead Belt mining district active from 1890 to 1972. Mining-related lead (Pb) contamination of channel sediment and floodplain deposits in Big River extends for over 170 km from Leadwood, Missouri (most upstream mine location) to its confluence with the Meramec River near Eureka, Missouri. Contaminated tailings particles released to the river span a size range from fine silt to medium gravel thus allowing interaction with depositional environments ranging from the channel bed to overbank floodplain. It has been reported that contaminated sediments present a toxic threat to fish and endangered mussels in Big River. This study evaluates downstream trends in bed composition, channel form, and floodplain properties to assess the role of alluvial storage processes and sediment wave transport in the geomorphic and geochemical recovery of the main stem of Big River. Historical legacy sediment inputs are still affecting geomorphic processes and contaminated sediment transport in the river today. More than 95% of the mining Pb is stored in overbank floodplain deposits, however, channel sediment Pb concentrations occur at toxic levels along 150 km of the river. Selective transport has sorted mine waste particles within channel bed and bar deposits by size class over distances from 20 km to 50 km. Fine gravel-sized mine waste particles have been transported about 30 km downstream from source over a period of 110 years. Sediment wave dispersion and translation have been observed in historical aerial photographs with bar form-sediment transport distances typically 0.1 to 0.3 km per year. Over 80 disturbance reaches occur in the study area and indicate breaks in connectivity of sediment transport capacity. These are composed of large, unstable channel bar complexes which provide in-channel storage capacity for contaminated bed sediments, but remobilize floodplain-stored Pb by bank erosion over decadal timespans. Geomorphic recovery to historical land use disturbances including channel belt widening to reconnect to new floodplains will release stored Pb from historical floodplain deposits to the channel for years to come. However, the question of whether long-term contamination rates will persist at toxic levels in the channel is not yet answered.

Keywords: Fluvial geomorphology; legacy sediment; Ozarks; floodplain deposits; channel bars; mining sediment contamination; sediment waves

(022) Re-Connecting Watersheds by Dam Removal: Sustained Geomorphic and Ecological Changes Following Dam Removal in an Upland Catchment

Frank Magilligan[1], Keith Nislow[2], Helen Doyle[1], and Carl Renshaw[1]

[1] Dartmouth College; [2] USDA-Forest Service

Because dam removal can minimize habitat fragmentation and re-connect riparian zones to fundamental hydrologic processes and channel-floodplain exchanges, many ecologists and environmental advocates embrace dam removal as a crucial element of river restoration. Taking advantage of the Fall 2012 removal of the 5 m high Pelham Dam in central Massachusetts, we evaluate the ecological and geomorphic shifts over a three-year monitoring period. We sampled pre- and post-removal geomorphic parameters (18 cross-sections along a 1.2 km reach, Wolman pebble counts, embeddedness surveys, and detailed long profiles) in Amethyst Brook (24 km^2). These geomorphic assessments were combined with detailed quantitative electrofishing surveys of stream fish richness and abundance and visual surveys of native anadromous Sea lamprey (*Petromyzon marinus*) nest sites. Geomorphic results document that all 11 cross-sections downstream of the former dam fined significantly within the first year, with typical reductions of 30-60% in mean particle size. Subsequent monitoring reveals that this fining has stabilized, maintaining the post-removal finer bed caliber. This fining has major implications for Sea lamprey that require fine gravel for spawning which was largely absent downstream of the former sediment-trapping dam. This fining was associated with downstream bed aggradation, reflecting the new, post-removal flux of material. Similarly, post-removal bed surveys indicate ~ 2 m of incision had migrated 25 m upstream of the former reservoir before encountering an exhumed historical dam, which now acts as the new grade control, limiting progressive headcutting. The combination of changes in channel bed sedimentology and the emergence of the new crib dam that is a likely barrier to fish movement was associated with major reductions in abundance and richness in sites adjacent to the former dam in sampling immediately following the dam removal. At the same time, we documented the presence of three species of fish, including Sea lamprey, which were not present above the dam prior to removal, indicating that upstream passage has been achieved. Our results point to the importance of interactions between dam removal and flood disturbance effects, with important implications for short- and long-term monitoring and assessment of dam impacts to river systems.

(023) Geomorphic Adjustments to Altered Sediment Supply on the Lower Missouri River: Consequences for River Management

Robert Jacobson

US Geological Survey

Impoundments and channelization have substantively altered the sediment balance on the Lower Missouri River, USA. Mainstem dams have decreased the downriver suspended-sediment load to 0.2 to 17 percent of pre-dam loads. Simultaneously, channelization has simplified and shortened the channel, and as much as 7.6 million metric tons per year of sand has been extracted from the bed-material load. Over nearly the same time frame, the channel has incised more than 3 m just downstream of Gavins Point Dam, South Dakota, and near Kansas City, Missouri. Between the Platte River and St. Joseph, Missouri, the bed has been aggrading slightly over recent decades, and at other locations the bed ranges from stable to slightly degrading. The potential causes for bed changes range from sediment deficits downstream of the dam, to channelization, to commercial removal of sand for aggregate. Although determination of cause and effect is challenging with these multiple, interacting, potential causes, all relate to interruption in sediment balance. The altered sediment balance and geomorphic adjustments constrain restoration and management opportunities. In incised river segments, ecologically desirable reconnection of the flood plain requires discharges that are beyond practical operational limits, whereas in aggraded river segments, smaller ecological flow releases can inundate or saturate agricultural lands. Lack of sediment downstream from Gavins Point Dam limits sustainable restoration of sand-bar habitat for listed bird species. In-channel restoration projects designed for current hydrologic conditions may not continue to perform as designed unless they are adaptively managed to keep pace with ongoing channel adjustments.

(024) Sediment Dynamics in the Hyporheic Zone of a Regulated River in Australia

Roser Casas-Mulet[1], Michael Stewardson[2], and Knut Alfredsen[3]

[1] University of Melbourne, Melbourne Research, Level 5, 161 Barry Street, Parkville 3010 VIC Australia; [2] Department of Civil and Environmental Engineering, University of Melbourne; [3] Department of Hydraulic and Environmental Engineering, NTNU, Trondheim, Norway

Fine sediments have the potential to impact both benthic and hyporheic ecology by processes such scouring and abrasion or by clogging the interstitial pores, with more relevance in regulated rivers due to natural dynamics alteration. Field studies to understand the fine sediment dynamics at the gravel scale in regulated rivers have hardly been examined. More knowledge on the interaction between fluctuating flow and sediment infiltration processes in the hyporheic zone is needed to fully understand the potential impacts of variable river flow due to regulation.

This paper aimed to investigate the effect of hydrological regime changes on sediment infiltration dynamics by assessing the mechanistic processes intervening in the sediment balance of a point bar subject to regular fluctuations due to hydropower regulation. An experimental set-up consisted on several sediment collectors with horizontal and vertical openings allowing finer sediment fractions to infiltrate. They were placed along and across a side gravel bar exposed to flow fluctuations. Preliminary results showed (i) strong positive correlations between sediment accumulation and flow duration and to less extent with magnitude, (ii) dominance of horizontal over vertical directions in the infiltration processes, (iii) differences in infiltration along and across the gravel bar with higher infiltration closer to the thalweg and in the downstream areas.

Further analysis of the results is currently ongoing and the final findings will be both important for fundamental understanding and for mitigation of adverse impacts and management in regulated rivers.

(025) Big River Benthos: Linking Year-Round Biological Response to Secondary Channel Connectivity within the Lower Mississippi River

Audrey Harrison[1], Clifford Ochs[2], William T. Slack[1], and Jack Killgore[1]

[1] University of Mississippi/ US Army Engineer Research & Development Center; [2] University of Mississippi

Benthic macroinvertebrates have long been used as habitat quality indicators in wadeable streams, but because of the difficulty of sampling, large river benthos are understudied. In this study, we focused on the benthic macroinvertebrate fauna as indicators of biological response to anthropogenic alterations of flow regimes, particularly closure dikes, within naturally occurring secondary channels of the Lower Mississippi. Closure dikes of different elevations are placed at the upstream end of secondary channels to direct water flow into the main river channel for maintenance of water depth for navigation. During mid to high river stages in spring, water flows over closure dikes and into secondary channels, but during low river stages, typically in late summer and fall, channels become more-or-less disconnected at the upstream end from the main river channel. We hypothesized that there would be an ecological legacy effect on benthos of secondary channels related to connection to the main channel in prior years. To test this hypothesis, we sampled nine secondary channels spanning a gradient of connectivity to the main channel at low river stages. Samples of benthic macroinvertebrates were collected in June 2014 during high stages (fully connected) using a modified benthic sled. There was a strong positive relationship between taxonomic richness and degree of connectivity to the main channel during low water of the previous year (2013), indicating a legacy effect. This study, combined with low-water sampling efforts, will contribute to the understanding of ecological response to altered flow regimes, as well as aid in decision making for river restoration projects.

(026) Habitat Requirements of the Endangered Think-Shelled River Mussel – An Integrative Approach

Katharina Stöckl and Juergen Geist

Technical University of Munich, Aquatic Systems Biology

The thick-shelled river mussel *Unio crassus* is one of the most endangered large freshwater bivalve species in Central Europe. To date, the main factors causing the dramatic decline still remain unclear, owing to a lack of information on the autecological and synecological requirements of the species. Herein, we present an integrative approach that has identified key habitat requirements of *U. crassus*, including flow regime, substrate composition and fine sediment deposition, water chemistry as well as host fish suitability and availability. Shear stress, flow velocity and penetration resistance of the stream substrate were examined in relation to mussel presence/absence data in functional streams. Physicochemical substratum characteristics and water quality were measured in a stream with recent recovery and recruitment. Host fish suitability was assessed both in standardized infestation experiments in the laboratory as well as in combination with fish community analyses under natural conditions to test host availability. The results of this study show that densely colonized stream patches were characterized by low flow velocities (< 0.3 ms^{-1}), low mean penetration resistances (0.36 ± 0.52 kg cm^{-2}) as well as by low bottom shear stress compared to non-colonized sites. Mussel density was significantly negatively correlated with bottom shear bed forces. At sites with juvenile recruitment, fine sediment deposition was high with 19.4 kg/m^2*month. Results of chemical water analyses indicated high nitrate loads in a range of 4.1 to 6.5 mg NO_3-N/l. In terms of host fish analyses, the laboratory infestations identified seven host fish species for *U. crassus*, with host-specific glochidial development times. In natural *U. crassus* streams, sixteen fish species were found and fish community structure and densities were highly variable. Consequently, the evaluation of host fish requires the inclusion of standardized laboratory experiments and field validation. Our results indicate that – despite its conservation status – *U. crassus* has a broader niche width for habitat concerning hydrological and substrate characteristics than expected. Interestingly, high mussel densities and mussel banks were predominantly found in areas with low flow velocities. These areas are presumably most crucial during the reproductive cycle, when gravid mussels change their location towards the stream bank to release their glochidia and thus have a higher risk of being displaced at high flows. The greater tolerance of *U. crassus* to adverse substratum and water chemical conditions suggests that conservation management should more strongly emphasize hydrological conditions in *U. crassus* streams as well as host fish availability and fisheries management.

Key words: freshwater mussel; substrate; conservation; ecological niche; shear stress; host fish; Europe

(027) Using Physical Ecology to Understand the Complexity of Freshwater Mussels

Josef Ackerman

University of Guelph

Unionid mussels are relatively sedentary on the bottom of lakes and rivers except for their early-life history that involves the broadcasting of sperm and parasitic glochidia larvae, large-scale dispersal via a host fish and local dispersal in the water column of juvenile mussels after excystment from their hosts. The fluid environment is, therefore, responsible for essential biological processes including the delivery of food resources and juveniles to the benthos as well as the removal of sperm and wastes. Consequently, an understanding of the hydrodynamics of aquatic habitats should provide insight into the physical ecology of unionid mussels.

This presentation will highlight several key transport processes that facilitate the physical ecology of important life history functions including dispersal of larvae and newly excysted juvenile mussels, the settlement of juvenile mussels on riverbeds, and the suspension feeding of benthic under flowing conditions. For example the settling velocity of glochidia and newly excysted juvenile mussels can be used to predict dispersal distances in stream flow. Stoke's Law predictions underestimated observed settling velocities in part because they are based on approximations of the shape and density of mussels, they are at the limits of stokes flows, and because they fail to account for behavioral changes that can reduce settling velocity. Behavior also provided juvenile mussels placed on the benthos mechanisms to withstand high bed shear stress and hence exceed critical shear stress values predicted by the Shields Curve.

There are no theoretical predictions, however, for the effect of mass transport on suspension feeding. Regardless, the clearance rates (CR; amount cleared per unit time per mussel) of < 9% of species of unionid mussels have been examined and CR estimates range over two orders of magnitude (e.g., Order $[10^{-2 - 1}]$ L mussel^{-1}hr^{-1}). This is due in part to the variety of material that the mussels cleared, the variety of body sizes examined – none of which have included recently excysted juvenile mussels – and the lack of incorporation of hydrodynamic factors in CR measurements. This is unfortunate because algal flux can significantly increase CR compared to the results obtained from studies undertaken under static conditions in beakers or aquaria. Moreover, the response of CR to flux is non-linear. Recent results obtained using river seston in flow chambers support these observations although at lower rates than those obtained using single algal species, as has been reported in other bivalve systems. Predicting the effect of suspension feeding of unionid mussels in their natural environment will require the inclusion of observations based on seston flux.

Whenever possible the transport process under consideration has been compared to the prediction of analogous physical process, which assumes that organisms are passive particles that vary in size, shape, or density. Theoretical predictions provide insight into such processes but these predictions are often limited in value because they fail to capture behavioral and the outcomes of ecophysiological processes. In other cases, where predictions do not exist, the analyses of static conditions do not provide insight

into natural conditions where hydrodynamics are involved. Conversely, it is clear that physical ecology can provide valuable insights that can be used to understand the complexity of freshwater mussels.

(028) The Effect of Natural Suspended Sediment on Adult and Juvenile Unionid Mussels (*Lampsilis siliquoidea*, *Lampsilis fasciola*, *Ligumia nasuta*, *Villosa iris*)

Shaylah Tuttle-Raycraft and Josef Ackerman

University of Guelph

Unionid mussels represent one of the most imperilled freshwater groups in North America, with steady declines in both species richness and abundance. Habitat modification and degradation have been proposed as factors that contribute to their declining populations. Identifying the qualities of a suitable habitat for unionid mussels is difficult because species can be found under very different conditions, for example in both clear (0 – 5 mg/L) and turbid (90 mg/L) rivers. An increase in total suspended solids (TSS) can impede reproductive function and decrease clearance rates and may be a contributing factor to the decline of mussel populations in general.

The nature of the relationship between unionids and TSS is poorly understood. Four species from the Lampsilinae subfamily of Unionidae, including three with conservation concerns (*Lampsilis fasciola*, *Ligumia nasuta*, *Villosa iris*) and a common species (*Lampsilis siliquoidea*), were used at both the adult and juvenile (transformed in the laboratory on host fish) life stages. It was hypothesized that, like marine mussels, clearance rates would decrease as the concentration of TSS increased due to the increased cost of cleaning the gills. The hypothesis was examined by exposing the adults to concentrations of river TSS between 0 and 100 mg/L. The adult experiments were performed in polyethylene funnels that were aerated to maintain the suspensions. The juveniles were placed in 12-well cell culture plates on a shaker table, to maintain the suspensions, as they were exposed to concentrations between 0 and 15 mg/L of river TSS. Each of the four to five replicates for both life stages had a mussel trial and no-mussel control for each treatment. The juveniles were tested at multiple ages when the animals were available.

The clearances rates of adult mussels significantly decreased at concentrations above 8 mg/L, similar to other bivalves. For example the clearance rate of the *L. siliquoidea* was 32% lower in 8 mg/L TSS than in 0 mg/L. The clearance rates of one-week old animals increased as TSS increased, for example the clearance rate of one-week old *L. siliquoidea* was increased by 25% in the 15 mg/L treatment when compared to the 0 mg/L treatment. This indicates that they were likely pedal feeding as opposed to suspension feeding. The older animals demonstrated the same trend as the adults, where the clearances rates decreased as TSS increased above 8 mg/L. For example, the clearance rate of four-week old *L. siliquoidea* was 33% lower at 8 mg/L than in the 0 mg/L treatment.

It can be concluded that TSS concentrations above 8 mg/L have a negative impact on the feeding efficiency of unionid mussels, across multiple species. Furthermore, this level of TSS should be considered when creating new, and enforcing the existing, regulations regarding suspended sediment. Given the above results, further investigation into the effects of TSS on unionid mussel clearance rates is required, as these mussels can survive and thrive in turbid rivers, where their feeding efficiency should be significantly decreased.

(029) Measuring Floodplain Surface Complexity

Murray Scown[1], Martin Thoms[1], and Nathan De Jager[2]

[1] University of New England, Armidale, NSW Australia; [2] U.S. Geological Survey - Upper Midwest Environmental Sciences Center

Floodplain surface topography is an important component of floodplain ecosystems. It is the primary physical template upon which ecosystem processes are acted out. There has been a limited appreciation of floodplain surface complexity because of the traditional focus on temporal variability in floodplains, largely attributed to hydrology, as well as limitations to quantifying spatial complexity. An index of floodplain surface complexity is developed in this paper and applied to eight floodplains from different geographic settings. The index is based on the two key indicators of complexity; variability in surface geometry and the spatial organization of surface conditions and was determined at three sampling scales. Relationships between these measures of spatial complexity and environmental drivers, namely; flow variability (mean daily discharge, the coefficient of variation of daily discharge, the coefficient of variation of mean annual discharge, the coefficient of variation of maximum annual discharge), sediment yield, valley slope, and floodplain width were examined. Floodplain surface complexity, variability in surface geometry, and the spatial organization of surface conditions all varied between the eight floodplains and this was dependent upon sampling scale. All complexity values declined with increasing floodplain width in either a power, logarithmic, or exponential function. There was little change in surface complexity with floodplain widths greater than 10 km. Variability in surface geometry was significantly related to sediment yield, and no significant relationships were determined between any of the hydrological variables and floodplain surface complexity. Our findings suggest that the physical complexity of floodplain surfaces is associated primarily with sediment and valley conditions, and less so to hydrology. This has implications for floodplain research and management given the traditional focus on hydrology as the primary driver of floodplain systems.

(030) Illinois' Cache River: The Ecological and Social Hurdles of Restoring a More Natural Hydrology to a Severed River

Tracy Boutelle Fidler

Shawnee Resource Conservation & Development

An unprecedented effort is underway in Southern Illinois to restore connectivity to a river that has been broken in two. A century ago, farmers sought to drain the Cache River Wetlands by digging a five-mile long ditch to the Ohio River, effectively breaking the river into two watersheds. This and other river modifications resulted in the reduction in the size, extent and physical make-up of the river's swamp, as well as a reduction in the amount, frequency and timing of water flow through the lower stretch of the river. These changes negatively affected wetland and aquatic communities. In 2006, regional conservationists launched an effort to restore a more natural hydrology to the lower Cache River through a managed connection between the upper and lower segments of this river. Since then, agency and non-profit natural resource professionals have sought to gather the modeling and ecological data necessary to develop this project, acquire funds and garner support from the local populace. The initial data gathering effort was to determine the potential impact to private lands through watershed modeling conducted by the Illinois State Water Survey. Once it was ascertained private lands were not a project constraint, we sought to make a direct connection between the envisioned project and the expected benefits to riverine wildlife and associated plant life. Collaborative projects with the research community were sought, and the evidence of the benefits of restoring a more natural water flow is now well documented. In 2014, the Cache River Wetlands Joint Venture Partnership—which includes Ducks Unlimited Inc., Illinois Department of Natural Resources, Natural Resources Conservation Service, The Nature Conservancy and U.S. Fish and Wildlife Service—approved a plan to restore the Cache. It identifies the specific structures required and the benefits of doing so. Even as planning, research and funding were being gathered, it was always clear that the support from the local community would be essential to achieving a desirable outcome. Natural resource professional engaged community members in a variety of ways, from attending official meetings, one-on-one conversations and on-going communication about research findings, which revealed important flood concerns. (The latter is especially relevant, as Illinois is in the process of updating its FEMA flood maps.) Input from local residents guided the plan's development. However, due to constraints in Illinois drainage law, natural resource professionals struggle to implement this project. We remain optimistic that — having overcome the project's design, ecological and funding challenges — a solution towards implementation is near. A more natural hydrology is needed if the Cache River Wetlands are to remain biologically diverse in this century.

Keywords: River ecology; wetlands; modeling; communication; outreach

(031) Invasion by Reed Canarygrass (*Phalaris arundinacea*) in the Upper Mississippi River: abundance, distribution, and potential spread

Yao Yin[1], Nathan R. De Jager[1], Meredith Thomsen[2], Amber Miller-Adamany[2], and Erin Hoy[1]

[1] USGS Upper Midwest Environmental Sciences Center, La Crosse, WI, USA; [2] University of Wisconsin-La Crosse River Studies Center, La Crosse, WI, USA; University of Wisconsin-La Crosse;, USGS Upper Midwest Environmental Sciences Center

Reed canarygrass (*Phalaris arundinacea*) is an aggressive invader of North American wetlands. In the Upper Mississippi River (UMR), forest management actions are beginning to focus on ways to prevent the spread of *Phalaris* into native wet meadows and forested areas and to restore invaded areas back to native vegetation. Such actions could benefit from quantification of the current abundance and distribution of this species as well as a better understanding of the mechanisms controlling its spread.

We combined several landscape-scale data sources to quantify the current abundance and distribution of *Phalaris* in the UMR floodplain. Aerial photos were used to identify native wet meadows and those dominated by *Phalaris* (>80% cover) while forest inventory data were used to identify forest stands with an understory dominated by *Phalaris*. We further examined the spatial distribution of native and invaded wet meadows relative to the flooding regime of the river using land elevation data (LIDAR) and river stage data. We examined effects of canopy-openness on the likelihood of finding *Phalaris* in the forest understory using logistic regression.

Results indicate *Phalaris* is a strong invader of herbaceous wet meadows in the UMR. Wet meadows make up approximately 12% of non-aquatic vegetation in the UMR. The ratio of invaded to noninvaded wet meadow areas was approximately 4:1 in areas where water surface elevation is within 0.3 m of land elevation but not above land elevation for longer than 16 days. In contrast, the ratio was closer to 1:1 in higher elevation areas. *Pharlaris* appears to out compete native vegetation along most of the elevation gradient, except at very low/wet and high/dry elevations, which are only a small fraction of the UMR floodplain.

Phalaris is also a strong invader of forest stands with relatively open-canopies. Floodplain forest makes up approximately 67% of the area occupied by non-aquatic vegetation in the UMR, and 50% of the forested area inventoried contained >70% cover by *Phalaris* in the understory. The likelihood of finding *Phalaris* in the forest understory increased with increasing canopy-openness.

Based on interpretation of aerial photographs, the present-day forest (2010) is more open than it was ten years ago (2000). Whereas 76% of the forest was rated to have a canopy closure greater than 90% in 2000, only 59% of forests had >90% closure in 2010. The change indicates that roughly 3000 ha of forest along 100 river miles of the UMR became more vulnerable to *Phalaris* invasion in the understory.

Our analysis confirms previous smaller-scale concerns about the current abundance and distribution of *Phalaris* in a large portion of the UMR floodplain and provides some insights into the mechanisms that might regulate its future spread.

(032) Linking Energy Expenditure and Habitat Use in *Scaphirhynchus* Sturgeon

Anthony Porreca[1], William Hintz[2], Awoke Teshager[3], and James Garvey[1]

[1] Southern Illinois University, Carbondale; [2] Rensselaer Polytechnic Institute; [3] Little River Research and Design

Lotic ecosystems have highly variable energy landscapes. The federally endangered pallid sturgeon *Scaphirhynchus albus* and threatened shovelnose sturgeon *S. platorynchus* are two fluvial specialists that occupy heterogeneous flow fields within microhabitats of large rivers. Recent field and experimental studies suggest that both species select for sand substrates over gravel substrates, yet no information exists regarding the energetic costs of occupying such microhabitats. We used intermittent, flow-through respirometry to quantify energy expenditure (MO_2: mg O_2 kg^{-1} h^{-1}) of age-0 pallid and shovelnose sturgeon within two experimental microhabitat types, sand and gravel, at low (range: 8.5-20.5 cm s^{-1}) and high (range: 13.8-33.0 cm s^{-1}) velocities. Micro-scale differences in velocity in the water column between the sand and gravel substrates were quantified using digital particle tracking velocimetry. Velocities near the substrate declined over the gravel compared to the sand bottom. Substrate altered energy expenditure; MO_2 values for both species were higher over the sand substrate. The MO_2 between sand and gravel was reduced more for pallid sturgeon than shovelnose sturgeon. Velocity did not affect MO_2. Energy expenditure for age-0 pallid and shovelnose sturgeon changed in a similar fashion with respect to velocity and substrate type. The benefits of occupying sand may outweigh the increased cost of station holding. Sand occurs in depositional areas that may hold more food or contain fewer predators. Gravel may create undesirable turbulence that sturgeon would otherwise avoid. Differences in MO_2 between species suggest that segregation may occur where pallid and shovelnose sturgeon overlap within microhabitats.

(033) Historical Changes of Large European River Systems

Christian Wolter

Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Germany

The Central European lowlands have been colonised immediately after de-glaciation about 8000 years ago. Four millennia later, first signs of anthropogenic impact and hydraulic engineering have been dated in the late Bronze Age 3500 years BP: artificial fosses for navigation. First canals primarily for navigation have been built in the River Rhine delta about 2000 years ago, the Fossa Drusiana 13-9 BC and the Fossa Corbulonis 47 AD. The first successful attempt to connect the rivers Altmühl and Rezat, i.e. the catchments of the rivers Rhine and Danube, via the built Fossa Carolina dated already from the year 793. Between 1391 and 1398 the canal Stecknitzkanal was built between the German cities Lüneburg and Lauenburg representing the first summit reach between two catchments. From the same time the first navigation locks have been reported, Vreeswijk at the mouth of a canal from Utrecht to the River Lek in 1373 and in the Stecknitz-Canal in 1395.

While these early river engineering works were probably mostly of local impact, the situation changed completely with the “Wiener Congreß-Acte” signed on June 08, 1815 and the foundation of the German Tariff Union on January 01, 1834. For the first time a convention was adopted to allow for free inland navigation, to set up common navigation commissions for multinational river systems, and to maintain the river systems to improve inland navigation. Following this arrangement many rivers became regulated by groynes to increase the fairway depth and width during mean flow to allow for longer traffic of larger barges. The foundation of the German Tariff Union was the beginning of the industrialization period, accompanied by the development of a competing mode of transport; the first railway started operation in 1835. After that, the navigation paradigm has completely shifted from the historical adaptation of numerous vessel types to the specific river conditions to an adaptation of the rivers by river engineering works to continuously increasing vessels. Up to the 17th century the average river depth required for navigation was 0.7-0.8 m. With raising traffic volumes on the railways vessels had to increase their loads and lower their resting times to remain competitive. This led to the so-called low water regulation of all major European waterways in the second half of the 19th century.

This study aimed to quantify the modifications of large river systems and the related habitat loss for aquatic biota based on written evidence, historical maps, and modeling analyses.

At the beginning of the 20th century, after all major regulations, navigable European rivers have lost on average 21% (8-45%) of their length, 89% of their islands, 90% of their floodplains, and 98% of their braided reaches. By that, >50% of the natural bank lines and littoral habitats disappeared. The remaining banks are commonly covered by embankments on >60% of their length, in canals up to 100%. The global inland waterway network has been enlarged from 8750 km canals and 3125 km regulated rivers before 1900 to 671,868 km today.

(034) The Volga River--a Historical and Contemporary Look at Navigation

Dorothy Zeisler-Vralsted

Eastern Washington University

Beginning in the 1930s the Volga River--in a development trajectory similar to the Mississippi River—became a major riverine highway, critical to the economic success of the nation-state. With the construction of the Moscow-Volga Canal, a navigational channel extending from Moscow to Astrakhan was achieved, assuring the shipment of goods and grains to the Caspian Sea for six months of the year. Traffic on the river increased annually as barges hauled goods worth millions of dollars. Navigation improvements persisted throughout the twentieth century including the Volga-Don Canal, completed in 1952, providing access to the Caspian and Black and Azov basins. Now the Soviet Union had access to five seas; a boon for shipping a number of goods with Donetz coal being among the most important. Throughout the 1960s and 1970s, the Volga was redesigned and engineered to curb flooding and serve irrigation, navigation and power needs under the dictates of the Great Volga Scheme. The navigation channels that were constructed are still heavily used in the twenty-first century. For example, the Volga-Don Canal ships an estimated ten million tons of cargo annually as ships navigate the thirteen locks in one day.

But the construction of this barge superhighway was not without environmental costs as a rich and diverse ecological regime has been threatened. One of the detriments has been a growing loss of wetlands. In 2006, a UNESCO publication cited this lack of wetlands preservation and found “an insufficient understanding of the relevance of the Volga wetlands; the lack of preservation efforts from governmental, private, and public organizations, but also from the local population; deficient training of professional environmentalists, teachers and educators; and the inexistence of joint action and coordination of the activities towards conservation among all these interest groups.” Today the issues persist and the Volga River basin is still highly polluted although there are efforts by fledgling environment groups and UNESCO to bring back a healthy Volga River and wetlands.

My presentation will examine the Volga through the lens of navigation, the cost of creating this riverine highway with a brief look at contemporary efforts to preserve the environmental health of the river.

(035) Mississippi River Development – Historic Engineering of the River for Navigation and Flood Control and the Current Modifications for the Ecosystem Restoration

Gretchen Benjamin[1] and John Anfinson[2]

[1] The Nature Conservancy, Fresh Water North America, USA; [2] U.S. National Park Service

Historically, the Mississippi River (UMR) floodplain was a diverse mosaic of habitats influenced by the seasonal variation of river flows and associated water levels. Primary, secondary and tertiary channels, backwater lakes, bayous, oxbows, sloughs, deep and shallow water wetlands, scour holes, and islands of variable topographic diversity describe many of the physical characteristics. Vegetative communities from floodplain forests, canebrakes, emergent, floating leaf and submersed vegetative communities cover that physical habitat. Biota including Louisiana black bear, muskrat, beaver, otter, over 150 fish species, about 50 species of native mussels, diverse array of heptiles, and invertebrates as unique as the Ohio River shrimp resided and traversed this waterscape during complex life cycles. As non-indigenous settlers began to spread across what is today the United State of America there was desire to modify the rivers to provide transportation of humans and goods. In 1824, the first funds were appropriated by the US Government to remove sandbars and debris on the Mississippi and Ohio Rivers. Subsequent Rivers and Harbors legislation provided additional funds to deepen the channel through increased dredging, engineering structures to force the river to self-scour, removal of natural rapids and continual debris removal. By 1930, a demand for a nine-foot navigation channel and need to put Americans to work during the Great Depression led to the construction of 26 locks and dams on the upper portion of the Mississippi to impound the river where that depth could not be maintained by traditional channel management actions. Below the impounded portion of the river increased use of channel structures funneled the water to maintain the nine-foot navigation channel. Alongside the changes for navigation, flooding and managing those floods became an ever pressing threat to the residents along the river. A "levees only" strategy or simply continually building the levees higher after each significant flood was in place from mid- 1800s until the massive flood of 1927. The 1927 flood proved that additional measures for flood control were essential as large and small levee breaches by floodwaters inundating 16.8 million acres, 170 counties and parishes in seven states, destroyed all properties within the flood path, dislocating one million people and killing by different accounts 200 to 1000 people. The Flood Control Act of 1928 provided the authorization for the Mississippi River and Tributaries project which consists of a total of 3727 miles of mainline and tributary levees, a series of floodways for use during large flooding events, and water storage capacity in key tributary systems. Additionally, the River was shortened by over 150 miles between 1929 and 1960 using bendway cutoffs. The centuries of constraining the river for commercial navigation and flood control led to degraded ecological condition on the river. Currently, river ecologists are trying to recover lost ecological attributes in the river. A brief overview of the measures used to improve ecological conditions will be introduced during this presentation with more detailed information provided in other special session presentations.

Keywords: Navigation, flood control, Mississippi River modifications, Mississippi River mainstem restoration.

(037) Big Data from the Big Muddy: Long-term Empirical Data from the Mississippi River Alluvial Valley on Baldcypress Swamp Function

Beth Middleton

U.S. Geological Survey

Long-term data on shifts in ecosystem function across large spatial and scales are rare, but vital for future biodiversity conservation and management. Such studies have been conducted since 2002 across the Mississippi River Alluvial Valley (MRAV) from Illinois to Louisiana, with five replicate sites at each of seven latitudes in the North American Baldcypress Swamp Network (NABCSN). More recently, sites have been established across the northern Gulf Coast in Texas, Louisiana and Florida, as well as along the Atlantic Coast in Delaware and Maryland. Geographical trends in tree production, growth, height, and regeneration have been observed in NABSCN. These studies also have explored the effects of climate change environments on soil organic matter storage and recruitment from the seed bank. These studies have found that leaf and root production, organic matter storage, and tree height are higher in the middle of the MRAV (Arkansas) than elsewhere in the range. Because IPCC models suggest that the MRAV may experience future episodes of climate warming, production levels may increase in the northern part of the bald cypress swamp range in the future, depending on water availability. Large scale information on the functional responses of baldcypress swamps to various geographical environments can provide predictive information on future baldcypress swamp distribution and function.

(038) Fifteen Years of Hydroacoustic Habitat Surveys on the Lower Missouri River: What Have We Learned?

Caroline Elliott, Robert Jacobson, Edward Bulliner, and Susannah Erwin

U.S. Geological Survey Columbia Environmental Research Center, Columbia, MO

For the past fifteen years, we have collected field data using a variety of hydroacoustic survey tools in support of physical habitat assessments for species of interest on the Missouri River, USA and its large tributaries. Although tools and techniques have changed through the years, the measurements taken over this fifteen year period provide a wealth of information on the physical habitats of the Missouri River. In total, the measurements represent more than 300 field days, a wide range of discharges, and a total mapped distance is approximately 400 kilometers of river. Data collection efforts have utilized single-beam and multibeam echosounders to map channel bathymetry, acoustic Doppler current profilers to measure river velocity, and sidescan sonar, underwater cameras, and stream bed sediment samplers to characterize and measure channel substrates. We have worked closely with fisheries biologists to develop habitat survey methods that are well-integrated with fish telemetry and large river sampling methods. Habitat assessments on the Missouri River have yielded new insights about migratory and spawning habitats used by the endangered pallid sturgeon and have provided context for the drift and dispersal of larval sturgeon and paddlefish. Survey data has also been used to build and validate multiple hydrodynamic models to aid and support Missouri River restoration and recovery efforts. We have accumulated and housed a clearinghouse of raw and edited depth and velocity datasets that includes over 1 terabyte of data. We present an analysis of this dataset utilizing python scripts that automatically query and summarize the catalog of field data and look at larger trends in the data set that spans the boundaries of individual projects and has increased our understanding of physical dynamics and geography on a large sand-bedded regulated river system.

(039) Little Bugs, Big Data, and Grand Canyon: Light Trapping by Citizen Scientists Yields Insights into Colorado River Aquatic Insect Dynamics

Theodore Kennedy[1], Jeffrey Muehlbauer[1], David Lytle[2], Charles Yackulic[1], Eric Kortenhoeven[1], and Anya Metcalfe[1]

[1] US Geological Survey; [2] Oregon State University

Glen Canyon Dam has greatly altered the discharge and temperature regimes of the Colorado River in Grand Canyon, which may explain why only two aquatic insect taxa—midges and blackflies—are common in this river segment. In 2012, we initiated a citizen science project in collaboration with professional and private river rafters to quantify insect emergence for the 386 km Grand Canyon segment of the Colorado River. Rafters conducted standardized light trapping each night in camp, yielding an unprecedented emergence dataset (750+ samples each year). This dataset has elucidated insect emergence patterns related to dam operations, including pronounced decreases in midge emergence (catch per hour) coincident with abrupt increases in regulated discharge. Longitudinal patterns of emergence for midges were sinusoidal and appear related to the time of day when low versus high water associated with hydropeaking waves occurs in different reaches. Specifically, we observed higher and lower rates of insect emergence at Grand Canyon locations where afternoon flows represented the daily minima and maxima, respectively. Because mating and egg-laying by aquatic insects often occurs in late afternoon/evening, these sinusoidal patterns in emergence may reflect differences in the quality of the egg-laying environment for aquatic insects. These results indicate that routine hydropeaking may represent a bottleneck that limits aquatic insect diversity and production by causing high mortality at the critical egg stage. Our findings suggest that aquatic insect assemblages might be enhanced through changes in flow management alone, even without more natural temperature regimes.

Keywords: Colorado River, Grand Canyon, hydropeaking, insect emergence

(040) Patterns of Biodiversity and Biogeochemistry in the Upper Mississippi River: Importance of Scale, Connectivity and Evolution

Nathan De Jager

U.S. Geological Survey - Upper Midwest Environmental Sciences Center

The interplay between hydrology and the evolutionary adaptations of biota to water movement has been used to explain numerous ecological patterns in river systems. However, patterns in the fundamental components of these systems remain unquantified for many rivers at landscape scales. The availability of large-scale and long-term data makes it possible to quantify patterns in basic ecosystem properties in ways and at scales that allow for stronger insights into the roles connectivity and evolution play in determining river ecosystem structure and function across a range of scales.

This presentation will focus on a series of recent studies that have used large-scale and long-term datasets to quantify spatial patterns in aquatic nutrients and fish communities, as well as patterns of floodplain vegetation and soils in the Upper Mississippi River (UMR). In the river, spatial patterns of nitrogen and phosphorous were shown to be highly patchy, reflecting patterns of nutrient delivery and processing by microbial communities with specific adaptations to hydrology. Fish communities differed among nutrient patches and their spatial distributions appear to be predictable based on water flow velocity and species-specific physiological adaptations to water movement. On the floodplain, patterns of soil texture and organic matter were shown to correlate with long-term inundation durations, while shorter-term nitrogen cycling rates reflect flood-pulse effects on microbial nitrification and denitrification. The distribution of patchy floodplain forest communities in the UMR has been linked to both long and short-term inundation durations, reflecting species-specific physiological adaptations to the duration of anoxic conditions.

Results from these studies strengthen our understanding of how connectivity can modify the distribution of processes and organisms with specific life history attributes. Perhaps most importantly, these relationships and spatial patterns have been quantified in ways that allow for model predictions of the effects of river modification and climate change on patterns of biodiversity and biogeochemistry in a large river.

(041) Citizen Science: Baseflow Nitrate Sampling in SE Minnesota Trout Streams

Jeffrey Broberg

WSB Associates, Inc., Rochester, MN

Recent key studies of nitrate-nitrogen in Minnesota surface waters completed by the Minnesota Pollution Control Agency (MPCA) and the 2014 publication "Geologic Control of Groundwater and Surface Water Flows in SE Minnesota and the Impact on Nitrate Concentrations in Streams" by the Minnesota Geological Survey (MGS) point to connectivity of nitrate groundwater contamination to the spring-flow discharge of contaminated groundwater to Minnesota streams as a major contributing factor in the total nitrate flux to the Mississippi River. Nitrate contaminated groundwater is connected to the nutrient enrichment and impairment of trout streams, the eutrophication of the Mississippi River, and SE Minnesota's contribution to hypoxia in the Gulf of Mexico. While the technical documents from the MPCA and MGS have refined our technical understanding of the source and fate of nitrate contamination in our agricultural landscape, and have advanced our understating of role of hydro-stratigraphy, these concepts rarely resonate with non-scientists, landowners, land managers and watershed organizations.

For two years the National Trout Center (NTC) in Preston, MN, in cooperation with the Fillmore County Soil and Water Conservation District, have invited trout anglers, local residents and others interested in water quality to collect February base-flow water samples from local water wells and area trout streams and teh SWCD has analyzed teh samples for nitrate-nitrogen at the NTC on a Saturday in mid-February. This longitudinal survey of late winter base-flow nitrates has involved local citizens and provided first-hand evidence of the contaminated status of our shallow karst aquifers, the importance of wetlands for water quality, and the water quality impact on local streams. This citizen science effort, led by professional water resource managers, has received wide coverage and has become part of the foundation for discussing the farming practices responsible for groundwater and surface water contamination in the region. Local participation has both confirmed the observations and hypothesis of the MPCA and MGS scientists and has educated the public about the technical and scientific complexity of the bedrock controlled hydrology of Minnesota's Driftless area. Citizen participation in base-flow nitrate sampling and testing can be used as a model for public involvement in groundwater and surface water management.

(042) Effects of Flooding, Invasion and Nitrogen Addition on Nitrogen Cycling in the Upper Mississippi River Floodplain

Whitney Swanson[1], Nathan De Jager[2], and Eric Strauss[1]

[1] University of Wisconsin-La Crosse River Studies Center; [2] U.S. Geological Survey - Upper Midwest Environmental Sciences Center

Nitrogen (N) additions through atmospheric deposition and agricultural runoff are increasing globally, often with harmful effects on terrestrial and aquatic ecosystems. Floodplain forests can act as effective sinks for nitrogen, with cycling leading to denitrification and atmospheric release of N, which could reduce downstream transport and eutrophication of aquatic ecosystems. However, the ability to remove excess nitrogen efficiently may be altered by invasion of exotic species or increasing nitrogen deposition. We examined the effects of flooding and nitrogen additions on physical soil properties and nitrogen cycling within 2 established vegetation communities (mature silver maple forest and invasive reed canarygrass) in Pool 8 of the Upper Mississippi River floodplain. A series of split plots were established within each vegetation type along an elevation gradient and treated with nitrogen additions throughout the summers of 2013 and 2014 following the end of spring floods. Nitrogen additions were administered to 2x the current ambient N deposition rate per year for the area and were applied in increments following the end of the spring flood with no applications for two weeks prior to any monthly soil sampling event. Differences in physical soil properties were explained best by elevation with the lowest plots maintaining the highest percent organic matter as well as the lowest bulk density throughout the growing season, regardless of vegetation type or time after flooding. Nutrient processes (mineralization and nitrification) and NH_4^+ and NO_3^- availability, however, were best explained by vegetation type and time after flooding. Reed canarygrass plots (with warmer, wetter soils) maintained higher rates of net nitrification (NH_4^+ to NO_3^-) as well as higher concentrations of available NH_4^+ and NO_3^- throughout the growing season. The differences due to vegetation type were consistent on top of the differences due to time after flooding. Fertilization resulted in a decreased soil CN ratio within forest plots in 2014. These results suggest that nitrogen accumulates faster in reed canarygrass soils compared to mature forest soils which can help to better understand the consequences of invasion on floodplain ecosystems. Results also suggest that mature floodplain forests in the UMR may show effects of long term N additions from atmospheric deposition.

(043) Summer Water Quality Associated with Hydrologic Management in Agricultural Streams

Richard Lizotte[1], F. Douglas Shields[2], Martin Locke[1], Jason Taylor[1], and Scott Knight[1]

[1] USDA-ARS National Sedimentation Laboratory; [2] Shields Engineering, LLC

We investigated the influence of water depth on water quality over a three-year period (2011-2013) in three western Mississippi agricultural stream bayous. Water depth during the study period was managed via summer crop irrigation, water impoundment weirs, and beaver (*Castor canadensis*) dam removals. Summer (July-September) water depth and water quality [nutrients, dissolved oxygen (DO), temperature, pH, chlorophyll *a*, Secchi visibility] were assessed in the deepest reach of each bayou when conditions were most stressful to aquatic biota. Average summer water depths across bayous ranged from 0.85 m after beaver dam removal in 2012 and 2013 to 2.04 m after construction of a new water impoundment weir in 2012. Regression analyses with summer nutrients revealed that total nitrogen (TN) increased with increasing maximum daily pH, and decreasing Secchi visibility ($R^2 = 0.328$ $p < 0.01$) while total phosphorus (TP) increased with decreasing water depth and increasing suspended solids ($R^2 = 0.511$ $p < 0.01$) and ortho-phosphate (PO_4) increased with decreasing water depth ($R^2 = 0.430$ $p < 0.01$). For critical summer DO measurements, minimum DO increased with decreasing ammonium and increasing N:P molar ratios ($R^2 = 0.314$ $p < 0.01$) whereas DO diurnal fluctuation increased with increasing chlorophyll *a* and maximum daily temperature, and decreasing water depth ($R^2 = 0.698$ $p < 0.01$). Increases in summer phytoplankton chlorophyll *a* were related to increasing nutrients TN and TP ($R^2 = 0.602$ $p < 0.01$). Increases in summer Secchi visibility were related to decreasing chlorophyll *a* and increasing water depth ($R^2 = 0.517$ $p < 0.01$). Results of this study show bayou water quality impacted by agriculture can be improved by management practices that increase water depth, mitigating eutrophication in agricultural stream bayous.

Keywords: Lower Mississippi Alluvial Plain; Stream bayou; Water depth; Best management practices; Phytoplankton; Nutrients; Dissolved oxygen

(044) Analysis of Nitrogen Balance within the Venice Lagoon Watershed for Better Territory Management

Bruna Gumiero[1] and Bruno Boz[2]

[1] Bologna University, Bologna, Italy; [2] Free-lance consultant

Human activities have caused in recent years a strong alteration of the nitrogen cycle. Furthermore the continuous increasing of the world population have led to an demand for resources and food. The consequence increase of reactive nitrogen input cause the gradual saturation of the terrestrial areas buffering capacity than the increase nitrogen load towards surface and ground waters. The not easy challenge of the new Common Agricultural Policy in Europe (CAP 2014-2020) is to reduce discharges of nitrogen output from the basin and simultaneously increase the productivity of agricultural areas. The ratio between exported and generated N can be considerate an integrate measure of the watershed metabolic capacity toward the reactive nitrogen. The retained N is the result of several processes. Not all very well investigated.

Several actions were carried on by the local government to achieve the reduction target of nitrogen loads delivered to the Venice Lagoon. Within the last Master Plan has been assessed as carrying capacity for the Lagoon 3000 t/year for the nitrogen. Considering that in the last decade the amount of nitrogen load range between 4000 to more than 7000 t/year, is still much work to be done both in increasing the buffer system all over the watershed and improving the efficiency of the existing ones.

In this study has been evaluated the nitrogen balance of Venice Lagoon drainage basin and in addition was reported several monitoring results from buffer system spread all over the basin. The application of this method allows to make some observations on the origin and the end of nitrogen loads. The network of buffer systems located within the basin, are not sufficient to reduce the amount of nitrogen needed to be at least not higher than carrying capacity of the Lagoon. The correlation between rainfall and the amount of nitrogen measured at the close of the basin shows a clear direct correlation between tons of nitrogen per year and millimeters of rainfall recorded. The buffer systems seem to work less in case of high rainfall. Although these are precisely the moments when the nitrogen in the soil waters is more washed away. Also the amount stored in the previous years. So it is of crucial importance to control and reduce this nitrogen peaks. For the above it is need to make the buffer systems more efficient and especially to ensure they be able to work well even in case of high leaching.

Keywords: Nitrogen balance at basin scale, nitrogen buffer systems, Venice Lagoon basin

(045) Rivers of the Anthropocene: The Need for Synergetic, Transformative Science

Andy Large[1], Andy Russell[1], Matt Perks[1], and Helen Berry[2]

[1] School of Geography, Politics and Sociology, Newcastle University, Newcastle upon Tyne, NE1 7RU United Kingdom; [2] School of History, Classics and Archaeology, Newcastle University, Newcastle upon Tyne, NE1 7RU United Kingdom

While still a contested geological concept, the 'Anthropocene' heralds a new epoch in which human intervention and activity, amplified by technology, have become profound and pervasive influences on Earth's environment, climate, and ecology. More than fifty per cent of humanity now lives in cities and major issues include river degradation, sea-level rise and sinking deltas, unsustainable water and land use across catchments, perturbed element cycles and increases in extreme weather events. The world-view of the Anthropocene is no longer one of natural ecosystems with humans disrupting them; rather, we are moving towards a new paradigm of coupled human-natural systems with natural ecosystems tightly embedded within them. Rivers underpin the natural goods and ecosystem services that support biodiversity and livelihoods, and acts as a dynamic conveyer within and between ecosystems. A paradigm shift toward synergetic, transformative science is urgently required to address these complex networks and pressures between coupled natural and human systems to in turn develop a step change in global mitigation strategies for our 'planetary life-support system' and for rivers in particular. There is an urgent need to work collaboratively in ways we have not before in order to achieve more resilient and sustainable river systems through education, behavioural change, environmental remediation, engineering and technological intervention. The incremental shifts that have characterised modern attempts at catchment sustainability have had impact, but negative impacts persist. For transformative change for rivers in the Anthropocene it is essential to build a transdisciplinary evidence base on vulnerability, resilience and adaptive capacity of societies, biodiversity, ecosystems and the services they deliver.

A case study of the River Derwent in northwest England illustrates some of the issues caused by longer-term anthropogenically-driven catchment boundary condition changes. In September 2009 the River Derwent was hit by the largest flood event on record, following the highest single-event rainfall total ever recorded in the UK. There was one fatality and significant flood damage in Cockermouth, the main urban centre in the catchment. While it was expected that the flood-driven geomorphological response would be predictable (pre-event *Google Earth* images showed little sediment accumulation along the river long profile), the reality was markedly different. The River Derwent essentially 'phase shifted', with significant sediment accumulation at a number of 'hotspots'. Research demonstrates the impact of altered boundary conditions through time and the need for new, transdisciplinary research approaches.

Keywords: Anthropocene; floods; ecosystem services; transdisciplinary research; boundary conditions; River Derwent

(046) Microbial Enzyme Activity in the Lower Mississippi River: Temporal Patterns from Hourly to Monthly Time Scales

Jason Payne, Bram Stone, Justin Millar, Colin Jackson, and Clifford Ochs

University of Mississippi, Oxford, MS

Large river systems act as conduits of massive quantities of organic and inorganic materials to the ocean. Bacterioplankton, occurring as free-living cells or attached to suspended particles, produce a suite of extracellular enzymes to degrade large or recalcitrant molecules into diffusible nutrient products. This microbial processing and transformation may have important consequences for the composition of materials eventually discharged at the coast. In this study, we addressed several questions related to microbial biogeochemical processing: (1) Do extracellular enzyme activities (EEA) vary temporally, and over what time scales?; (2) Are free-living and particle-attached cells different in EEA?; (3) What factors influence EEA? Water samples were collected at a site on the LMR 76 river km below Memphis, TN. Sampling took place concurrently over four temporal phases: monthly (February 2013-January 2014, n=12), weekly (June 2013-July 2013, n=7), daily (June 24-July 1, 2013, n=8), and sub-daily (July 2, 2013 from 8:30 am to 7 pm, n=8). Triplicate water samples were collected from 0.5 m in the well-mixed main channel in late morning (except for sub-daily samples). Subsamples were fractionated through 3-µm and 0.22-µm pore size filters to remove larger suspended particles and cells, respectively. Potential EEA (µmol h^{-1} L^{-1}) of six enzymes important in C, N, and P processing were measured in bulk water, 3-µm filtrates, and 0.22-µm filtrates (dissolved EEA). In addition, we measured bacterial production (BP), and dissolved and particulate organic C, total N and total P. EEA for all enzymes was highly variable in time, and often as variable over short time scales (daily and sub-daily) as it was over longer time scales (weekly, monthly). However, there were substantial differences in activities of different enzymes: Leucine aminopeptidase and phosphatase had the highest activities, up to an order of magnitude greater than the other four enzymes. Although similar in overall activities, the temporal patterns of these two enzymes were dissimilar, with phosphatase consistent in mean values across all time scales, and leucine aminopeptidase notably lower in summer than at other times of year. Furthermore, both EEA and BP associated with particles were consistently greater than for free-living cells or in cell-free water. These results indicate that organic matter degradation was performed primarily by suspended, particle-bound bacterioplankton, and suggest that to evaluate biogeochemical processing in large river systems our focus should be on these microhabitats.

(047) The Need for Fine-Grained Analyses to Identify the Structures and Processes Intervening in River Ecosystem Services. Operational Perspectives

Thierry Tormos[1], Kris Van Looy[2], and Yves Souchon[3]

[1] French National Agency for Water and Aquatic Environments, France; [2] National Research Institute of Science and Technology for Environment and Agriculture, Department of Waters, France; [3] IRSTEA, Laboratoire d'Hydroécologie, Villeurbanne, France

The Ecosystem Services (ES) framework is much enrolled nowadays, yet remains problematic on the one hand due to the complexity of the conceptual approach developed (distinguishing provisioning, regulating and cultural services) and on the other hand due to the over-simplicity entered with valuing (pricing) non-valuable things. Especially the dynamics and interaction of ecological and societal ES needs more attention. Most studies to managerial questions use ES frameworks developed for status assessment, even in a more operational context without questioning its applicability in spatially and temporally dynamic contexts. Furthermore, due to the complexity, mostly a single process is investigated within the wide array of intervening processes. Even though some straightforward aspects in spatial and geographic context might arise, most ecosystem processes involved are highly complex and need fine-grained analysis and many biotic and abiotic factors entering the analysis.

We will point out some caveats for using ES frameworks in operational contexts of restoration strategies from a riparian ecosystem services exploration. Riparian ecosystems play a critical role in strategies for ES provision and climate change adaptation. Riparian forests are generally assumed to deliver services to both the aquatic and terrestrial ecosystem and particularly to nutrient retention in stream networks. Furthermore, they are associated to natural floodplains delivering multiple regulating (flood protection, nutrient cycling, sediment retention), provisioning (timber production, carbon sequestration) and cultural services. Still, strong disparities in proposed strategies exist when ES frameworks are applied to their restoration. Most quantitative studies are either very local, or too coarse scale analyses that lack confidence to the identification of abiotic drivers. We question the spatial-temporal contexts of ES provision for riparian corridors; whether the upstream or downstream basin context prevails for nutrient retention, whether the configuration and specific rate/scale of ruptures is crucial in the processes, whether riparian or in-stream measures are most effective, and whether biotic responses can be predicted. We present an ES framework that deals with these aspects in a dynamic basin-wide context, highlighting the necessary fine-grained analysis and high-resolution data required to answer these questions.

(048) Is The Capacity for River Networks to Deliver Ecosystem Services Affected by Network Structure

Michael Stewardson[1] and David Gilvear[2]

[1] Department of Infrastructure Engineering, University of Melbourne, Australia; [2] Plymouth University, United Kingdom

River networks support ecosystem service flows by connecting provisioning (i.e. the hillslope) and benefitting areas downstream along the river network. The spatial flow of potential ecosystem services through the river network is rarely a direct transfer because river ecosystem processes modify potential benefits by affecting downstream transport, transformation and retention of water, sediments, energy, nutrients, contaminants and other material. To be effective, the analysis of river ecosystem services needs to address the significant complexities of riverine macrosystems, and in particular large spatial connections and multi-scale temporal and spatial variability.

This study develops a model for evaluating the capacity for river networks to deliver ecosystem services considering the effects of river type and network structure. This model is applies this to three idealised river patterns described as: dendritic inland network; dendritic coastal network; and a trellis network. Results show that network structure has an important effect on ecosystem services including water supply, hydropower generation, fine sediment retention, flood attenuation and physical habitat provision. This study suggests that the capacity of river basins to deliver ecosystem services varies with basin morphometry. This may by critically important in planning river basin development and restoration.

(049) Successional Dynamics of Submerged Aquatic Vegetation – Restoration, Resiliency and Response to Flooding

Andrew F. Casper[1], Todd D. VanMiddlesworth[1], and Nerissa N. McClelland[2]

[1] Illinois Natural History Survey, University of Illinois Champaign-Urbana, Urbana, IL, USA; [2] Division of Fisheries, Illinois Department of Natural Resources

Prior to start restoration the former floodplain lake complex at Emiquon had been disconnected from the Illinois River and in continuous agricultural production for more than 70 years. In 2007 a set of low-impact actions were undertaken, mainly floodplain inundation by precipitation without either mechanical landscaping or planting, that resulted in establishment of robust submerged aquatic macrophyte (SAV) beds within 2 years. By 2014 more than 19 plant species were being consistently collected, including several that are rare in the rest of river. At different times during this restoration, there have been several shifts in species dominance and exposure to invasive aquatic plants, common carp, elevated depth and turbidity, and unmanaged flooding. Despite these stresses the amount of SAV and its taxonomic richness and evenness have consistently improved through time, even to the point of receiving RAMSAR designation in 2010. This is evidence that large floodplain wetland restoration projects (<2800 acres of aquatic habitat) and their potential system wide benefits are achievable. The influence of common carp, turbidity, and lack of seasonal water level fluctuations are potentially limiting some aspects of rehabilitation. However, some level active water level management is being added in 2015 to ensure that succession does not continue past the SAV rich stage to a less desirable open water stage.

(050) Biocontrol of Invasive Fish Species Using Native Predators in a Large Floodplain River Restoration

Todd D. VanMiddlesworth[1], Andrew F. Casper[1], and Nerissa N. McClelland[2]

[1] Illinois Natural History Survey, University of Illinois Champaign-Urbana, Urbana, IL, USA; [2] Division of Fisheries, Illinois Department of Natural Resources

Floodplains provide many ecosystem services including biodiversity, fish and wildlife refuge, flood-peak reduction, shoreline stabilization, groundwater recharge, sediment accretion, nutrient uptake, as well as recreational, educational, research, economic, and aesthetic services. River connectivity is critical for maintaining ecosystem integrity and services. The Illinois River is one example of a productive floodplain river system, but its natural biological productivity has changed through floodplain disconnection, elevated nutrient inputs, and invasive fish species introductions. Currently, floodplain restoration efforts are intended to benefit and improve the Illinois River, as well as others throughout the Midwest. The Nature Conservancy's (TNC) Emiquon Nature Preserve serve as one example and have sustained a diverse (10 species) and abundant native submersed aquatic vegetation (SAV) community that is otherwise difficult to find within the Illinois River Valley today. As the diversity and plant density increased since restoration, so has the species richness and biomass of native fishes. However, the disruptive Common Carp *Cyprinus carpio* is also present in the Emiquon Preserve and management is critical for maintaining balance in aquatic ecosystems. Because rotenone is not 100% effective, additional research on Largemouth Bass *Micropterus salmoides*, Bowfin *Amia calva*, and Gars *Lepisosteus* has been conducted and suggested that they cannot control Common Carp population growth through direct predation. Additionally, research has been conducted to assess how the aquatic vegetation and fish communities respond to river connection and natural flood events. The knowledge gained from this research will continually serve useful for the Emiquon Preserve and future floodplain restoration projects.

(051) The Response of Emergent Marsh and Wetland Vegetation During 8 Years of Restoration: Implications for Essential River Floodplain Habitat

Christopher S. Hine, Heath M. Hagy, Michelle M. Horath, Aaron P. Yetter, and Joshua M. Osborn

Illinois Natural History Survey, Forbes Biological Station

Since the early 1900s, the Illinois River valley has encountered substantial wetland loss through conversion of large portions of its floodplain to drainage and levee districts for agricultural production. Emiquon Preserve (Emiquon) is a restored wetland complex isolated from the Illinois River within a drainage and levee district. We monitored the response of wetland vegetation communities to restoration at Emiquon during 2007–2014. Spatial extent of wetland vegetation and other cover types grew rapidly, and vegetation communities developed throughout restoration with little supplemental planting or hydrological manipulation. Emiquon produced aquatic plant communities that were nearly eliminated from wetlands connected to the Illinois River, such as floating-leaved and submersed aquatic vegetation. We suggest restoration efforts targeting aquatic macrophytes in highly-altered river systems should consider floodplain areas with sufficient infrastructure to retain isolation from the deleterious effects of river-floodplain connectivity.

(052) The Response of Waterfowl Abundance and Diversity to Floodplain Habitat Restoration

Heath M. Hagy, Christopher S. Hine, Heath M. Hagy, Aaron P. Yetter, Michelle M. Horath, and Joshua M. Osborn

Forbes Biological Station, Illinois Natural History Survey

Floodplains of large river systems in the Midwest are often disconnected or partially disconnected from flood waters for the benefit of agriculture, urban development, and managed natural resource management. Many of these rivers are drastically altered from their natural state to allow commercial navigation, recreation, and managed flows. In these altered systems, tradeoffs in ecosystem services exist between connected floodplains and disconnected floodplains. We will present data from two case studies on the Illinois River of central Illinois that illustrate the tradeoffs in biotic communities, especially waterbirds, using floodplains that have been connected hydrologically and those that are isolated behind levees. Wetland birds, fishes, and vegetation all respond differently to floodplain connectivity and management objectives must be considered carefully prior to restoring hydrologic connections between floodplains and highly altered river systems.

(055) The Fourth Upper Mississippi River – Restoration, Monitoring, and Research

Marvin Hubbell[1]

[1] U.S. Army Corps of Engineers, Rock Island District, Rock Island, IL, USA

As described in the book, The River We Have Wrought by John Anfinson, the establishment of the Upper Mississippi River Restoration Program (UMRR) "…emerged from the largest battle between navigation interest and environmental organizations in the upper river's history." And, declaration of the Upper Mississippi River System (UMRS) as both a nationally significant ecosystem and a nationally significant navigation system was a means for Congress to "…direct the parties to divide the (financial) pie" on the UMRS.

The Water Resource Development Act (WRDA) of 1986 was the legislative vehicle that established these two unique designations. Creation of UMRR (previously referred to as the Environmental Management Program) made it the first comprehensive large river ecosystem restoration, monitoring, and research program in the United States and ushered in what John Anfinson refers to as the "fourth upper Mississippi River…". Declaration of the UMRS as both a nationally significant ecosystem and a nationally significant navigation system makes it the only large river system in the United States to receive such a designation.

The political climate that created UMRR lead to a provision in WRDA1986 that directed the Corps of Engineers to consult with the natural resource agencies from the five states, the Department of Interior, and other federal agencies in the implementation of UMRR. The result was creation of a Coordinating Committee, development of a working relationship with nine other UMRS groups, and working relationships with numerous NGO's and the public. This regional partnership has evolved into a highly effective regional entity, and to date, UMRR has invested more than $510,000,000 in restoration and scientific efforts in the five state region. In addition, state and federal partners have contributed more than $32,000,000 in support of the UMRR.

Not only did UMRR pioneer environmental restoration for this and other larger river systems, it is truly unique in that it combines the ability to design and construct large and small scale river rehabilitation projects with the ability to monitor and research key environmental attributes of the UMRS. Both Program elements have increased our understanding of the river and have helped refine restoration techniques.

UMRR's authorized boundary covers 1,200 miles of navigable rivers within the UMRS, including 2.7 million acres of floodplain, and is helping to restore and protect the world's 3rd largest watershed. Since 1986, UMRR has benefitted approximately 102,000 acres of critical habitat through the completion of 55 habitat rehabilitation projects. In addition, UMRR has collected data on key environmental attributes of the river in six key pools within UMRS.

This presentation will highlight the vision, key efforts and future direction of the UMRR and working relationship with navigation interest to manage the UMRS as both a nationally significant ecosystem and a nationally significant navigation system

Key Words: Large River Restoration, Mississippi River, River Policy, Large River Monitoring

(056) Diversifying Habitat in the Lower Mississippi River

Jack Killgore[1], Paul Hartfield[2], Angie Rodgers[3], and Barb Kleiss[4]

[1] US Army Engineer Research & Development Center; [2] U.S. Fish and Wildlife Service; [3] Lower Mississippi River Conservation Committee; [4] USACE, Mississippi Valley Division

The Lower Mississippi River (LMR) extends over 950 miles from the confluence of the Ohio River to the Gulf of Mexico. In response to the 1927 flood, the Mississippi River and Tributaries (MR&T) project was initiated by the U. S. Army Corps of Engineers (USACE). The project consists of levees, revetments, flood storage reservoirs, and floodways to reduce flood risk, as well as dikes, and other river training structures in the channel to facilitate low-water navigation by towboats. The construction of the Mississippi River levee system altered natural patterns of surface water drainage within the region and reduced the floodplain by over 80%. Channel engineering for navigation over the past 30 years has resulted in a gradual but significant loss of secondary channels and in the area of associated seasonally flooded in-channel habitats in the LMR. It became apparent that the very programs that have most significantly affected the river are potentially the most important and cost-effective tools to maintain and enhance its ecological functions. This is accomplished by considering and incorporating ecological engineering opportunities during the design and construction phase of river training structures. For example, over 30% of the wing dikes along the main channel have been notched and the flow in over 40 miles of secondary channel habitat has been enhanced by notching closing structures. These projects have shown no negative effect to the USACE's primary missions of flood damage reduction and provision of a safe, stable commercial navigation channel. In addition, monitoring of the three endangered species (Pallid Sturgeon, Least Tern, and Fat Pocketbook Mussel) in the LMR associated with habitat restoration measures has shown positive benefits. Most projects are the result of collaboration among federal agencies and have been documented in a Section 7(a)(1) Conservation Plan of the Endangered Species Act. The Conservation Plan led to a non-jeopardy Biological Opinion for the three endangered species by the U.S. Fish and Wildlife Service demonstrating how federal agencies can work together to implement ecosystem restoration measures in a non-confrontational manner.

(057) Incorporating Long-Term Remote Sensing and Discharge Datasets to Characterize Sandbar Dynamics of Central U.S. Rivers

Edward Bulliner, Caroline Elliott, and Robert Jacobson

U.S. Geological Survey Columbia Environmental Research Center, Columbia, MO

Sandbars and associated channel morphological features in sand-bedded rivers of the Central U.S. are important habitats for a variety of avian, fish, and invertebrate species. Many such rivers are regulated by reservoirs and channel engineering structures which alter channel morphodynamics. A better understanding of sandbar dynamics, particularly with respect to varying hydrology, may lead to improved management actions to mitigate some ecological impacts of these large-river alterations. Sandbars on these rivers are highly dynamic and change substantively across multiple temporal and spatial scales, making full characterization at the landscape scale challenging. Quantifying changes to sandbars over time is confounded by varying river stage, which alters the area of a given sandbar visible above water. The assessment of landscape scale trends in large river features over time requires datasets with relatively high temporal resolution and long periods of record covering large geographic areas, and remotely-sensed datasets must also consider changes in river stage. To address these issues, we incorporated Landsat thematic mapper (TM) Climate Data Record (CDR) surface reflectance data with river discharge records to characterize sandbar dynamics for large rivers of the Central U.S. over a nearly 30 year (1982-2011) period of record. Available since 2014, Landsat CDR data, for Landsat TM imagery, have undergone additional post processing compared to standard Level 1 Landsat products, and can provide better classification of surface features. We developed a database to integrate this imagery data with river discharge records, primarily from USGS gages. The database reports a daily average discharge for each segment of a river in a given Landsat image. River segments were identified as lengths of rivers between major tributaries with available discharge data for the Landsat TM period of record. We conducted geospatial analyses to identify areas of overlap between river segments and Landsat world reference system path-row (WRSPR) grid cells for which Landsat images were regularly recorded at a 16 day return interval. These overlaps were used as the basis to join discharge data to individual Landsat images. Furthermore, we included features in the database to track images that were unusable for given analyses due to cloud or ice coverage. Using a classification ruleset, we have identified and classified over 16,000 unique combinations of river segment (with associated discharge) and applicable Landsat images. This analysis provides time series of sandbar areas for rivers accounting for varying river discharges. Further geospatial analysis allows for the quantification of relations between sandbar characteristics and channel morphology. Our database can also be queried and sorted by images for a given discharge or date range. For example, we have used this feature to identify peak discharges during the time-series and to measure sandbar and river channel change at comparable discharges before and after flood events. This work showcases the power of integrating long-term, large-scale datasets from different sources using modern software tools to enhance understanding of large-river ecology.

(058) Spatially Extensive, Long-Term Data Provide Insights into the Ecological Structure and Function of the Upper Mississippi River

Jeffrey Houser, Nathan De Jager, Brian Ickes, James Rogala, and Yao Yin

U.S. Geological Survey - Upper Midwest Environmental Sciences Center

The Upper Mississippi River (UMR) and its floodplain comprise a highly productive ecosystem that supports abundant and diverse fish and wildlife. Despite extensive modifications, the upper reaches of the UMR remain hydrologically connected with the floodplain, and provide a remarkable opportunity to study the structure and function of a large, floodplain river. The Upper Mississippi River Restoration Long Term Resource Monitoring element has collected data in diverse aquatic areas (e.g., main and side channels, and backwaters) across six study reaches distributed over 1300 km of the Upper Mississippi and Illinois Rivers for more than 20 years. These data demonstrate a diversity of spatial and temporal patterns in nutrients, suspended material, and the abundance, production, and community composition of biota. These patterns provide insights into structure and function of a large, floodplain river. Three examples follow. First, there has been a long-term decline in suspended solids in the upper study reaches of the UMR. This decline appears associated with declines in tributary input and increases in aquatic vegetation in backwater areas. Coincident with these changes, patterns in the contrasts between main channel and backwater suspended solids concentrations have changed; when backwater vegetation was relatively scarce, backwater suspended solids concentrations often exceeded those of the main channel during summer, but in study reaches where vegetation has become more abundant in recent years, the opposite pattern has been observed. Second, spatial and temporal patterns indicated fundamental differences in nitrogen (N) and phosphorus (P) cycling. Maximum N concentrations are generally observed during spring and in the main channel whereas maximum P concentrations often occur during summer and in floodplain backwaters. These patterns reflect that backwaters are generally an area of nitrogen loss (via denitrification and biotic uptake), but P recycling (via sediment P release). A result is that during summer, P concentrations are often high and N concentrations low—a condition that has been shown to be favorable for blue green algal abundance. Blue green algal blooms have occurred in both backwater and channel areas of the river. Third, in the northern study reaches, some long-term changes in the fish communities reflect changes in vegetation abundance and distribution, whereas in the southern study reaches, the dominant driver of fish community change has been the proliferation of invasive Asian carps. These patterns provide insights into likely mechanisms and pathways of nutrient cycling and biotic production in the river, and illustrate the utility of data collected across large temporal and spatial scales for improving our understanding of the ecology large floodplain rivers.

(059) Temporal Trends in Water Quality and Biota in Segments of Pool 4 Above and Below Lake Pepin, Upper Mississippi River: Indications of a Recent Ecological Shift

Walt Popp, Robert Burdis, Steve De Lain, and Megan Moore

Minnesota DNR, Upper Mississippi River Restoration – Long Term Resource Monitoring Program, Lake City, MN

High suspended sediment loads from agricultural tributaries and the sediment trapping efficiency of the riverine Lake Pepin have together created a navigation pool unlike any other in the Upper Mississippi River with upper and lower segments that are sharply dissimilar with regard to turbidity and aquatic vegetation. This study used 19 years of water quality, aquatic vegetation and fish data from the Upper Mississippi River Restoration - Long Term Resource Monitoring Program to better understand the relationships among the biota, hydrology, and physical/chemical habitats in upper and lower Pool 4. We present evidence indicating a recent ecological shift in both upper and lower segments of Pool 4. Decreases in discharge, water elevation and total suspended solids during the period 2005-11 drove increases in aquatic macrophytes which resulted in a shift in the fish community toward more vegetation-associated species in both segments of Pool 4. The results observed in this study demonstrated that degraded habitat and biota could be ameliorated through long-term improvements in water quality and restoring a more natural hydrograph through water level management.

(060) The Joint Danube Survey – Selected Results on River Water Quality

Thomas Hein[1], Elisabeth Bondar-kunze[1], Igor Liska[2], Nina Welti[3], and Tz-Ching Yeh[1]

[1] WasserCluster Lunz & University of Natural Resources and Life Sciences, Vienna; [2] International Commission for the protection of the Danube River; [3] University of Eastern Finland, Kuopio Finland

The Third Joint Danube Survey took place in 2013. The aim of the JDS was to achieve a consistent assessment of the Danube River situation including hydromorphological, chemical and biological measurements and assessments. Large rivers such as the Danube are controlled by various human impacts such as land use change, channelization and pollution in the catchment. The resulting water quality is the results of the interaction of these factors. A key ecosystem property is the composition of DOM, controlling microbial degradation and reflecting various processes along a river continuum. In line with these observations also the Danube receives significant dissolved organic matter (DOM) inputs from human activities and terrestrial sources and in selected river sections they also show in-stream production of DOM. The resulting DOM pools are a heterogeneous mixture controlling further biological activity. Key questions address how different fractions change along the course of this large river and which inputs and processes best reflect the identified patterns for different sections. Of special interest are the anthropogenic modifications in some sections of the Danube on the DOM pool (e.g. disconnection of side-arms, drying of wetlands, constructing dams and reservoirs). During the third Joint Danube Survey in August and September 2013 the first time DOM properties were investigated along a 2600 km stretch of the Danube River by taking 3 samples roughly every 50km in the main channel and sampling the major tributaries. Optical properties of DOM, DOC concentrations and a variety of different DOM indices showed clear longitudinal patterns and distinct differences for some sections and indicate the shifting dominance of human inputs, terrestrial catchment sources and in-river sources of DOM. We present potential drivers for the changes in DOM and discuss consequences of observed changes.

(061) Cadss: A Decision Support Tool for Prioritizing Fish Passage Projects

Craig Roghair[1], C. Andrew Dolloff[1], Scott Klopfer[2], and Dawn Kirk[3]

[1] USDA-Forest Service; [2] Conservation Management Institute-Virginia Polytechnical Institute; [3] George Washington and Jefferson National Forests

The crossing assessment decision support system (CADSS) is an add-in for ArcMap containing a suite of tools developed to assist managers with prioritization of aquatic organism passage improvement projects at road-stream crossings. Currently there are two prioritization tools: the Watershed Prioritization Tool (WPT) and the Crossing Replacement Tool (CRT). The tools use geographic, physical, and biological data in combination with user-defined criteria to develop a list of high priority hydrologic units and a list of high priority crossing replacements within hydrologic units, typically 12-digit HUCs. Several other tools are included to assist with data editing tasks. Here we provide a brief overview of the CADSS tools and demonstrate the application of CADSS tools in an analysis of a high priority watershed on the George Washington National Forest, VA, USA.

(062) Accessibility of Restored Side-Channel Chutes on a Large, Regulated River

Susannah Erwin[1], Robert Jacobson[1], Caroline Elliott[1], Craig Fischenich[2], and Todd Gemeinhardt[2]

[1] US Geological Survey; [2] US Army Corps of Engineers

River restoration projects that do not address barriers to connectivity may have limited success if species of concern are unable to access the full range of habitats required to complete their life cycles. Such is the case on many large rivers, such as the Missouri River, USA, which has been extensively modified for the purposes of navigation, power generation, water supply, and flood protection. These changes have been implicated in the decline of native fishes, including the endangered pallid sturgeon. A key component of the Missouri River Recovery Program has been the construction of shallow water habitat (SWH); areas of low velocity and shallow depth are thought to be important for larval retention, food production, and foraging but are largely absent from the modern river. Although the construction of SWH has emphasized the total area of constructed habitat, recent focus has shifted to include the issues of accessibility and connectivity of restored features. We present the results of hydroacoustic surveys, hydrodynamic models, and particle tracking simulations conducted to evaluate the potential for interception and retention of drifting larval fish within constructed side-channel chutes. We find that although some restored reaches provide what is thought to be quality habitat they are relatively inaccessible, whereas other constructed chutes are well-connected to the navigation channel but it remains unclear whether these features provide functional habitat. The work highlights issues of lateral and longitudinal connectivity that are important in large river restoration and provides information for future recovery actions on Missouri River.

Keywords: River restoration; connectivity; fish habitat; shallow water habitat; Missouri River.

(063) Prioritizing Conservation Strategies with Web-Based Watershed Connectivity Tools

Kyle McKay

US Army Corps of Engineers

Dams, road crossings, and water diversions often fragment watersheds for migratory and resident fishes. The cumulative effects on fish passage of many structures along a river are often substantial, even when individual barriers have negligible impact. Habitat connectivity can be improved through dam removal or other means of fish passage improvement (e.g., ladders, bypasses, culvert improvement). However, environmental managers require techniques for comparing alternative fish passage restoration actions at alternative or multiple locations. A family of techniques based on network analysis and graph theory is emerging for assessing watershed connectivity and prioritizing restoration actions. When coupled with numerical solvers (e.g., optimization algorithms), connectivity restoration strategies may be developed for large geographic regions. While proving powerful for assessing basic research questions and applied restoration problems, these methods often require significant geospatial and numerical modeling expertise. This presentation will address ongoing efforts to reduce the technological hurdles for watershed-scale connectivity assessments with a web-based toolkit.

(064) A Decision Support System for Managing Aquatic Connectivity in the Great Lakes Basin

Matthew Diebel[1], Thomas Neeson[2], Allison Moody[2], Margaret Guyette[2], Patrick Doran[3], Michael Ferris[2], Peter Mcintyre[2] and Jesse O'Hanley[4]

[1] Wisconsin Department of Natural Resources; [2] University of Wisconsin – Madison; University of Wisconsin - Madison, [3] The Nature Conservancy; [4] University of Kent, Canterbury, England

Tributaries to the Great Lakes are highly fragmented by dams and road crossings that act as potential barriers to migratory fishes, restricting their access to historical riverine spawning grounds. There is growing investment in removing or modifying barriers to restore native fish migrations and ecosystem function, but these efforts may also increase available habitat for invasive species like sea lampreys. The restoration community lacks a systematic method for comparing these costs and benefits to assess which barrier removal projects would offer the greatest return on investment. To address this problem, we developed a basin-scale mathematical optimization model to prioritize barriers for removal on the basis of upstream breeding habitat for both native and invasive fishes. We parameterized this model using a recently developed database of dams and road crossings; economic models of projected barrier removal costs; and historical data describing distributions of native and invasive species. In realistic funding scenarios, coordinating investments across geographic and political boundaries, and concentrating funds to complete large projects dramatically increases the efficiency of connectivity restoration. While dam removals make up a larger fraction of projects in early phases of investment, road crossing reconstruction projects gain importance quickly. We are currently building a web-based decision support system to allow stakeholders to browse and edit barrier data, and to construct and submit their own decision-making scenarios for optimization. Scenarios may include several types of constraints, including the ability to exclude certain barriers, budget limitation, and geographic and species focus. The interface includes several ways of reviewing optimization results, including maps, tables, and charts comparing the relative benefits of multiple scenarios for the fish community as a whole and for individual species. We hope that this tool will become an integral part of managing the Great Lakes ecosystem, and may serve as a model for similar efforts elsewhere.

(065) Linking Indigenous Knowledge and Science in River Management: A New Zealand Case Study

Kevin Collier[1], Maui Hudson[1], John Quinn[2], John Te Maru[3]

[1] University of Waikato; Waikato, New Zealand; [2] National Institute of Water & Atmospheric Research, New Zealand; [3] Waikato-Tainui College of Research & Development, New Zealand

Rivers provide essential services to human societies, including indigenous peoples who have spiritual connections to and obtain sustenance from waterways. Many indigenous peoples, including Maori in New Zealand (Aotearoa), assert rights in relation to water, and advocate for the inclusion of indigenous knowledge into policy and management frameworks. The Waikato River, New Zealand's longest river, demonstrates the value of integrating indigenous perspectives into management aimed at providing more holistic and enduring social and environmental outcomes. A settlement between river tribes (Iwi) and the Crown led to the formation of the Waikato River Authority charged with co-ordinating a clean-up to restore the health and wellbeing of the Waikato River in partnership with Iwi. A national policy statement for freshwater now recognises the role of Māori communities in decision-making and acknowledges the potential for indigenous knowledge (matauranga Maori) to inform the management of freshwater. To support this policy, a national objectives framework explicitly recognises Maori values, including traditional food-gathering practices. Report cards are being developed to monitor progress towards restoration targets for food species in the Waikato River, supported by research to predict outcomes of catchment management by testing approaches that link science and indigenous knowledge. Logic wheels and Causal network diagrams for focal species have been developed by scientists and an advisory group to help identify key factors that influence desirable states for traditional food-gathering. We demonstrate how these tools are being used to integrate matauranga Maori from local communities into management frameworks for the Waikato River, and to understand environmental limits required to sustain values. The New Zealand experience illustrates the challenges of integrating different value sets and knowledge traditions as part of river management.

(066) The USGS Midwest Region Large River Initiative: An Update on Current Activities

Robert Swanson[1], William Richardson[2], Robert Jacobson[3], Jessica Garrett[4], and Ronald Zelt[1]

[1] U.S. Geological Survey, Nebraska Water Science Center; [2] U.S. Geological Survey, Upper Midwest Environmental Sciences Center; [3] US Geological Survey Columbia Environmental Research Center; [4] U.S. Geological Survey, Iowa Water Science Center; U.S. Geological Survey, Nebraska Water Science Center

Connectivity is a fundamental concept in river ecology and refers to opportunities for water, biota, and water-borne constituents to flow along and through riverine ecosystems. Connectivity is considered one of the primary drivers of river productivity, biological diversity and ecosystem health. Dimensions include: lateral connectivity; longitudinal, vertical connectivity, and the temporal dimension. Connectivity is also a property that relates to flooding, flood hazards, and flood risk; it can therefore serve as a central theme in evaluations of trade-offs between ecosystem and socio-economic services in river corridors.

In 2013, USGS Midwest Region scientists began development of a scientific framework to quantify connectivity in large-river ecosystems. Ecosystem connectivity was selected as the central concept for the Large River Initiative (LRI) because of the extensive interest of natural resources managers in the topic and its timeliness and applicability to societal issues along most Midwestern large river reaches. The LRI builds on earlier successes of the USGS Midwest Region's River Sediment and Nutrients Investigations, which developed tools and methods for scientists and managers.

Three reaches on large rivers in the Midwest were selected to further develop strategies for understanding the complexities of river ecosystems. The Maquoketa-Mississippi reach, the Niobrara-Missouri reach, and the Lower Missouri reach each are representative of issues and ecosystem processes that water and river restoration managers are struggling to understand. Scientists have conducted stakeholder meetings and are developing work plans and objectives that will guide future research at the landscape scale.

Keywords: Upper Mississippi River, Missouri River, ecosystem services, connectivity, ecological inundation model

(067) A Reservoir Operating Approach to Balance Economic Development and Biodiversity Protection in River Systems

Zhihao Xua, Zhifeng Yanga, and Xinan Yina

State Key Laboratory of Water Environmental Simulation, School of Environment, Beijing Normal University, Beijing, China

Reservoir operation in river systems is a global hot topic, needing to consider both economic development and river ecosystem protection. A satisfactory balance between economic development and biodiversity conservation is difficult to be obtained, because it is generally thought that more water discharges from reservoirs lead to better river biodiversity while worse economic benefits. However, from the perspective of migratory fish, this study proposes that more water discharges do not always result in better biodiversity and over discharge may even bring negative effects on river biodiversity. Migratory fishes are important components of river biodiversity, putting forward a strict requirement to river flow discharge. The discharge should be no lower than the minimum acceptable value to trigger fish migrating and provide guide flow; whilst it should be no higher than the maximum acceptable value to ensure that the swimming ability of migratory fish is strong enough for them passing through the high flows. In this study, we analyze the flow requirements of various migratory fishes and propose an acceptable flow discharge for protecting migratory fishes in a river. Then a relationship between specie richness and flow discharge is developed based on the actual measured data, considering the effects of flow discharge on migratory fishes. The relationship offers a tool to assess the effects of reservoir's water discharge on river biodiversity. After that, we build a calculation system for economic benefits of water resources. Water resources in reservoirs are mainly used for hydropower generation, agricultural irrigation, industrial production and domestic utilization. We consider the economic benefits of water resources from these four aspects and develop a relationship between water consumption and its economic benefits, which is used to assess the effects of flow discharge on economic benefits of reservoirs. Through combining the specie-discharge and benefit-discharge relationships, a multi-objective optimization model is developed for directing reservoir operation. The model has two objectives including maximizations of economic benefit and species richness. Two weighting coefficients are respectively set for the two objectives, which are determined based on the requirement of managers. In the case of this study, we create three scenarios based on different requirements of managers, including giving priority to economic benefits, giving priority to biodiversity protection, and giving equal status to the two objectives. An optimal operating scheme is proposed in each scenario to balance economic development and biodiversity protection in the river system. This study puts forward a new specie-discharge relationship in rivers and develops a multi-objective optimization model for directing reservoir operation, which offers a useful reference for future reservoir management and river ecosystem protection.

Keywords: flow discharge; species richness; migratory fish; economic benefits; river management

(068) Upstream Reservoir Release Plan for the Ecological Restoration of Downstream Rivers and River-Connected Wetlands

Ying Yang, Zhifeng Yang, and Xin'an Yin

State Key Laboratory of Water Environmental Simulation, School of Environment, Beijing Normal University, Beijing, China, 100875

Reservoirs facilitate water supplies for the growing demands of urban, agricultural, and industrial development. Meanwhile, it has long been established that dramatic changes of the flow regime below reservoirs can severely degrade the associated riverine and wetland ecosystems. To minimize the negative impacts of reservoirs on aquatic ecosystems, the importance of maintaining environmental flow is widely recognized by scientists and managers, and numerous approaches have been developed for determining sustainable environmental flow in different ecosystems. However, a river and its connected wetlands should be regarded as an ecosystem, and environmental flow management schemes should considered the river and its connected wetlands simultaneously. Besides, in most present research, the water allocated to satisfy ecosystem requirements was originally calculated based on the need to release the minimum environmental flows from reservoirs. Although minimum environmental flow is considered as a simple and measurable metric to compare ecological objectives with other potentially conflicting users in water allocation, it is difficult to restore and preserve the whole integrity of downstream ecosystems. In this study, a new framework was proposed to develop the sustainable environmental flow release plan with an emphasis on the protection of ecosystem integrity. First, a structurally dynamic model (STDM) based on nutrient cycling within the food web was established to analyze the major hydrological and ecological processes in ecosystem. Second, a holistic ecological indicator eco-exergy was used for characterization of ecosystem integrity according to the model results of STDM. Third, a generalized additive model was applied to examine the interrelations among eco-exergy values and flow regime alterations. Last, an optimization model was developed to determine the required release of environmental flow, and the adaptive genetic algorithm approach was applied to solve the model. Scenario analysis then provided a range of potential release strategies for maintaining environmental flow. Effectiveness of this framework was tested with a case study in the Baiyangdian wetland basin, China. Over last decades, Baiyangdian wetland has become a semi-closed water body with few natural inflows due to flow regulation by upstream reservoirs. Results show that to protect Baiyangdian ecosystem at the optimal status, water release from reservoirs should range from 6.99×10^8 m^3 in wet years to 12.30×10^8 m^3 in dry years; and to protect ecosystem at acceptable status, water release from reservoirs should range from 3.35×10^8 m^3 in wet years to 5.94×10^8 m^3 in dry years. The optimal results are helpful for the managers to establish sustainable environmental flow management schemes for the river system restoration and preservation.

Key words: environmental flow; water release strategies; ecosystem restoration; structurally dynamic model; optimization model.

(069) Potential Impacts of Commercial Navigation in a Pristine River, the Tapajos, in the Brazilian Amazon

Edenise Garcia and Gretchen Benjamin

The Nature Conservancy

Located in the middle of the Amazon basin, the Tapajos is a main tributary of the Amazon River and one of the most intact riverine systems in the world. Large blocks of natural pristine terrestrial landscapes and undammed free flowing rivers make the Tapajos River Basin an important ecological corridor. Approximately 61% of the basin is covered by large blocks of rainforest, and 7% is covered by remaining savannah spots; a total of 42 indigenous lands and 30 conservation areas are located in the basin. The Tapajos River harbors a diverse fauna, but biodiversity information is still relatively limited. For example, in terms of ichthyofauna, 324 fish species are currently recognized, 65 of which are endemic; but during the last 10 years alone, 35 new endemic species have been described, suggesting that the diversity is far higher than previously estimated and far from being completely catalogued. However, the Tapajos River Basin is becoming a confluence zone of agribusiness expansion (e.g. large-scale cattle-ranching and mechanized agriculture) and infrastructure development. As part of the Brazilian Energy Expansion Plan, 40 large hydropower dams on the main rivers and 52 small and micro dams are being planned in the Tapajos and its tributaries. Additionally, soybean production, which already occupies most of the savannah southern portion of the basin, is expanding towards the rainforest, in the north. This expansion and the opportunity for more economical transport by barge is boosting large investments in port facilities and navigation in the Medium and Lower Tapajos, and will facilitate the flow of grains to exportation. Currently, there is one grain terminal constructed along the Tapajos River with nine more planned and in various stages of the permit process. Approximately 800,000 hectares of soybeans will be transported to these terminals, which will reduce transport via semi-truck by 800 kilometers. New grain terminals and increased navigation will not only lead to numerous barges hauling grain, but also will provide the opportunity to transport other associated agricultural products such as fertilizer, pesticides, fungicides, etc., which will further increase barge traffic on the river. Here we focus on an assessment of potential direct and indirect impacts of navigation development in the Tapajos River. Direct impacts considered included: bank erosion, water displacement, dredging, channelization, spill of hazardous products, invasive aquatic species, noise, and impingement. Based on a comparison with similar systems, our results indicate that direct impacts of commercial soybean transport on the Tapajos aquatic ecosystems are not likely to be severe. However, many unique aspects of the Tapajos system are poorly understood. Therefore, monitoring needs to begin as soon as possible to document baseline conditions, and potentially vulnerable species and key indicators should be monitored regularly. On the other side, the grain terminals and related navigation will bring prosperity and new industrial, commercial, and regional development. If poorly managed, ecological impacts of this secondary development could be more severe than the direct impacts of navigation.

Keywords: Tapajos River, Amazon, navigation impacts, pristine river

(073) Data, Data Everywhere and Not a Will to Think

Martin Thoms

University of New England, Armidale, NSW Australia

Extensive, complex data sets of biological, chemical, hydrological and physical information for riverine landscapes are increasingly becoming available to river scientists. These data frequently cover multiple spatial and temporal scales that are commonly collected from long-term monitoring programs and/or spatial reconnaissance surveys. Programs and surveys established and designed for a specific purpose that generate data with variable quality control and assurances and where data gaps may or may not be synthetically in filled. The use of such data can be fraught with issues, especially in an interdisciplinary setting and without careful consideration of the data, its quality and scale as well as the questions it is used to address. Some of these issues of inappropriate data use and its implications are illustrated in a series of examples. A conceptual framework is provided to enhanced the use of long-term data and overcome inappropriate applications. The framework is based on hierarchy theory, which uses a set of principles to keep track of the complex structure and behaviour of systems at multiple scales and therefore allows the identification of appropriate data to answer specific questions at the correct scale. Conceptual frameworks are useful tools to order phenomena and material, thereby revealing patterns and processes; in successful interdisciplinary river science they enable the joining of two or more areas of understanding into a single conceptual-empirical structure. The framework includes: the recognition of parallel subsystem hierarchies and the different organisational elements and levels of each discipline; the assignment of spatial and temporal scales for each level of organization for the different subsystem hierarchies whereby different subsystem parts can be distinguished by different frequencies of occurrence and/or rates of change. Integration of the different subsystems, within the context of a particular study, is represented by flow chain model that provides the basis for describing interactions within and between the different subsystem hierarchies. Application of the framework concepts requires a detailed description of the relevant organizational levels that characterise the different subsystems of the river ecosystem in the context of the problem being addressed.

(074) The Mactaquac Aquatic Ecosystem Study: Aquatic Environmental Science in Support of The Mactaquac Hydro-Electric Generation Station Renewal Project

Allen Curry[1], Tommi Linnansaari[1], Wendy Monk[1], Gordon Yamazaki[1], Anthony Bielecki[2], and George Porter[2]

[1] Canadian Rivers Institute, University of New Brunswick; [2] New Brunswick Power Corporation

The Mactaquac Aquatic Ecosystem Study (MAES) is a partnership with NB Power that provides the aquatic environmental science in support of the Mactaquac Hydroelectric Generation Station renewal project. The MAES will support a pending decision to either rebuild or remove the dam, which would be the largest planned dam removal to date. It is a highly integrated research program planned for the next 20+ years and designed to explore the potential consequences for the river and its reservoir. The study will describe the spatial and temporal characteristics of the river ecosystem's structure and function. This information will be used to explore the potential consequences of the proposed manipulations, i.e., what are the environmental challenges and opportunities for either replacing or removing the dam. We are establishing baseline environmental conditions, developing appropriate indices for environmental monitoring, and predicting the flow, sediment, and temperature regimes which control future habitats in the river. The research also describes the consequences of dam rebuilding for species at risk, fish passage, and managing flows to protect the river ecosystem's goods and services. The planned manipulation of an ecosystem at this scale constitutes one of the largest freshwater studies and experiments ever attempted. The MAES is an investment by NB Power in its green economy, and the partnership acknowledges the emerging economic significance of ecosystem goods and services. It is a precedent-setting case study for Environmental Impact Assessment in Canada. The MAES will create a template of approaches and methods that will facilitate the incorporation of aquatic ecosystem science into informed decision-making and management for this site and future hydropower projects as well as contributing important new knowledge for river restoration. The challenges addressed and environmental sciences solutions derived from the MAES will be a landmark achievement for the future of EIAs in Canada and around the world.

(075) Drivers of Change in Ecological Function and Loss of Resilience in Hydrologically Modified Rivers

Michael Delong[1], James Thorp[2], and Jeffrey Anderson[3]

[1] Winona State University; [2] University of Kansas; [3] Indiana University and Purdue University, Fort Wayne, IN

It has been a long-held view that biotic processes response to exogenous drivers is stochastic. Recent research has, however, demonstrated that external abiotic forces create biotic feedback loops that establish alternate functional states that are dependent on the nature of a given external driver. This dynamic process allows the system to shift back and forth across alternate functional states as long as the system is not pushed past a tipping point, whereby it may be impossible for the system to return to any of the previous states. We asked the question "does anthropogenic changes in hydrological conditions influence the nature of alternate functional ecological states within rivers and could/have these modifications led to a reduced capacity for trophic processes to respond to hydrological disturbance." This study used fish and mollusc specimens from museum collections to obtain carbon and nitrogen stable isotope ratios and the trophic position of fish over a period spanning before and after river modification. Isotopic ratios and trophic position were compared over time and to hydrological measures to ascertain if changes were associated with hydrological modification. Hydrological and trophic measures were examined in 5-yr intervals across the timeline. Analysis of isotopic ratios and trophic position over time demonstrated a pattern of change over time that coincided with the onset of operations of modern dams. Comparison of hydrological variables with isotopic ratios and trophic position substantiated the linkage between river modification and shifts in ecological functional state. Changes in landuse also appear to have influenced both hydrology and trophic structure prior to completion of modern dams; however, any impact of landuse was overridden by the shifts induced both hydrologically and ecologically by the modern dams. Additionally, variability in isotopic ratios and trophic position are lower between 5-yr intervals than was evident before completion of the modern dams. This loss of variability is evidence of a reduced capacity for the system to respond to natural changes in hydrological conditions. As a result, these systems have become less resilient and, as such, have the potential to undergo catastrophic regime shift should there be long-term natural or anthropogenic disturbance to the hydrological regime.

Keywords: resilience, regime shift, disturbance, hydrology, alternate states

(076) Modeling Ecosystem Metabolism Influenced by Hydrological Pulse in the Yellow River Estuary: Using a Bayesian Hierarchical Model of Oxygen Dynamics

Xiaomei Shen and Tao Sun

State Key Laboratory of Water Environment Simulation, School of Environment, Beijing Normal University

Aquatic metabolism is an integrative measurement of ecosystem functioning and can be used to assess impairment. Accurate estimation of aquatic gross primary production and respiration rates is helpful for our understanding of energy flow, material cycling, and trophic state in the aquatic ecosystems, especially when the water column was subjected to varied changes resulting from human activities and natural processes. Previous approaches of metabolism estimation generally fail to consider uncertainty (such as measurement error, process uncertainty, and model uncertainty), including in how ecological models are parameterized and in interpreting results, thus, may lead to errors. Models with higher uncertainty will be less helpful for prediction and inference. In this study, a Bayesian hierarchical model of oxygen dynamics was used to quantify aquatic gross primary production, ecosystem respiration and oxygen exchange influenced by hydrological pulse based on the variations of dissolved oxygen concentration, water temperature, and irradiance. The effects of turbidity pulse on metabolism and the temporal variation of metabolism were emphasized following integration of a light attenuation coefficient–turbidity submodel into the oxygen dynamic model. A logarithmic relationship between turbidity and freshwater inflow was derived from field data. Subsequently, the effects of discharge magnitude and flow timing on aquatic metabolism variation were analyzed in a case study of China's Yellow River Estuary. The model results indicated the estuarine ecosystem shifted from net autotrophy to net heterotrophy associated with extremely low gross primary production (approximate 0.002 mg $L^{-1}d^{-1}$) and high ecosystem respiration (approximate 8.968 mg $L^{-1}d^{-1}$) due to the effects of turbidity pulses and flow regulation in July. The developed Bayesian hierarchical model is particularly useful in quantifying aquatic ecosystem metabolism and the uncertainty.

Keywords: Bayesian hierarchical model; oxygen dynamic; turbidity; aquatic metabolism; Yellow River estuary

(077) Approaches for Characterizing Highly Fragmented Stream Systems in the Southeast: So Many Culverts!

Duncan Elkins[1], Evan Collins[1], Tom Prebyl[1], Nate Nibbelink[1], Will Duncan[2]

[1] University of Georgia; [2] United States Fish and Wildlife Service

Stream systems of the southeastern US are among the most diverse in the temperate zone, but this fauna is highly endemic, with many species being stream-resident and found in isolated and sometimes disjunct populations. Dams and road crossings further fragment this habitat and may contribute to imperilment. Improperly installed or maintained structures at road-stream crossings may pose the biggest passage impediment, but which of the tens of thousands of structures pose passage problems? We have used a GIS and targeted field sampling to model the presence and passability of stream crossing structures in three pilot watersheds. Modeling approaches indicate that catchment size was important for predicting passability. Our analysis also suggests that passability is related to physical and land cover characteristics at both the local and watershed scale. We use the resulting potential barrier maps to identify structures with the greatest potential impact on connectivity and to identify sub-watersheds at high risk for fragmentation. We are currently extending this approach for portions of six states from Alabama to Virginia.

(078) National Stream Fish Passage Barrier Inventory: Connecting Fragmented Data

Daniel Wieferich, Andrea Ostroff, and John Kosovich

U.S. Geological Survey

There is a growing focus on landscape-scale efforts to quantify, assess, and prioritize management of potential in-stream fish passage barriers. The task of developing fish passage inventories is time intensive and often limited to compiling publicly available data. The accessibility, data structure, and incompleteness of existing aggregated data often constrain database development and passage analyses. To address the growing demand for standardized fish passage data the USGS Aquatic Gap Analysis Program researched recent and ongoing fish passage data compilation efforts including the California Passage Assessment Dataset and Southeast Aquatic Connectivity Assessment Project and characterized the regional similarities and differences in data needs and data availability. The Aquatic Gap Analysis Program is using results from the analysis along with literature to develop a nationally consistent framework that can be used to help build, standardize, maintain and distribute a publicly available dataset of fish passage barriers. This framework will be structured to contain an array of physical barrier descriptions and site descriptions that were found to be useful to researchers and managers for the analyses of stream connectivity and barrier passability by fish. Ongoing efforts are being coordinated to allow current and past data collection efforts to implement this suggested framework and standard set of terms that will facilitate the synthesis of national stream connectivity and fish passage data. A national standard following this framework will help expand accessibility and usefulness of existing data and allow future research to advance data collection and synthesis efforts.

Keywords: Fish passage; data standards; stream connectivity; barrier Inventories

(079) Dams, Culverts, and Cumulative Effects: Examining Effects of Riverine Barriers to Longitudinal Connectivity using a Spatial Decision Support Toolset and Optimisation in Nova Scotia, Canada

Grieg Oldford[1], Peter Duninker[1], Dan Kehler[2], and Eldon Gunn[1]

[1] Dalhousie University, Halifax, Nova Scotia; [2] Parks Canada

We extend and apply an open-source spatial decision support toolset, the Fish Passage Extension (FIPEX), to model the cumulative effects of riverine barriers to longitudinal connectivity (LC). Two mixed integer linear programming models that aim to maximize both LC within the system (i.e., potamodromous or undirected LC) and between the river network and the outflow (i.e., diadromous or directed LC) while minimizing cost are adapted to focus on the relative ecological effects of dams and culverts. This is achieved by setting all barrier remediation project costs equal and instead restricting optimisation analyses by the total number of barriers to be remediated. We apply this method to three river systems heavily fragmented by both culverts and hydroelectric dams in Nova Scotia, Canada. First, total cumulative effects to LC by barrier type are estimated using two simulations: (1) the removal of all culverts and (2) the removal of all dams. Total benefits to LC are estimated by FIPEX using the Dendritic Connectivity Index (DCI). Next, a series of optimisation analyses are conducted, sequentially increasing the number of barriers to be remediated. Results indicate that on these three rivers, despite relatively greater numbers of culverts, they do not cumulatively outweigh the effects to directed LC of dams. However, culverts appear to play a greater role in affecting undirected LC, with at least one culvert appearing instead of a dam in optimal decision sets for all three rivers. We conclude that the simulated removal of riverine barriers using FIPEX and optimisation is an insightful approach to assessing the cumulative effects to LC of riverine barriers.

(081) Testing and Evaluation of The Hec-Ras-Riparian Vegetation Simulation Module

Zhonglong Zhang

LimnoTech, ERDC-EL

Riparian ecosystems are being influenced by a variety of stressors. The survival of riparian vegetation within impacted riverine ecosystems is a growing challenge due to the increasing priority of maintaining ecosystem function while sustaining water supply and providing flood protection. To support these efforts, a riparian vegetation simulation module (RVSM) has been developed to model riparian vegetation life cycle and linked with HEC-RAS model. This tool is intended to allow scientists, engineers, and planners to assess riparian vegetation and interaction with flow changes and to evaluate restoration implementation (and other management actions). The RVSM simulates the establishment, growth, and mortality of various vegetation types such as cottonwoods, and other riparian species. Vegetation establishment, growth, and mortality are computed in response to inputs of flow, and the computed hydraulics, groundwater surface, and sediment transport. River flow, sediment transport, and groundwater computations are provided in HEC-RAS. HEC-RAS-RVSM has been tested and validated using Sacramento River data sets. In this presentation, we will discuss the model results, testing and evaluation.

(082) Applying Hierarchical Models to Understand Asian Carp Movement and Spawning Activity in the Wabash River

Richard Erickson[1], Christopher Rees[1], Christopher Merkes[1], S. Grace Mccalla[1], Alison Coulter[2], Katherine Touzinsky[2], Reuben Goforth[2], and Liza Walleser[3]

[1] U.S. Geological Survey - Upper Midwest Environmental Sciences Center; U.S. Geological Survey - Upper Midwest Environmental Sciences Center; [2] Purdue University, West Lafayette, IN; [3] Wisconsin Department of Natural Resources

Monitoring environmental deoxyribonucleic acid (eDNA) allows researchers and resource managers to detect aquatic species based upon DNA that is present in water. Currently, eDNA approaches are used for presence/absence monitoring. We are developing monitoring approaches that will also allow the comparison of relative abundance of aquatic species. We are specifically focused on invasive Asian carp species that are found in the Wabash River, IN, USA, a tributary of the Mississippi River. We collected daily eDNA samples at three transects across the river. We also tagged 297 carp in the Wabash River, INand monitored their movement using passive and active telemetry and sampled the water for drifting carp eggs. We sought to develop a quantitative method for linking carp eDNA with changes in river flow, fish movements, and drifting egg densities. These observations were at the transect-level. However, each transect had 18 sampling points and each point had 2 replicates from the laboratory analysis. We used a hierarchical model to estimate the eDNA at each point and then compare eDNA within transects while also comparing across sites and time. We found no eDNA trends within transects (e.g., samples from the thalweg did not differ from those near the bank), but did find trends through time. We found that eDNA, fish movement, and drifting egg densities all increased with river flow during the first major rise in the hydrograph, but were not correlated after that first surge. We also found that eDNA was correlated with our telemetry data, but not egg densities. Our findings suggest eDNA may also be used to provide identification of spawning events or relative abundance of invasive Asian carp species.

(083) Application of Wavelets-Based Clustering of Multivariate Time Series in Flow Regime Alteration Asessment

Chunxue Yu, Zhifeng Yang, Xin'an Yin

State Key Laboratory of Water Environmental Simulation, School of Environment, Beijing Normal University, Beijing, China

The concept of natural flow regime is essential for sustaining riverine ecosystems and biodiversity. Unfortunately, climate change and human activities, such as construction of reservoir and weir, have altered the natural flow regime of rivers. To characterize the natural and human impacted flow regimes, numerous assessment methods for flow regime alteration have been developed. In existing methods, the flow regime is usually characterized by multivariate (i.e., multiple hydrological indicators) time series data. Each component (hydrological indicator) of time series is treated independently and their alterations are combined to reflect the overall flow regime alteration. However, the limitation of treating each indicator series independently is that they do not take into account the relationship between the components of the multivariate time series. The relationship of these components to one another, and how they can be meaningfully combined, remain unsolved. The relationship of components can provide useful information to the flow regime alteration assessment. To overcome the limitation of previous studies, in this paper, we adopt a new method, wavelets-based clustering of multivariate time series, for flow regime alteration assessment. It has been applied to many fields, such as forecasting inflow, and evaluating efficiency of monitoring network. It can reflect not only the characteristic of individual components, but also the relationship across the multivariate time series. Here, (1) for each component (hydrological indicator) of multivariate time series, the proposed method is designed to decompose each component into wavelet series on a number of scales and obtain the wavelet variances at each scale; (2) at each scale, the relationship between the every pair of component is calculated as the wavelet correlations; (3) and then the wavelet variances and correlations are concatenated into a single vector to represent the multivariate time series. The multivariate time series of pre- and post- impact data are represented as two vectors. The similarity of two vectors is effectively calculated by clustering methods to reflect the overall flow regime alteration. To illustrate the usefulness and effectiveness of the proposed method, a case study of a river in China are carried out. The application indicates the wavelet variances and correlations combined together as inputs into the clustering method have a good discriminatory power for flow regime alteration. Compared with some existing methods, the results show that the proposed method could provide comprehensive representation of flow regime alteration.

Key words: Flow regime alteration; Assessment method; Wavelets analysis; Multivariate time series.

(084) Quantification of Habitat Restoration Impacts on Flood Wave Attenuation in the Middle Rio Grande

Colin Byrne, Mark Stone, and Jourdan Adair

University of New Mexico

Although river engineering practices can provide benefits such as flood protection and floodplain accessibility, engineered structures have greatly impacted the geomorphology and flow characteristics of rivers throughout the world. Changes to the natural flow regime and geomorphology can reduce main channel-floodplain connectivity, thus leading to changes in the ecosystem services provided by a river system. Flood wave attenuation, one ecosystem service related to floodplain connectivity, involves the dampening and elongating of a flood wave as it moves downstream through momentum transfer at the channel floodplain interface, loss of momentum due to roughness effects of vegetation, and water storage within the floodplain. The Middle Rio Grande of New Mexico, historically, is susceptible to flood events due to both spring snowmelt and late summer monsoonal precipitation. The river, once classified as shallow, sandy, and bar-braided with a wide floodplain is, at present, generally deeper and meandering due to channel training with jetty jacks and the historic floodplain is inaccessible because of constraining levees. In addition, the flow regime has been altered as a consequence of upstream flood control and diversion dams. With these changes creating a reduction in channel width and floodplain connectivity, the Rio Grande Silvery Minnow (RGSM), *Hybognathus amarus*, no longer thrives in the system and is classified as an endangered species. As part of the requirements of the Endangered Species Act, habitat restoration projects often focus on reconnecting portions of the existing in-levee floodplain. The objective of this study is to quantify the impacts of four river restoration projects on flood wave attenuation along the heavily engineered Middle Rio Grande from San Acacia Diversion Dam to Socorro, NM. As these are the first habitat restoration projects within this reach, quantification of flood wave attenuation is addressed in pre- and post-restoration river conditions. Although it is expected that individual small-scale restoration projects have little impact on attenuation in the region, it is the goal of this study to determine whether these habitat restoration projects, implemented in series, have the additional benefit of attenuating flood waves. Deltares' D-Flow – Flexible Mesh, a two-dimensional hydraulic model based on an unstructured mesh approach, is used to model flood waves moving through the system and to quantify the impacts on attenuation. This study uses metrics for quantifying relative attenuation along a reach of river as percentages from an upstream flood wave source. The metrics focus on discharge, flood stage, and inundated area. In addition, changes to the celerity of the flood wave at downstream distances are assessed.

Keywords: floodplain connectivity, flood wave attenuation, hydraulic modeling, river restoration

(085) The Spatial Arrangement of Backwater Habitats Along the Upper Mississippi River

Munique Reid[1], Martin Thoms[1], and Michael Delong[2]

[1] University of New England, Armidale, NSW Australia; [2] Winona State University, Winona, MN, USA

Backwater habitats are important features of highly connected, large river-floodplain ecosystems. They are sites of high primary productivity supplying organic matter important to trophic dynamics of the broader river ecosystem; they contribute significantly to nutrient cycling; are general hot spots of biodiversity; and are recognised as key nursery sites for many aquatic biota. These habitats are geomorphologically, hydrologically and ecologically different to main channel habitats and thus contribute to the diverse habitat mosaic of large river systems. Flow regulation, through the presence of low-level weirs and dams, has the potential to alter the spatial organisation and geodiversity of backwater habitats within riverine landscapes by not only changing the character of hydrological connectivity but also their geomorphological and hydrological character. The presence of low-level weirs has been conceptualised to generate three artificially distinct hydro-geomorphic zones along weir pools. This conceptual model based on work in the River Murray, Australia, by Walker and Thoms (1992), has not been empirically tested elsewhere so its value as a general predictive model is not known. This paper aims to quantify the spatial arrangement of backwater habitats according to their hydro-geomorphic character and test the application of this three zone model along a 112-km reach of the Upper Mississippi River, USA. It is hypothesized that the distribution of habitat patches along this regulated reach of the Upper Mississippi River will not conform to the Walker and Thoms (1992) model of distinct, reoccurring patterns. Instead, a more distinct spatial arrangement irrespective of the lock and dam system will exist. We hypothesize this is because the lock and dam system of the Upper Mississippi has less control over high flow and sediment transport conditions than the influences exerted by weirs on the Murray River Australia where the model originated. In the current study 100 backwater and island lake habitats along Pools 5 to 8 were surveyed. Fifteen hydro-geomorphic variables were calculated for each and this data set was subjected to a range of clustering, multivariate and GIS analyses in order to explore the similarities and spatial arrangement of patches within and between the five weir pools.

Key words: hydro-geomorphic character, hydrological connectivity, geo-diversity, low-level weirs, dams

(086) Designing an Optimal Environmental Flow in a Regulated River Reach in Southern Norway

Ana Adeva[1], Knut Alfredsen[1], Richard Hedger[2], Hans-petter Fjeldstad[3], David Barton[2], and Håkon Sundt[3]

[1] Department of Hydraulic and Environmental Engineering, NTNU, Trondheim,Norway; [2] Norwegian Institute for Nature Research (NINA), Trondheim, Norway; [3] SINTEF Energy Research, Trondheim, Norway

Designing optimal environmental flows in Norwegian regulated rivers is a challenge that needs to be addressed. The effects produce by a river regulation in the ecosystem have been broadly study. Consequently, their ecosystem services are also affected. Norwegian regulated rivers are mainly intended for energy production, but this production has started to be affected by the application of Environmental Law measures. The present case study shows the design of an optimal environmental flow in Mandalselva, a regulated salmon river in Southern Norway. A number of 20 simulations has been carried out combining hydrological data and 1-D hydraulic modeling (HEC-RAS) with an Individual based model for Atlantic salmon *Salmo salar* (IB-salmon). The optimal environmental flow designed is suggested as an alternative to the minimum flow proposed by the Norwegian Water Resources and Energy Directorate (NVE), which is being implemented at Laudal Hydropower. This minimum flow was designed with a lack of environmental scientific background. It is producing a high energy loss to Laudal Hydropower plant with a double discharge released than the previous released discharge. The same methodology has been also implemented in Bjelland Hydropower plant (upstream Laudal) in order to trade-off spatial scales and to test the applicability of the method. The two hydropower plants are located in the anadromous part of the river, this highlight the confrontations between interest groups and ecosystem services. Applying the methodology here proposed, it is possible to compare salmon production, energy production and rating cost among the different scenarios. The main result is that it is possible to find and optimal flow that balance energy and salmon production. The suggested optimal scenario combines an intermediate discharge release with habitat modification measures. The results show that the NVE minimum flow scenario generates a loss of energy compared with the previous release and higher smolt production compared with the previous release scenario. Meanwhile, the optimal scenario with habitat modification gives highest number of smolt density production than the previous release and NVE. In terms of energy loss, with the optimal scenario are lower than the losses from the NVE scenario. The results for the cost for habitat modification actions suggest that apply habitat modification is the most cost-effective measure. It has an increase impact in the number of smolts by itself, and the cost associated is a onetime investment compare with the annually loss generated by different release scenarios. Concluding that environmental flows in regulated rivers can be designed using an integrate methodology combining: hydrology, hydraulic, Individual based model and economic rating to find and optimal balance of ecosystem services between the stakeholders. The results and the possible future development of the method and its applicability will be discussed.

(087) Beyond Ecohydrology: Dimensions of Flow Management in Highly Altered River Systems

Robert Jacobson

US Geological Survey

Identification of the flow regime as the master variable in aquatic ecology has a robust scientific pedigree. At the same time, it has been noted that in highly altered, multi-objective river systems, restoration (or rehabilitation, or naturalization) typically requires working with other related variables. The foremost consideration is that ecological management objectives compete with well-established socio-economic objectives, typically resulting in negotiated settlements that attempt to optimize all objectives. The trade-off process often results in decisions that recover only a portion of the natural flow regime or result in a hybrid flow regime intended to support narrowly defined ecological objectives. A second factor in highly altered river systems results from dam operations that decouple some variables from flow, including water temperature, water quality, and sediment regimes. As these variables are no longer related to flow regime in the same degree as in the natural system, the ecological results of naturalizing the flow regime cannot be assumed. A third factor in highly altered systems is the geomorphic adjustment of river systems to diminished or augmented sediment supply, channelization, bank stabilization, or vegetation dynamics. Geomorphic adjustments of the channel to these somewhat independent processes result in altering the relations between flow and habitat availability and quality. The Missouri River and its tributaries provide examples of how recognition of these dimensions of ecohydrology can inform restoration decisions.

(088) Designing Flow Regimes to Manage Instream Water Quality

Sarah Null, Logan Elmore, and Nathaniel Mouzon

Utah State University, Logan, Utah, USA

Reduced instream flows and increased nutrient concentrations limit native fish populations in Nevada's Walker River through warm daily stream temperatures and low nightly dissolved oxygen concentrations. Water rights purchases are being considered to maintain instream flows, improve water quality, and enhance habitat for trout, such as native Lahontan cutthroat trout. We use extensive water quality monitoring and River Modeling System (RMSv4), an hourly, physically-based hydrodynamic and water quality model, to estimate streamflow, water temperature, and dissolved oxygen concentrations. We simulate water temperature and dissolved oxygen changes from increased streamflow to prioritize the time periods and locations that water purchases most enhance trout habitat as a function of water quality. Monitoring results indicate stream temperature and dissolved oxygen limitations generally exist in the 115 kilometers upstream of Walker Lake (about 37% of the study area) from approximately May through September, and this reach currently acts as a water quality barrier for fish passage. Model results indicate that low streamflows generally coincide with critically warm stream temperatures, water quality refugia exist on a tributary of the Walker River, and environmental water transfers can improve stream temperature and dissolved oxygen conditions for some reaches and seasons, especially in dry years.

(089) Connectivity Determines Ecosystem Shifts and Resilience Mechanisms in Stream Communities of France, Observed in Three Decade Macroinvertebrate Sampling Data

Kris Van Looy[1], Mathieu Floury[1], Martial Ferréol[1], Marie-line Merg[1], Jérémy Piffady[1], and Yves Souchon[3]

[1] National Research Institute of Science and Technology for Environment and Agriculture, Department of Waters, France; [2] IRSTEA, Laboratoire d'Hydroécologie, Villeurbanne, France

Global warming is assumed to be a threat to temperate stream biodiversity, still many of the processes and mechanisms behind the predicted threats to diversity remain uncertain. We identified current trends and drivers of change for freshwater communities over a large spatial and temporal scale already revealing a strong ecosystem shift.

We analysed diversity and composition shifts in stream invertebrates communities during the last three decades in relation to geographic elements and human stressors over the French river network (circa 1000 km in longitude and latitude). We observed a 42% increase in the taxonomic richness of stream invertebrate communities, largely caused by climate change (23% purely climate-induced taxonomic richness increase). As a local mechanism, a bottom-up food web productivity response to rising temperature was responsible for this strong increase in site diversity. Stochastic assembly processes (both environmental stochasticity and dispersal related stochasticity) increased the regional scale diversity, giving spatial insurance to biodiversity and lowering the risks of biotic homogenisation.

Thus, stream invertebrate communities show strong resilience to environmental changes thanks to local and regional responses of productivity changes and connectivity. The productivity response at the local scale we classify as resource resilience, whereas the regional scale changes are connectivity driven mechanisms of refugia resilience related to landscape heterogeneity and recruitment resilience related to dispersal processes. For the French stream invertebrate communities, up to now the resilience mechanisms seem to outweigh the predicted climate-induced threats. From this knowledge emerge scenarios that enhance the temperate streams' resilience to cope with further global changes.

(090) Latitudinal Variation in Fish Migratory Strategies in Large Temperate Rivers of the Southern Hemisphere

Konrad Górski[1], Evelyn Habit[2], and Aliro Manosalva[2]

[1] Departamento de Ecología, Facultad de Ciencias, Universidad Católica de la Santísima Concepción, Chile; [2] Facultad de Ciencias Ambientales y Centro EULA - Chile, Universidad de Concepción, Chile

A relationship between life histories and increasing latitude has been described for Northern Hemisphere riverine fish, whereby life cycles that complete most of the growth in the ocean are favoured at higher latitudes. In the riverine ecosystems of the Southern Hemisphere many species of galaxiids display highly flexible migratory life histories and the mechanisms driving employment of different strategies remain unclear. Our objective was to unravel the mechanisms driving the selection of migratory strategies of *Galaxias maculatus* from rivers across a gradient of latitude. Fifteen fish from three size classes as well as water samples were collected from upper, middle and lower sections of 10 river systems in Chile across latitudes 36°- 47°S. Otoliths and water samples were analysed for a suite of trace elements using Laser Ablation Inductively Coupled Plasma Mass Spectrometry. Otolith elemental composition was analysed through depth profiling to assess the frequency of marine migrations in each section of each river. The propensity of marine migrations was strongly related to latitude as well as flow and temperature dynamics of each river system. Fish in river systems at higher latitudes more frequently displayed use of marine and brackish habitats, potentially enabling them to maximise foraging opportunities and increase recruitment success. River systems originating from large Andean lakes with more predictable flow pattern (large scale spring floodplain inundations and therefore more predictable food supplies) accommodated more resident individuals with no marine signatures even at higher latitudes. Therefore, climate as well as both longitudinal (headwaters-estuary) and lateral (main channel-floodplains) hydrologic connectivity seem to govern migratory strategies of riverine *Galaxias maculatus*. Consequently, management strategies that promote both lateral and longitudinal connectivity within riverine ecosystems are crucial to maximise habitat availability for native fish species. (Financial support: Fondecyt 3130690, DIUC 213.310.063-1AP)

(091) Genetic Stock Structure of Juvenile Channel (Ictalurus Punctatus) and Blue (*Ictalurus furcatus*) Catfish in a Large Unimpounded Midwestern River

Alex Sotola[1], Aaron Schrey[2], Eric Bollinger[1], Les Frankland[3], and Robert Colombo[1]

[1] Eastern Illinois University, Charleston, IL, USA; [2] Armstrong State University, Savannah, Georgia, USA; [3] Illinois Department of Natural Resources

For sportfishes in large rivers, little information is currently available regarding their genetic stock structure which can be vital to continuing the sustainable exploitation of these fisheries. In Illinois, Channel and Blue Catfish are some of the most important fisheries in large rivers; therefore, understanding and assessing their genetic integrity should be of utmost importance for managers. Sixteen microsatellite loci were utilized to assess the genetic structure of juvenile Channel (n = 30) and Blue (n = 11) Catfish from two sites approximately 290 river km apart on the Wabash River. Both species from both sites showed high observed heterozygosity (HO > 0.90), low inbreeding (FIS < -0.18), and low mean pairwise relatedness (MPR < 0.07). Additionally, there is significant genetic variation for both Channel (FST = 0.017, P = 0.003) and Blue (FST = 0.033, P = 0.007) Catfish between the two sites which indicates there are isolated populations. Although isolated populations are present, they all have high heterozygosity, low inbreeding, and low relatedness which is ideal for commercially exploited fishes. Additionally, we plan to test other sites between the two sites already tested, and upstream of the northern most site.

(092) Links Between Rainfall, Land Use, and Ecological Processes Acrosse the Landscape Matrix of the Upper Mississippi River Basin

Walt Sadinski[1], Mark Roth[1], Perry Jones[2], and Alisa Gallant[3]

[1] Upper Midwest Environmental Sciences Center, U.S. Geological Survey, La Crosse, WI, USA;
[2] Minnesota Water Science Center, U.S. Geological Survey, Mounds View, MN, USA; [3] Earth Resources Observation and Science Center, U.S. Geological Survey, Sioux Falls, SD, USA

Streams and rivers draining into the upper Mississippi River are prominent links in the hydrologic network of the Upper Mississippi River Basin. Links that extend up to more elevated portions of the basin landscape matrix are less obvious but important to consider. These elevated areas include wetlands and interconnected uplands of various land-cover types that not only provide ecosystem services vital to humans, but also function as physicochemical interfaces between global-change factors and ecological effects across the basin. For example, precipitation that falls diffusely through the atmosphere on the upper landscape and ultimately flows downhill to the Mississippi River, drives and links ecological processes like surface-water availability and the persistence of wetland-dependent species along the way. In upland areas with agricultural land use, precipitation and water movement also can drive and link the transport of agricultural chemicals and exposure of sensitive species to potential toxicants across upper and lower parts of the basin. Our results from studying rainfall-related changes in water levels, amphibian calling, and atrazine concentrations in palustrine wetlands illustrate such relations. Wetland water levels we measured in three basin study areas from 2008 to 2012 often were associated with the quantity of local rainfall and generally appeared related to downstream water volumes in the nearby St. Croix, Wisconsin, and Mississippi Rivers. Wetland water levels also were associated with amphibian calling dynamics, which indicate reproductive activity and can be used to estimate site occupancy over time in relation to environmental conditions. Calling ebbed and flowed with water levels within seasons, but did not occur when sites were dry. In contrast, calling did not occur at floodplain sites when the Mississippi River flooded, sometimes for the entire breeding season, perhaps causing populations to rely on recruitment from more elevated sites during such years. Rainfall and flooding potentially can impact amphibians via more insidious processes related to land use as well. Farmers historically have planted corn across vast portions of the upper basin landscape and applied large quantities of atrazine to corn fields to suppress weeds. Rainfall and flooding can leach atrazine from the atmosphere and soils and transport it across the landscape, as apparently happened in 2004. Extensive heavy rainfall occurred in the basin during May, causing the Mississippi River to flood. Coincidental with this flooding, triazine concentrations spiked in the river and in the slightly perched floodplain wetlands where amphibians bred. This same regional rainfall likely also helped transport atrazine into wetlands approximately 235 km further to the west, in an Iowa conservation area surrounded by row crops but lacking inflow from streams and rivers, where we measured higher triazine levels than we did in 2005. Thus, the likelihood that various amphibian populations across upper and lower portions of the landscape were exposed to toxic levels of atrazine was higher in 2004 due to links among regional rainfall, agricultural land use, and flooding. Overall, our observations suggest that broad, multifaceted connectivity exists between climate, land-use, and ecological processes across the landscape matrix of the Upper Mississippi River Basin.

(093) Landscape Scale Assessment of Floodplain Inundation Frequency Using Landsat Imagery

Yvonne Allen

US Fish and Wildlife Service

In large river ecosystems, the timing, extent, duration and frequency of floodplain inundation greatly affects the quality of fish and wildlife habitat and the supply of important ecosystem goods and services. Seasonal high flows provide connectivity from the river to the floodplain and seasonal inundation of the floodplain governs ecosystem structure and function. River regulation and other forms of hydrologic alteration have altered the connectivity of many rivers with their adjacent floodplain – impacting the function of wetlands on the floodplain and in turn, impacting the mainstem river function. Conservation and management of remaining floodplain resources can be improved through a better understanding of the spatial extent and frequency of inundation at scales that are relevant to the species and/or ecological processes of interest. Spatial data products describing dynamic aspects floodplain inundation are, however, not widely available. This study used Landsat imagery to generate multiple observations of inundation extent under varying hydrologic conditions to estimate inundation frequency. Inundation extent was estimated for 50 Landsat scenes and 1331 total images within the Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative (GCPO LCC), a conservation science partnership working in a 730,000 km^2 region in the south central United States. These data were composited into a landscape mosaic to depict relative inundation frequency over the entire GCPO LCC. An analytical methodology was also developed for linking the observed inundation extent and frequency with long-term gage measurements so that the outcomes may be useful in defining meaningful critical thresholds for a variety of floodplain dependent organisms as well as important ecological processes. Examples of how results and products from these data may be applied to a wide diversity of conservation, research and management applications will be discussed.

Keywords: inundation; frequency; Landsat; landscape; remote sensing; floodplain

(094) The Future of Rivers With Artificially Enhanced Baseflows: Central England

Emma Neachell and Geoff Petts

University of Westminster, London, UK

In this paper the term “artificially enhanced” is used to describe watercourses which have experienced the prolonged and sustained artificial augmentation of baseflows. This scenario may result from consented discharges, engineered transfers and flow regulation, but this paper focuses on the enhancement of baseflows resulting from consented discharges from Sewage Treatment Works.

To date, such increases in baseflows have usually been regarded as positive, or at least not detrimental to river ecology. Initial characterisation for the European Water Framework Directive (WFD) suggested that as many or more river reaches have artificially enhanced baseflows as are over-abstracted (Waddingham et al., 2008).

Assessment of the artificial influences operating in the catchments upstream of gauging stations indicated that a large number of rivers located within Central England have experienced artificially enhanced baseflows, some for three decades or more. Flows at over 10 per cent of gauging stations within the River Great Ouse basin have been substantially augmented by effluent return, this figure increases to almost 40 per cent within the heavily modified River Trent basin.

This paper analyses flow data from contrasting rivers located across the River Trent and River Great Ouse basins. Low flows within one river, the River Tame immediately downstream of a large Sewage Treatment Works were identified as more than six times higher than they would have been naturally. A conceptual model is used to illustrate the intra and inter-annual variability in the impact of artificial augmentation upon baseflows.

The Rivers Tame, Trent and Bedford Ouse and many other rivers have experienced artificially enhanced baseflows for several decades. In such rivers the ecology may have adapted over time to the artificially enhanced flow regime, and recreational values have emerged such that flow management approaches aiming to restore naturalised flows would potentially be detrimental. The conceptual model highlights the impacts of enhanced baseflows as loss of habitat partitioning in summer and maintained flows during the autumn (October and November) critical ecological period.

The Abstraction Licensing Strategies produced from the Catchment Abstraction Management System (CAMS) process views rivers with artificially enhanced baseflows as a potentially underdeveloped resource. There are numerous uncertainties surrounding future climate change and flow regimes due to non-stationarity, and population growth and increased abstraction demands will see more water stress in the future. Research is urgently needed to assess the societal value of rivers with artificially enhanced baseflows.

Keywords: Modified Rivers; Artificially Enhanced Baseflows; Water Framework Directive; Water Resources; Future Pressures; Abstraction Pressures; Ecological Integrity; Artificial Influences

(095) Extreme Floods in River Landscapes: Disturbance or Disaster?

Melissa Parsons

University of New England, Riverine Landscapes Research Laboratory, University of New England, Armidale, NSW Australia

Extreme floods – defined here as those with a recurrence interval >100 years – occur in all rivers as part of the natural flow regime. From a river-science perspective, extreme floods are disturbances that shape the hydro-geomorphic and ecological character of river landscapes. Extreme flood disturbances connect the river and floodplain, redistribute sediment and nutrients, form geomorphic features, disperse organisms and initiate recruitment and regeneration. From a social-science perspective, extreme floods are natural hazards. Extreme floods can lead to natural disasters with great loss of life, social disruption and economic loss. Much focus is placed on the mitigation of flood hazards and the reduction of flood risk, through hard (engineering) and soft (behavioural and policy change) interventions. In general, extreme floods are seen as a benefit to river ecosystems but a detriment to social systems. Consequently, the literature on flood disaster rarely discusses the benefits of flood disturbance and the literature on flood disturbance rarely discusses the social impacts of flood disasters. This is at odds with the growing management of rivers as social-ecological systems which recognizes the two-way feedbacks between river processes and human actions. Reconciling floods as both ecological disturbances and risks to human well-being requires a social-ecological perspective to understand the feedbacks between floods as beneficial disturbances and harmful social disruptions. Resilience – the capacities within the system to absorb shock, maintain the same state and respond and adapt to change – is a concept used in the fields of environmental management and disaster management. Resilience may be a useful umbrella for aligning the beneficial and harmful effects of floods, forming a framework for participatory decision making, risk assessment, adaptation and public policy. This review paper explores the connections between extreme flood disturbances and extreme flood disasters and proposes a research framework for reconciling the study of extreme floods as a continuum of disturbance and disaster.

(097) Hydro-Geomorphic Considerations for River-Floodplain Reconnection Along the Lower Illinois River, USA

Jonathan Remo, Ann Rushing, and Ross Guida

Southern Illinois University, Carbondale, IL, USA

Hydrologic alterations of the Illinois River Basin have resulted in increased river discharges. The increase in river discharges coupled with levees for flood mitigation and locks and dams for the facilitation of navigation have substantially increased river stages along the Lower Illinois River (LIR) over the past ~100 years. These changes to the hydrology and hydraulics of the LIR have permanently altered the natural relations among hydrology, geomorphology, and floodplain soils. Floodplain reconnection has gained more prominence as a part of the solution for redressing flood-risk reduction and riverine ecosystem restoration goals along the LIR. However, no systematic analysis has been undertaken to assess the capacity of potentially reconnected floodplain areas via levee setbacks or removals to create new or enhance existing LIR floodplain habitats.

In this study, we build upon the Land Capability Potential Index (LCPI) to systematically evaluate the restoration potential of the floodplain areas along the La Grange segment (~130 km long) of the LIR. The LCPI is a tool for identifying and mapping floodplain restoration potential which accounts for hydrologic, hydraulic, and geomorphic changes. Our LCPI uses 1D/2D hydraulically-modeled water-surface elevations, LiDAR-constructed DEMs for floodplain topography, and soils data to index the relative wetness of floodplain patches. We apply two approaches to quantify existing and potential creation of these physical-habitat patches after floodplain reconnection. The first approach applies these physical-habitat patches to a suitability analysis for a floodplain species of interest. The second approach applies spatial statistics to the physical-habitat patch mosaics to assess both the current and potential floodplain patch types and patch diversity for the floodplain-reconnection scenarios. The physical-habitat patch diversity indices were used as a metric to assess and rank currently levee-protected floodplain areas for their potential to create diverse suites of floodplain habitats.

The results from the LCPI-based suitability analysis were applied to identify areas suitable for the recruitment of the threatened Deccurent False Aster (Boltania decurrens). Depending on the reconnection scenario, we identified 2 km^2 to 12 km^2 of floodplain which could be new habitat for this threatened species. The results from the physical-habitat patch assessments suggest floodplain areas containing landforms with relatively high topographic relief (i.e., tributary fans and Pleistocene aeolian and glacial-fluvial landforms) have the most physical-habitat patch diversity and presumably the greatest potential for creating a diverse array of floodplain habitats. Both LCPI-based approaches are capable of providing valuable information for evaluating the rehabilitation potential of levee-protected floodplains.

(098) Evaluating the Socioeconomic Tradeoffs of Floodplain Reconnection Along the Lower Illinois River, USA

Ross Guida, Jonathan Remo, and Silvia Secchi

Southern Illinois University, Carbondale, IL, USA

Mounting flood losses, continued floodplain development, climate variability and change, and the decline in ecosystem services (ES) from floodplains underscore the need for a large-scale shift in land use and policy to achieve economically and environmentally sustainable floodplain management. In the Upper Mississippi River Basin alone, over $46.5 billion dollars in flood damage has occurred over the past 40 years. We are evaluating strategic floodplain reconnection along the Lower Illinois River (LIR) as a means of achieving sustainable floodplain management. The overarching hypothesis being tested is that strategic reconnection of floodplain areas to rivers can reduce flood risk and infrastructure maintenance costs while providing additional ES benefits. To test this hypothesis we are conducting spatially-explicit hydrodynamic, economic, and ecological modeling.

In this study, we assess several floodplain reconnection scenarios, including levee setbacks and removals, along the La Grange reach of the LIR. For these scenarios we employ the 1D/2D SOBEK hydraulic modeling suite to model water-surface elevations for the standard suite of flood-recurrence intervals (i.e., the 5- through 500-year events). Using these water-surface elevations for each reconnection scenario, we develop a corresponding suite of expected annual damages (EADs) using FEMA's Hazus-MH flood-loss modeling software. We then use the EADs to evaluate the socioeconomic tradeoffs for each of the floodplain reconnection scenarios.

Results indicate that levee removal and/or setbacks can provide flood-height reduction of over one meter for portions of the LIR. While urban areas have the highest expected damage curves under the reconnection scenarios, several agricultural levee districts show potential for reducing flood heights while minimizing damage costs. Further, some of these rural districts have below 40% of their land area under cultivation, representing greater potential to reduce flood losses. Overall, these results, coupled with ecological assessments, provide a baseline to assess the feasibility of strategic floodplain reconnection along the LIR.

Keywords: Floodplain reconnection; hydraulic modeling; floodplain damage estimates; socioeconomic impacts

(099) Reconstruction of Upper Mississippi River National Wildlife and Fish Refuge Floodplain Forest Characteristics to Restore Ecosystem Function

Richard King[1], Lisa Maas[1], and Jon Stravers[2]

[1] U.S. Fish and Wildlife Service; [2] Driftless Area Bird Conservation, National Audubon Society's Mississippi River Initiative

Floodplain forests within the Upper Mississippi River National Wildlife & Fish Refuge have significantly declined since installation of a series of locks and dams in the 1930s. Floodplain forests that remain have been significantly altered as a result of hydrologic changes and are threatened by invasion of invasive species. Restoration of the floodplain forests on the Upper Mississippi River provides an opportunity to manage sediment. Use of sediment for restoration has additional benefits as sedimentation threatens many aquatic systems within the floodplain. Sediment can be dredged and used for forest restoration via elevation modification with the goal of creating characteristics that approximate pre-lock and dam flood duration conditions. Flood duration modeling can be used to determine the elevation needed to approximate pre-lock and dam conditions. However, the location of a restoration within the floodplain can significantly affect ecosystem function. We used the cerulean warbler (*Setophaga cerulea*) to determine the effect of forest location within the floodplain on ecosystem function. Results indicate both forest health and location affect cerulean warbler abundance within the Upper Mississippi River National Wildlife & Fish Refuge. To maximize ecological benefit, restoration programs involving elevation modification should be designed to maximize the interface between upland and floodplain forest. In most cases, this means focusing efforts on near shore restoration will provide an ecosystem benefit that the same restoration in the middle of the floodplain will not.

(100) Models for The Restoration of Streams and Wetlands in Retired Cranberry Bogs

Martin Melchior[1], David Gould[2], and Alex Hackman[3]

[1] Inter-Fluve; [2] Town of Plymouth, MA, USA; [3] Massachusetts Department of Ecological Restoration

The Eel River restoration project is the first example of active cranberry bog restoration in Massachusetts. Prior to restoration, the Eel River headwaters had been in cranberry culture for over 150 years. The stream was dammed and groundwater elevations manipulated with numerous water control structures. Former sloped fens were converted to cranberry culture through the application of sand and management of these water control structures for watering, insect control and harvest. Design of the restoration project began in 2005 and construction was completed in July 2010. The Eel River project included restoration of 40 acres of Atlantic white cedar swamp and minerotrophic fen habitat, sphagnum moss restoration, fish and wildlife passage culvert replacements, removal of small dams, raptor perch habitat construction, 8,000 feet of new stream channel construction, over 1,000 pieces of large woody habitat, and stormwater detention and infiltration ponds. Habitat for salter Brook Trout, Bridle Shiner and Eastern Box Turtle, Massachusetts special concern species, were constructed. The project also included the removal of a 15 foot dam and restoration of a boulder step pool channel. Post restoration monitoring has been completed by U-Mass, Mass Dept. of Ecological Restoration and by the Town of Plymouth.

Manipulation of groundwater elevations was critical in balancing final wetland surface elevations, vegetation goals, fisheries goals and water quality. Seepage basins were designed to capture surface runoff and meter out groundwater, while grade controlling riffles raised overall water elevations within the wetlands. Two culverts were also replaced with natural bed materials and wildlife passage benches to control grade and allow for both fish and terrestrial wildlife continuity.

The Tidmarsh Farms restoration site is a 400 acre retired cranberry bog. Construction began in March 2015 for 250 acres of wetland restoration and 25,000 feet of stream channel restoration, including fish passage restoration for blueback herring, American eel and alewife. This project incorporates the Living Observatory, a collaboration among the project owners, Massachusetts Division of Ecological Restoration, MIT Media Laboratory, various universities and project partners in which remote sensing techniques will be incorporated into visitor experience to both monitor ecological recovery and educate the public regarding cranberry bog restoration. Both projects involve partnerships with the Town of Plymouth, Mass DER, US Fish and Wildlife Service, NRCS, NOAA and many other project partners.

As cranberry bogs are retired in the U.S., alternatives to traditional passive revegetation and restoration approaches are valuable. This talk examines the design and construction challenges faced in developing a repeatable template for large scale cranberry bog stream and wetland restoration.

(101) The Mississippi River Cities & Towns Initiative

Collin Wellencamp

Mississippi River Cities & Town Initiative. St. Louis, MO, USA

The Mississippi River Cities & Towns Initiative is an effort of 68 mayors along the Mississippi River from Bemidji, MN to New Orleans, LA. Stretching across ten states, our membership includes some of America's largest cities and smallest towns. Shaped by one of the most important rivers in the world, our cities are the laboratories of sustainable economies must achieve – growth with a neutral or beneficial impact on our natural resources and ecological services. Co-chairs Mayor Roy Buol of Dubuque, IA and Mayor AC Wharton of Memphis, TN, are supported by an executive committee of ten mayors – one from each state that touches the waterway.

This strong cohort of elected officials, the ONLY association of elected officials centered on the Mississippi River's entire length, finds more in common than different regarding our shared challenges living next to the waterway. This uniqueness brings value that we as mayors can leverage with more torque than most - innovating advanced conservation policy and performance in the public sphere for America's Great Waterway. This discussion will focus on the strategies employed to bring local governments together into a collective chorus for 2500 miles of waterway through ten states.

(102) What's Your Favorite Animal?

Jared McGovern

National Mississippi River Museum & Aquarium and its RiverWorks Discovery program, Dubuque, IA, USA

There are more than 220 AZA accredited zoos and aquariums in the United States. Visiting these 220-plus institutions a year are 180 million citizens searching for knowledge and entertainment; AZA member institutions attract more visitors annually than all professional sporting events in the country. Included in these 180 million annual visitors are 200,000 visitors to the National Mississippi River Museum & Aquarium of which 45,000 are school age children, many of whom have one very important question to ask; what's your favorite animal?

At the National Mississippi River Museum & Aquarium, our favorite animals are people. People have the greatest power of all extant animals on earth to do great harm, to do great good, and to enact positive change. This message is delivered across the country through RiverWorks Discovery, the national outreach program and traveling exhibit of the National Mississippi River Museum and Aquarium and National Rivers Hall of Fame. Here we engage our favorite animals; the public, in the future of Americas rivers. Join us during this special session and discover how RiverWorks Discovery actively engages the public in 18 states in the future of rivers.

(103) Creating Community Stewards of Local Watersheds

Natalie Marioni

National Great Rivers Research & Education Center, East Alton, IL, USA

The National Great Rivers Research and Education Center out of Lewis and Clark Community College studies the ecology of the big rivers, the workings of the watersheds that feed them, and the ties to the river communities that use them. Its education team has a K through Gray approach; everyone from the early years of kindergarten to retired adults can learn to appreciate, respect, and even become engaged in their local watersheds. Through local programs such as community outreach festivals, citizen science programs, and student stewardship efforts, our center actively engages communities throughout Illinois and the Mississippi River Watershed with science education, training, and opportunities for community involvement.

Through RiverWatch we train an average of 80 new adult volunteers each year (800 in the past ten years), who collect physical and biological data at approximately 105 stream locations to assess the health of Illinois streams. The classroom version of RiverWatch, called Stream Discovery, trains educators to conduct stream health surveys in their classrooms or with student groups, such as 4-H clubs. As the Illinois host for the national Project WET (Water Education for Teachers) program, we reach pre-service and current classroom teachers and their students, and also the general public by providing training workshops to reach communities through a variety of avenues to help inform and inspire greater public stewardship of our large rivers and their watersheds.

(104) From Arm Chairs to Wading Boots

Kelly McGinnis

Mississippi River Network

The Mississippi is truly America's River—a critical source of drinking water for 18 million people, a diverse habitat for wildlife, the backbone of our economy and a rich part of our heritage. But today, this great River is in trouble. Pollution from farms, untreated sewage and factories along with weak enforcement of water laws has caused our once might Mississippi to decline. The Mississippi River Network was formed in 2005 as a collaborative effort among a number of nonprofit organizations who saw a need for greater river-wide cooperation to achieve large-scale successes.

Now in its tenth year, the Network has grown to over fifty members among the ten main-stem states with over 14,000 River Citizens engaged in river issues and helped to create a national identity for this American treasure. This presentation will share the story of how this coalition has leveraged its collective resources to create a ten-state public communications campaign aimed at recruiting 20,000 River Citizens by mid-2016. Complementing this campaign is a policy strategy to create political will among decision-makers to restore and protect our mighty River.

(105) Considering Future Flow Regimes: A Modelling and Scenario Planning Case Study from Australia

Fiona Dyer, Evan Harrison, Paloma Lucena-Moya, and Jarrod Kath

Institute for Applied Ecology, University of Canberra, Australia

The establishment of environmental flow regimes typically uses historical data to determine the flows needed to maintain aquatic ecosystems. Such an approach is pragmatic but does not consider the consequences of fundamental shifts in the drivers of aquatic ecosystems that may already be occurring as a result of climate change and human impact on the flow regime. It is expected that climate change will affect the quantity and quality of water in freshwater streams with consequences for aquatic ecosystems. Additionally, other stressors such as population growth, community preferences and management policies can be expected to interact in various ways with climate change and stream flows, and outcomes are uncertain.

Setting future environmental flow regimes requires an understanding of the interactions between future climate, human activities, streamflow, water quality and ecology. To explore such interactions, we used Bayesian network models which combine scenario planning with ecological responses and changes in climate and management activities in the Upper Murrumbidgee River catchment, Australia. Six climate scenarios were selected representing minor, moderate and major changes in stream flow for 1oC and 2oC temperature increases. Climate scenarios were combined with four alternative ways of managing water supply, water demand and stream flow, which captured a range of local adaptation initiatives. These external drivers of the stream ecosystem were used to define stream flow, water quality and thus predict ecological responses represented by the macroinvertebrate community and key fish species. Subsequent field studies investigated the response of macroinvertebrate communities to specific sequences of events to augment the interpretation of model predictions.

For the upper Murrumbidgee River catchment, our models demonstrated the projected changes in flow caused by climate change are small compared with changes already caused by regulation. This means that the management of water supply and demand is particularly important for future ecological outcomes. Our analysis suggests two types of regulated rivers that need to be considered when determining management options: Type 1 Regulated Rivers in which environmental flows already form part of the operating procedures and Type 2 Regulated Rivers in which environmental flows are not currently provided.

In Type 1 Regulated Rivers, current macroinvertebrate and fish communities are likely to be maintained provided that an increased demand for water does not reduce the amount of water available for the environment. In Type 2 Regulated Rivers, field investigations show that the macroinvertebrate communities are resilient and robust but have become adapted to a flow regime that does not receive regular moderate to high flow events. Consequently, different flow management options were predicted to have a significant effect on the character of the macroinvertebrate community and it may take many years for the ecosystem to adjust to a new flow regime. Establishing environmental flows in such systems requires clear objectives for a future ecological state, rather than the simplistic notion of

restoring an historical state, and means that water managers have an active role in determining the future environmental character of these streams.

(106) Functional Flows in Modified Riverscapes: Hydrographs, Habitats and Opportunities

Sarah Yarnell[1], Geoff Petts[2], Jack Schmidt[3], Alison A. Whipple[1], Erin Beller[4], Cliff Dahm[5], Peter Goodwin[6], and Joshua H. Viers [7]

[1] Center for Watershed Sciences, University of California, Davis, CA; [2] University of Westminster, London, UK; [3] Utah State University, Logan, UT, USA; [4] San Francisco Estuary Institute, Richmond, CA, USA; [5] University of New Mexico, Albuquerque, NM, USA; [6] University of Idaho, Moscow, ID, USA; [7] School of Engineering, University of California, Merced, CA, USA

Building on previous environmental flow discussions and a growing recognition that hydrogeomorphic processes are inherent to the ecological functionality and biodiversity of riverscapes, we propose a functional flows approach to managing heavily developed rivers. The approach focuses on retaining specific functional flows or process-based components of the hydrograph rather than mimicking the full natural flow regime. These components include: wet season initiation flows, peak magnitude flows, recession flows, dry season low flows, and the interannual climatic variability of flows. We illustrate the importance of each key functional flow using examples from western U.S. rivers with seasonably predictable flow regimes. To maximize the functionality of flows, connectivity to morphologically diverse overbank areas must be enhanced in both space and time, and consideration must be given to the sediment transport regime. Lastly, we provide guiding principles for developing a functional flows approach or incorporating functional flows into existing environmental flow frameworks.

Keywords: hydrology; river ecology; water resources; land use management; applied ecology

(107) Improving River Restoration Metrics: Connecting Environmental Flow Management to Restoration Objectives Across US Bureau Of Reclamation Initiatives

Jennifer Natali, Zan Rubin, and G. Mathias Kondolf

UC Berkeley, Department of Landscape Architecture and Environmental Planning, UC Berkeley, Berkeley, CA, USA

With legislative pressure from the Endangered Species Act (1973), The US Bureau of Reclamation (USBR) has initiated at least ten river restoration programs focused on sustaining endangered fish populations with some component of environmental flow regulation via dam operations or dam removal. USBR restoration budgets approached a sizable $200 million as of 2011, but stretch thin when attempting to address threats to endangered fish species in the largest and most manipulated river systems in the U.S.: the Colorado, Columbia, Platte, Missouri, and San Joaquin Rivers, as well as the Rio Grande. With growing interest in fiscal responsibility, return on investment and balancing competing ecological and social demands for water resources, river restoration programs across the globe are developing increasingly comprehensive monitoring programs to assess attainment of goals.

To evaluate the effect of restoration programs, early USBR programs relied heavily on easily quantified metrics such as acres of habitat or length of bank restored, and number of riffles or pools created. More broadly, common restoration metrics include chemical measurements of water quality, physical measurement of habitat quality or a range of biological indicators that may or may not focus on target species. Yet oftentimes, a higher score or increase in some index is more indicative of the accessibility of the measurement rubric rather than an appropriate and direct measure of complex, process-based restoration goals. In some cases, commonly applied water quality indicators can be contrary to system-specific restoration goals. For instance, generic water quality and habitat metrics (i.e. EPA's Rapid Bioassessment Protocol or the Ohio Qualitative Habitat Evaluation Index) may assume that turbidity and bank erosion are negative, yet erosion and sediment transport are essential functions sought from increasing hydrologic flows. In the case of the Trinity River Restoration Program, increasing coarse sediment inputs downstream of Lewiston Dam is critical to restoring river function yet could be considered a negative "sediment input" in water quality assessments elsewhere. We find that these water quality evaluations are often inappropriate for restoration assessment, especially in the case of restoration via environmental flow manipulations.

Our study evaluates ten USBR river restoration program goals and metrics to understand how to best define metrics for assessing environmental flow objectives which relate species conservation targets and complex ecosystem processes to assess short-term, incremental outcomes. We find that a comprehensive and meaningful set of restoration metrics must be set within historical, regional, and experimental context of the specific river system. Accessible metrics of short-term habitat goals, such as habitat complexity, don't directly measure objectives, yet ultimate biological goals require intensive monitoring over long time periods. We identify and catalogue restoration program metrics within the USBR restoration program that connect short-term targets to ecological goals in order to improve the efficacy and efficiency of monitoring and evaluation for restoration-based environmental flow programs.

(108) Response of The Fish Egg Community to Re-Operation in Flow Regime from Three Gorges Reservoir Based on Sampling Conducted from 2011 to 2012, China

Yang Qihong[1], Ye Qiao[2], Zhang Lin[1], Wang Jiasheng[1], and Zeng Yue[1]

[1] Changjiang River Scientific Research Institute; [2] Institute of Hydroecology, Ministry of Water Resources and Chinese Academy of Sciences

The flow regime is a critical factor in the sustained ecological integrity of flowing water systems. The Yangtze River is the most important river in China. The Three Gorges Reservoir greatly changed the flow regime of the Yangtze River, resulting in decreasing of fish population dramatically since the Three Gorges Reservoir was impoundment in 2003, particularly those of the four major Chinese carps (FMCC): black carp, grass carp, silver carp, and bighead carp. Flood pulse and empirical fish research were initiated in 2011， as a pioneering way to protect FMCC resources in the Three Gorges Reservoir. When water temperature was greater than 18˚C, re-operation was implemented, and the time of the floods lasted for four to five days. This study investigated the impacts of flow regulation and re-operation on fish spawning, particularly for the FMCC, and validated the environmental factors that promote spawning of the FMCC.

The FMCC egg biomass was assessed by density (number•1000 m^{-3}). the FMCC egg mean density ranged from 0.29 to 17.05 ind•1000 m^{-3} among the eight floods. For the re-operation and regulation floods on occasions D and A (during the flow rise and the flood decrease), N total number of individuals ($F=7.01$, $p=0.01$) was significantly different, as was S species richness ($F=4.58$, $p=0.04$). A significant difference in FMCC egg density was observed among eight floods between 2011 and 2012 in different occasion, and the FMCC mean egg density during the re-operation flood was nearly four times than that of the regulation flood. Fish egg number and Pielou's evenness index were different among the eight floods (N, $F=2.63$, $p=0.05$; J', $F=2.80$, $p=0.04$;). In egg community, nine species contributed 50.41% to the difference in community composition between re-operation and regulation floods on occasions D and A, particularly two species with sticky egg, *Parabramis pekinensis* and *Hemiculter leucisculus* (Basilewsky). The grass carp contribution to the difference between the re-operation and the regulation floods on the second rank was 6.12%, however, it was almost equal in the re-operation and regulation floods. The abundances of silver carp, black carp and bighead carp, during the re-operation were two to fourfold greater than that during the regulation floods. A difference in community composition was observed between re-operation and regulation, indicating that the re-operation schedule was sufficient to change the egg community composition. The egg community was significantly correlated with four environmental factors, i.e. water transparency, change in daily water discharge, and change in daily water level.

(109) Methane Assimilation in the Floodplain Aquifer: Can Chemotrophy Power an Ecosystem?

Amanda G. Delvecchia and Jack A. Stanford

Flathead Lake Biological Station, The University of Montana, Polson, MT, USA

River floodplains are among the most biodiverse, productive, and threatened ecosystems globally. In expansive alluvial floodplains, the hyporheic zone often encompasses the entire alluvial aquifer. These aquifers are almost entirely recharged by river water and tend to be well oxygenated with extremely carbon limited (<2mg/L) production. Despite these conditions, the aquifers contain diverse and productive communities dominated by obligate large-bodied hyporheic stonefly nymphs. This is exemplified by the Nyack Floodplain (Middle Fork of the Flathead River, Montana), where we recently found that biomass of hyporheic stoneflies is predominately composed of methane-derived carbon. We asked: what is the source of methane and what role does it play in the aquifer food web?

We sampled the aquifer via monitoring wells mainly in Nyack and also in two other floodplains where groundwater stoneflies are abundant: Kalispell (MT) and Methow (WA). We used stable isotope analysis of three stonefly species, particulate organic matter (^{13}C and ^{15}N), and methane gas (^{13}C and ^{2}H), radiocarbon dating of stonefly biomass and dissolved methane, and routine measurement of dissolved oxygen and dissolved methane to infer sources of methane, fractional contributions of methane to stonefly biomass and the extent to which direct grazing on methanotrophic biofilm might drive ^{13}C depletion.

Stoneflies were 13C depleted despite low dissolved methane concentrations, implying that methane is rapidly assimilated: Nyack stoneflies averaged $\delta^{13}C$ -49.22 ± 2.59 ‰, Kalispell -41.66 ± 2.66 ‰, and Methow -39.87 ± 2.56 ‰, but methane concentrations (excluding two wells on the Nyack) averaged 0.67 ± 0.19 µmol/L, 0.13 ± 0.05 µmol/L, and 0.30 ± 0.03 µmol/L, respectively. Our conservative estimate of Nyack mean methane dependence calculated using a two-source mixing model was 51.95 ± 7.0 % but ranged to >100% (methane $\delta^{13}C$ of -67 ‰, POM $\delta^{13}C$ of -30 ‰). Methane sources in high concentration wells (means 5.43 ± 0.45 δmol/L and 9.89 ± 1.14 µmol/L) varied between acetoclastic methanogenesis and thermogenic outgassing as shown by: $\delta^{13}C$ -69.46 ± 0.64 and $\delta^{2}H$ averaging -289.2 ± 8.2 with age <1000 years, and $\delta^{13}C$ -40.50 ± 0.30 ‰ and $\delta^{2}H$ -63.7 ± 0.6 ‰ with age >7000 years. We found significant negative linear relationships between δ15N and methane dependence; slopes varied significantly by wells. This suggests that the most methane dependent individuals might be using methanotrophic biofilm directly, and only some locations present the possibility for variation in food resources. The most variation in food resources occurred where the well location was most directly connected to the river, as shown by temperature variability. Thermogenic and biogenic methane therefore subsidize the hyporheic food web at all locations, but almost completely drive it where little other food resources exist. We show, for the first time as far as we know, the first aquatic system supported by aged methane, and demonstrate a mechanism to support life where river-supplied organic carbon is extremely limited.

(111) Impacts of Low-Head Dams on Fish Assemblages and Habitat in Two Illinois Rivers

Shannon Smith[1], Ryan Hastings[1], Trent Thomas[2], Scott Meiners[1], Devon Keeney[3], and Robert Colombo[1]

[1] Eastern Illinois University, Charleston, IL, USA; [2] Illinois Department of Natural Resources; [3] Le Moyne College, Syracuse, NY, USA

Artificial impoundments such as dams have the potential to change river habitat type and hydrologic regimes by shifting riverine lotic habitats to lentic habitats. These changes can influence fish movement and dispersal, leading to changes in fish community assemblages over time. Two low-head dams on two rivers in eastern Illinois have been in place for nearly a century and are scheduled to be removed in 2015. To determine how these dams impact biotic communities and habitat quality, we have semiannually assessed fish assemblages and habitat characteristics in six sites on each river using DC electrofishing since 2012. Sites included two below each dam, two sites in the pool created above the dam, and two sites upstream of the pool extent. Data verified fish assemblage differences between sites; below dam sites on both rivers had the highest diversity while pool sites had the lowest ($p=0.0005$). Habitat quality scores were lowest in the pool sites ($p=0.002$), indicating that these dams have altered habitat immediately upstream of the dams. Data also suggest these different habitat types favor different functional groups of fishes, influencing the dispersal of habitat and trophic groups. Genetic analyses will be conducted on populations of select fish species at all sites to assess potential genetic differentiation above and below the dams; these data will be presented as a part of this project. Overall, our data indicate that the presence of dams on these rivers influences and shapes habitat type and therefore fish assemblages. Further monitoring of fish assemblages and habitat will continue after these dams are removed to assess subsequent changes to the river system.

(112) Hydrologic Connectivity as a Driver of Zooplankton Community Structure Across a Large River Floodplain

Jarrod Sackreiter and Clifford Ochs

University of Mississippi, Oxford, MS, USA

The Lower Mississippi River is well-studied with respect to its hydrology, but there has been comparatively little research of its ecological components and processes. For example, studies of zooplankton in the Lower Mississippi are practically non-existent. Zooplankton are an important link in the transfer of nutrients from primary producers to higher trophic levels. Establishing the dynamics and drivers of community structure is an essential step for determining their roles in the food web and elemental cycling. We examined variation in zooplankton community structure across a gradient in connectivity of backwater sites with the main channel of the Lower Mississippi River. Specifically, we asked: How do zooplankton vary temporally in abundance and community composition from the main channel to strongly connected channel margin sites to less strongly connected floodplain lakes? To address this question, samples of rotifer and crustacean zooplankton were collected between spring and fall from several backwater sites and the main channel of the Lower Mississippi River. We found that degree of connectivity with the main channel was strongly linked to physical/chemical features and algal biomass, which in turn drove changes in zooplankton abundances and community composition in backwaters. Crustacean abundances and taxonomic richness were higher in backwater sites compared to the main channel in the spring, but were similar in the fall. Rotifer abundances were consistently higher in backwaters compared to the river, but taxonomic richness was similar among sites throughout the sampling period. Crustacean and rotifer community compositions were consistently different between main channel and backwater sites suggesting that representative taxa are restricted in habitat use. Results of this ongoing study will contribute foundational knowledge to the understudied ecology of Lower Mississippi River ecosystem.

Keywords: Zooplankton; Lower Mississippi River; Community Structure

(113) Understanding Ecosystem Change in Upper Mississippi River Backwaters Through Geochemical and Biological Analyses of Sediment Cores

Colin Belby and Gretchen Gerrish

University of Wisconsin - La Crosse River Studies Center, La Crosse, WI, USA

Anthropogenic activities have altered the natural ecology and hydrology of the upper Mississippi River (UMR). Land-clearance for agriculture during mid-19th century European-American settlement changed regional plant communities and increased sediment transport. Locks and dams were constructed in the UMR in the late 1930s, raising water level at mid-pool by approximately two meters. This altered UMR floodplain geomorphology, expanding wetlands and increasing connectivity between backwater lakes and the river's main channel. Biogeochemical properties, pollen, and zooplankton composition were analyzed for sediment cores from upper Lawrence Lake, a backwater lake, in Pool 8 near La Crosse, Wisconsin. Integration of these data provides an understanding of how landscape level changes affected UMR aquatic habitats. Land clearance in the mid-1800s likely caused high turbidity, drastically altering the aquatic ecosystem. Magnetic susceptibility and ragweed pollen more than doubled at the same time point that zooplankton diapause egg abundance began decreasing. Sedimentation rates increased from 0.02 cm/yr during the 1,200 years prior to settlement to 0.55 cm/yr following mid-19th century land clearance. Recovery of zooplankton communities was not observed until dam closure in the 1930s. Both lock and dam closure, and modified agricultural practices likely contributed to the re-establishment of the aquatic biota post-1930s. Post-1964 sedimentation rates in the UMR backwater increased to 1 cm/yr despite improvements in land management that greatly reduced topsoil erosion in nearby tributary basins. The occurrence of large magnitude floods on the UMR and tributary streams combined with the remobilization of post-settlement alluvium in tributaries may explain the high rate of sediment delivery to the UMR floodplain during the past 50 years.

Keywords: Geomorphology; sedimentation; Upper Mississippi River; paleolimnology; ecosystem disturbance

(114) Active Channel Loss Due to Reed Canary Grass Along the Lower Chippewa River, West-Central Wisconsin

Douglas Faulkner

University of Wisconsin-Eau Claire, Eau Claire, WI, USA

For this study, I and several undergraduate student researchers used aerial photographs to study planimetric channel change along a 52-km reach of the Chippewa River, a major tributary to the Mississippi River in northwest Wisconsin. The study area, located downstream from the river's last dam, is characterized by a variable channel planform, with two single-thread meandering reaches and two anabranching reaches. It is also characterized by numerous active cutbanks and various floodplain features (such as abandoned channels and meander scars) that suggest a history of planimetric change. For this research, we obtained ten sets of aerial photographs, taken between 1938 and 2008. Three of these were available as georeferenced digital orthophotographs. The other seven were available only as contact prints, which we scanned and georeferenced with the remote sensing application ENVI. Using the georeferenced digital photos as base maps, we then digitized the active channel of the river in ArcMap. The resulting maps document dramatic channel changes, with marked differences between the different sections of river. In the anabranching reaches, several channel avulsions and cutoffs occurred, and many meander bends experienced relatively rapid lateral migration (up to 5 m/yr). In contrast, the upstream meandering reach remained laterally stable over the period of study, while the middle meandering reach experienced a moderate amount of lateral channel movement. Overall, however, the most notable change, which happened to some degree along all reaches, was a sharp decline in the planimetric area of the river's active channel. In 1938, the area of the active channel was 14.0 km2, and in 2008, it was 10.2 km^2, with most of this loss (nearly 70%) happening since the 1970s. Records from a USGS stream-gaging station located 10 km downstream from the study area reveal no stream-flow trends that would clearly explain the decline. Instead, the loss of channel appears to be due, at least in part, to the stabilization of in-channel flood deposits (point bars, lateral bars, midchannel bars) by herbaceous plants. One particularly significant plant is reed canary grass (RCG), an invasive wet/mesic species that apparently began encroaching upon the Chippewa River in the 1980s. To test the hypothesis that RCG is promoting channel loss, we surveyed patches of RCG along the river using Trimble Juno GPS units. We exported the RCG data as polygons to ArcMap and then intersected them with the active-channel polygons derived from 1973-2008 aerial photos. Our results indicate that RCG-dominated surfaces account for approximately 30% of the channel loss between 1973 and 2008. The apparent effects of RCG on channel area have not been, however, spatially uniform. In one reach, for example, RCG accounts for nearly 100% of the channel loss; in another, it accounts of barely more than 10%. Thus, while reed canary grass seems to have played a role in the loss of active channel, it is clearly not the only factor. More research is needed to determine what other factors are also driving the decline.

Keywords: aerial photographs, historic stream-channel change, Wisconsin, invasive plants

(115) Stratigraphic Records of Past Erosion and Sedimentation in the Southern Blue Ridge Mountains, USA.

David Leigh

The University of Georgia, Athens, GA, USA

Late Holocene (past 3000 years) vertical-accretion sediments from streams of the Southern Blue Ridge Mountains provide detailed multi-millennial stratigraphic records of past erosion and sedimentation. Twelve geochronologies have been measured from vertical accretion stratigraphic sections spanning pre-settlement and post-settlement strata in catchments ranging from 7 to 319 square kilometers in headwaters of the mountainous Little Tennessee and Hiawassee River basins in western North Carolina and northeastern Georgia. Geochronologies for each stratigraphic section are based on multiple radiocarbon, luminescence, cesium-137, and correlation dates. Post-settlement vertical accretion began in the late 1800s and appears to be about an order of magnitude faster than pre-settlement rates, at approximately 1-10 mm/yr versus 0.1-1.0 mm/yr, respectively). The pre-settlement/post-settlement stratigraphic boundary is demarcated by the surface of a buried paleosol, which has been dated at about A.D. 1870. Fast post-settlement rates occurred because of widespread deforestation for timber harvest, farming, housing development, and other erosive activities of people. Very recent (since A.D. 1963) sedimentation rates continue to be very rapid and are comparable, or faster than, earlier post-settlement accretion rates of A.D. 1870-1963, especially on bottomlands of the largest streams. Six stratigraphic sections have sufficient temporal resolution to evaluate the hypothesis (postulated by others) that indigenous people of Mississippian and Cherokee cultures were the first to cause accelerated erosion and bottomland sedimentation to produce “legacy” sediment. However, all six of the stratigraphic sections register decreasing sedimentation rates spanning pre-Mississippian through Cherokee time at rates less than 1 mm/yr. Natural, climate-driven, or non-anthropic forest disturbance is subtle and difficult to recognize in pre-settlement deposits. These data generally support Jim Knox’s “Universal Model of the Driftless Area”.

(116) Use of Historical Sediment Budgets to Link Agricultural Stream Sediment and Phosphorus Yields to Upland Management, Legacy Sediment, and Stream Restoration in the Driftless Area, Wisconsin

Faith Fitzpatrick

U.S. Geological Survey WI Water Science Center, Middleton, MI, USA

Significant amounts of time and money have been spent over the last 40 years in the U.S. by farmers, soil scientists, hydrologists, geomorphologists, engineers, and ecologists in upland management activities related to reducing stream sediment and phosphorus yields in agricultural landscapes. These issues are especially pertinent in the steep erodible landscape of the Driftless Area in southwest Wisconsin. Many miles of world-class spring-fed trout streams remain designated as impaired waters due to excessive sedimentation and degraded habitat. Between field practices and watershed outlets lies a vast repository of fine-grained sediment in overbank areas and lowland channels. These agricultural streams generally have slopes between 0.1 and 0.3 percent. Streams with this slope range have the ability to store or move sediment depending on localized low flows, floods, and hydraulic conditions. Historical fine-grained, organic-rich sediment stored in valley bottoms, banks, channels, and even in small watersheds less than 20 square miles, likely contributes an important portion of the suspended sediment and phosphorus loading to the upper Mississippi River Basin and the Gulf of Mexico. Streambanks, elevated by accelerated rates of overbank sedimentation during the late 19th and most of the 20th century, may be major sources of sediment, especially in channelized and straightened stream reaches. Tree-lined channels are prone to collect sediment because of the increase in roughness; thus it is important to look beyond vegetation type and into the sediment record to understand the usefulness of wooded vegetative filter strips along riparian corridors. This presentation will explore results from historical sedimentation and channel change studies in the Driftless Area with modern studies of bank erosion and fine sediment deposition in channels and modern rates of soil loss. Specifically, results from the targeted conservation study from Pleasant Valley, a pilot study of the Wisconsin Buffer Initiative, will be highlighted.

(117) Listening, Learning, and Working Together: Landowner Outreach and Communication Within The Fishers and Farmers Partnership

Ken Lubinski

USGS, Upper Midwest Environmental Sciences Center, La Crosse, WI (Retired)

In 2009, conservation and agriculture experts completed the first strategic plan of the Fishers and Farmers Partnership for the Upper Mississippi River Basin. Included in the plan were short-term goals to establish the Partnership's identify and support farmer-led stream conservation projects. Also included were long-term goals to progressively become more effective at improving stream health, and at engaging more of the basin's ranchers and farmers. These goals, in part, grew out of a fundamental belief that long-term stream conservation success at the scale of the basin will be dependent on enlisting the trust and help of informed private land owners. A website was created to achieve the immediate outreach goal of establishing the Partnership's identity.

Although a strategic outreach and communication plan was also completed, much of the Partnership's early budget has by necessity been focused on demonstrating farmer-led conservation successes at a limited number of stream sites. Continuing partnership outreach challenges include clarifying our agricultural audiences, and developing brief messages that verbalize our intent to merge two different systems of goals by building trust and utilizing the knowledge and experience of conservationists and land owners.

(118) Creating River–Friendly Communities

George Arimond

Arimond Consultants, LLC and University of Wisconsin – La Crosse, La Crosse, WI, USA (Retired)

Your strongest supporters for preserving the health and nature of our rivers can and should be the communities on and near our rivers. In this presentation we address effective methods for engaging the support and help of local government leaders and citizen groups. There never seems to be enough monies to educate and win public support for river preservation causes not to mention having the financial resources to properly manage and protect said river resources. Here you will learn how to identify civic groups who will support your river causes, and learn how to design a persuasive promotional message that will engage their full support and commitment.

(119) Take Me to the River

Susan Overson

Mississippi National River and Recreation Area, Minneapolis/St. Paul, MN 55101

People who enjoy the river protect the river. The Mississippi National River and Recreation Areas, a 72-mile national park in the Twin Cities, is engaging the public in multiple planning activities including development of a national water trail plan, a visual resource protection plan, creation of a continuous trail, open space, and alternative transportation system along the river, and has various volunteer and recreational programs. This session will focus on how the NPS helps create river stewards through its recreational planning and experiences.

(120) Citizenship, Civic Engagement, and Public Resources: Finding Common Ground

Jo Arney

Department of Political Science, University of Wisconsin – La Crosse, La Crosse, WI, USA

Managing our shared resources requires the ability to find shared values and create common ground. It is only by acting together as citizens that we can overcome the organizational and political challenges we face in being good stewards of the natural world. As part of this presentation, Ms. Arney will share stories and lessons gleaned from creating a Stewardship of Public Lands national blended course and faculty seminar for the American Association of State Colleges and Universities. As part of this work, she speaks with a variety of stakeholders regarding issues of disease control, wildlife management, and winter use of the land in and around Yellowstone National Park.

(121) Spatial and Temporal Dynamics of Phytoplankton Assemblages in Selected Reaches of the Upper Mississippi River: Navigation Pools 8, 13, and 26

John Manier[1], Jeff Houser[1], and Roger Haro[2]

[1] US Geological Survey Upper Midwest Environmental Sciences Center, La Crosse, WI, USA; [2] University of Wisconsin - La Crosse River Studies Center, La Crosse, WI, USA

Phytoplankton are a critical component of large river food webs and they provide large quantities of organic carbon and biomolecules that sustain large river ecosystems. Relatively few studies have examined large-scale patterns in phytoplankton community composition in the Upper Mississippi River (UMR). The purpose of this study was to examine the spatial and temporal dynamics of phytoplankton community composition across diverse aquatic areas of the UMR, and to investigate factors affecting phytoplankton community composition and, in particular, the abundance of blue-green algae. Phytoplankton and water quality samples were collected by the U.S. Army Corps of Engineer's Upper Mississippi River Restoration Long Term Resource Monitoring element. Samples were collected during the summer months of 2006-2009 from the main channel, backwater, and impounded areas of navigation Pools 8 and 13, and from the main channel of Pool 26.

Forty-seven genera of phytoplankton were identified in the samples analyzed. The three most abundant genera included *Aulacoseira*, *Aphanizomenon*, and *Microcystis*. Phytoplankton community composition differed among aquatic areas and pools. The main channel and backwaters were dominated by a mixture of cyanobacteria and diatoms, however the main channel also displayed large abundances of green algae, while the backwaters were typified by flagellated species (i.e., cryptomonads and euglenoids). The impounded areas were similar to the backwaters, but exhibited a greater proportion of cyanobacteria. With respect to longitudinal changes in phytoplankton community composition, the main channels of Pools 8 and 13 could be dominated by either cyanobacteria or diatoms (depending on conditions), while Pool 26 was always dominated by diatoms.

Phytoplankton community composition was strongly influenced by discharge. In navigation Pools 8, 13, and 26, taxonomic richness tended to increase with increasing discharge (possibly reflecting recruitment from off-channel areas and scouring of the periphyton). Moreover, the main channel communities of Pools 8, 13, and 26 became more similar during high discharge years. Surprisingly, cyanobacteria were dominant in the main channel of Pools 8 and 13 during the highest discharge year (2008). The major finding of this study was the prominence of cyanobacteria in the UMR. Cyanobacteria were present in 204 of 224 samples (96%). In addition, 1 in every 10 of my samples could be classified as having a moderate to severe cyanobacteria bloom (Kasich et al. 2013). There were no linear correlations between cyanobacteria total or proportional biovolume and selected covariates (including nitrogen and phosphorus). Instead, most occurrences of abundant cyanobacteria occurred coincident with moderate nutrient concentrations, suggesting that nutrient limitation was not a major driver of the patterns in cyanobacterial abundance. Phytoplankton communities were more likely controlled by physical factors, such as discharge, turbidity and residence time.

Keywords: Phytoplankton; Cyanobacteria; Upper Mississippi River; Large rivers

(122) Habitat Use and Movement of Channel Catfish in a Large Midwestern River Using Acoustic Telemetry

Hanna Kruckman[1], Les Frankland[2], Scott Meiners[1], and Robert Colombo[1]

[1] Eastern Illinois University, Charleston, IL, USA; [2] Illinois Department of Natural Resources

Channel Catfish *Ictalurus punctatus* are one of the most sought after commercial and sport fish species throughout the Mississippi River Basin. Understanding seasonal habitat preference and movement behavior is essential to properly manage the species in a lotic system. The Wabash River provides an ideal study site to assess fish movements because it is free flowing and home to a well-established channel catfish population. Since September 2014, we tagged 15 Channel Catfish with acoustic transmitters within a 16-km reach of the lower Wabash River. To locate fish we conducted seasonal 24-hour active tracking supplemented with site specific tracking. Habitat parameters were recorded at each location. Of the 15 tagged fish, one individual has been harvested and six individuals have been located more than once. We found Channel Catfish occupying a 2-km reach with most fish being located along rip rap banks, sand bars, and main channel habitat. Other habitats occupied included log jams and tributary mouths and all catfish were found between 1 and 12 m in depth. During 24-hour tracking, distance moved ranged from 1 – 396 m. Channel Catfish were most active at night swimming distances over 350 m within one hour time intervals. Monitoring movement patterns and seasonal habitat preference will help managers determine at which scale these fish should be managed to maintain a sustainable, healthy, and economically productive fishery.

(123) Consideration of Longitudinal and Lateral Connectivity When Evaluating Environmental Flows

Mark Stone and Ryan Morrison

University of New Mexico, Albuquerque, NM, USA

Water management activities can impact aquatic ecological processes across a variety of temporal and spatial scales. Common approaches for examining changes in natural flow patterns, such as the Indicators of Hydrologic Alteration (IHA) approach, focus on shifts in flow patterns at various time scales but cannot capture changes to flow-channel interactions. Although strong connections can be made between some ecological processes and changes in temporal flow patterns, other important processes rely on hydrogeomorphic interactions. Our objective was to examine the impacts of water management activities on aquatic ecological processes by combining temporal and spatial attributes of flow-channel interactions into a single modeling tool. We focused on three important riverine processes: the distribution of allochthonous material within the floodplain, incipient motion of the channel bedload, and recruitment of riparian vegetation in the floodplain. We developed a two-dimensional hydrodynamic model of targeted reaches of the Gila River in New Mexico, USA, to explore changes in hydrogeomorphic interactions due to water diversions in the system. Approximately 70 years of continuous hydrologic records were used to compare ecological impacts under natural and altered conditions. Our results show that the distribution of allochthonous material, sediment transport occurrence, and riparian vegetation recruitment are all negatively impacted by water withdrawals. In addition, specific spatial extents and landforms that are most impacted are easily discernable. Our approach to examining spatial and temporal flow-channel interactions is useful for understanding the impacts of water management activities on ecological processes that rely on more than temporal hydrologic patterns. In our case study of the Gila River, we have also found this approach to be an important screening tool for identifying the ecological processes that should be studied more closely and those that will be minimally impacted by water diversions.

(124) The Role of Independent Science Review in Large River Management

David Galat

University of Missouri, Columbia, MO, USA

Programs to enhance or rehabilitate large rivers are typically costly and are often controversial and politicized. Consequently, these programs are frequently encumbered with historical dogma, socio-economic implications, and cultural values that may influence decision making. Well-informed decision making for adaptive management of large rivers calls for inclusion of 'best available science'. Independent science review (ISR) can contribute to more effective decision making by focusing on objective scientific variables in the context of high socio-ecological complexity and uncertainty. Roles of independent science include: (1) identifying the best available science on relevant river management topics by assembling prominent scientists; (2) minimizing bias and special interests by recruiting technical experts external to the program and independent of special interests; (3) determining if the best available science was used in preparation of program objectives, methods, models, targeted outcomes; monitoring activities, etc.; (4) articulating risks associated with different interpretations of scientific information or alternative management decisions; (5) transferring lessons learned from other restoration programs to specific applications; (6) providing guidance in application of adaptive management and/or structured decision making; (7) maintaining scientific integrity to help build trust among stakeholders; (8) providing guidance in communication of science to decision-makers and the public; (9) serving as a communication vehicle with decision-makers, and; (10) increasing public involvement in the scientific element of a river management program. Independent science programs for several major large river restoration programs in the U.S. are reviewed to illustrate elements of effective science review. These elements include identifying various forms of ISR application; the importance of independence; accountability of scientific input; timing of input; maintaining integrity of the process; conflict management; and communication among participants. How ISR can be misused is also briefly addressed.

Keywords: Independent science review (ISR); best available science; adaptive management; uncertainty; decision making; river restoration

(125) The Significance of Groundwater for Atlantic Salmon (Salmo Salar) Egg and Alevin Survival in Regulated Rivers

Svein Jakob Saltveit[1], Knut Alfredsen[2], Åge Brabrand[1], and Roser Casas-Mulet[3]

[1] University of Oslo, Natural History Museum, P.O.Box 1172 Blindern, 0318 Oslo, Norway; [2] Department of Hydraulic and Environmental Engineering, NTNU, Trondheim, Norway; [3] University of Melbourne, Melbourne Research, Level 5, 161 Barry Street, Parkville 3010 VIC Australia

Atlantic salmon (Salmo salar) spawn during late autumn in redds in river bed gravels lacking fine sediments and with high oxygen levels. The eggs develop during winter with hatching and alevin development in early spring. Groundwater may constitute 40-100 % of total discharge during low flow periods in Norwegian rivers and can create refugia for eggs and alevins during low flows or hydropeaking episodes in regulated rivers. The significance of groundwater for salmon redd site selection, egg development, egg and juvenile survival is poorly documented in regulated rivers.

In two regulated rivers, Lundesokna and Suldalslågen, with permanent winter drawdown and hydropeaking regulation, respectively, field experiments were conducted to study the importance of hyporheic surface-groundwater interactions for the survival of Atlantic salmon embryos. Cylindrical boxes, each with two compartments (at 15 and 30 cm depth respectively) containing between 30 and 50 Atlantic salmon eggs, were placed in the gravel bed of the permanently wetted area as a reference and in the drawdown zone. They were regularly checked for survival from December 2012 to May 2013, coinciding with salmonid egg development, egg hatching and “swim up” in these catchments. To study surface and subsurface hydrological processes in the hyporheic zone, water pressure sensors were placed in piezometers to monitor water level and flow with 2-5 minutes time resolution. In addition, temperature, conductivity and dissolved oxygen were measured at the sites.

The main driver for egg survival in the dewatered areas was groundwater showing sufficient oxygen concentrations. In the hydropeaking Lundesokna, egg survival rates were significantly lower in the top compartments in the ramping zone (78%) compared with the boxes in the permanently wetted area and the lowermost compartments in the ramping zone (survival rates >99%). Egg survival rates in the permanent drawdown river bed of the Suldalslågen, were between 8 and 78 %, compared to 80 to 99 % in the reference wetted area. Survival rates varied with both the relative horizontal position and their relative vertical position along the gravel bar. With no water quality issues and very low inputs of fine sediments in the egg compartments, desiccation and subzero temperatures were the main egg mortality factors.

Newly hatched alevins are more vulnerable, with higher mortality compared to eggs. Alevin survival was remarkably high in the permanently wetted area of both rivers and in the drawdown zone of Lundesokna, contrasting greatly with the drawdown zone of Suldalslågen with 52% survival and a tremendous variability. Shorter periods of dewatering in the river with hydropeaking, gave higher alevin survival compared to the seasonally regulated river, when still permanently drawn down after egg hatching.

The interactions between groundwater and surface river water should therefore be considered when managing fish populations in regulated rivers. The results also emphasize that to maintain a sustainable salmon population in regulated rivers, all life history stages must be taken into account when implementing flow strategies.

(126) Influence of Unregulated Perennial Tributaries to Longitudinal Trends of Benthic Invertebrates in a Regulated River

Victoria Milner[1], Sarah Yarnell[2], and Ryan Peek[2]

[1] Institute of Science and the Environment, University of Worcester, Worcester, UK; [2] Center for Watershed Sciences, Univeristy of California, Davis, CA, USA

Undisrupted flows move energy, matter and organisms through river networks linking aquatic habitats and driving biotic patterns and processes. In regulated rivers, dams alter longitudinal gradients in geomorphology, water quality, temperature regimes and flow regimes with associated impacts on aquatic biota. Unregulated tributaries can increase ecological complexity in regulated environments by contributing colonists to the main channel and creating transitional habitats at the stream junction that are typically more heterogeneous compared to neighbouring habitats. We assessed whether unregulated perennial tributaries influence ecological gradients in two mainstem rivers during summer low flow conditions. Three tributary junctions of upland cobble-gravel bed streams were surveyed in an unregulated and regulated river in the Sierra Nevada Mountains, California, USA. Our study found 1) unregulated tributaries enhanced ecological complexity by increasing abundance, taxonomic richness and composition of macroinvertebrate assemblages on the regulated river, and 2) unregulated river sites had diverse macroinvertebrate communities similar to unregulated tributaries. Flow and temperature regime were the main drivers of macroinvertebrate diversity and community composition within and between the two rivers. Our findings highlight the importance of unregulated perennial tributaries as vital sources of colonists that increase ecological complexity within regulated rivers at intermediate scales (100-102km). We suggest unregulated perennial tributaries are an integral component of river networks, serving as valuable links in the landscape for enhancing biodiversity, and should be protected in conservation and management plans.

(127) Adaptive Cycles of Floodplain Vegetation Response to Flooding and Drying Sequiences

Rajesh Thapa, Martin Thoms, Melissa Parsons, and Michael Reid

University of New England, Riverine Landscapes Research Laboratory, University of New England, Armidale, NSW Australia

Flooding is a key driver of floodplain vegetation productivity. Adaptive cycles provide a model for examining the productivity of semi-arid floodplain vegetation in response to inundation. We examined the response of vegetation productivity (measured as NDVI) through an adaptive cycle to determine if the cycle repeats over time and how it is affected by different sized flood events. The adaptive cycle consists of four phases: wetting (exploitation phase), wet (conservation phase), drying (release phase) and dry (reorganisation phase). The results demonstrated that an adaptive cycle repeated over multiple events but there were significant differences in the area of floodplain inundation among the wetting, wet, drying and dry phases in each event. These differences were consistent with changes in NDVI class area, the number and direction of transitions between NDVI vigour classes, probability of transitions and NDVI class diversity. The quality of vegetation productivity followed the hypothesised pattern of higher quality vegetation vigour in the wet and wetting phase, lower vigour occurred in the drying phase and lowest vigour occurred in the dry phase. Although, the multiple events exhibited an adaptive cycle, the duration of each phase differed. Overall, two of the adaptive cycle phases, release and reorganisation were as hypothesised in contrast the exploitation to conservation phase, which were not. The conservation phase was more dynamic but relatively stable. The behaviour of NDVI over the multiple events also indicates that semi-arid floodplain vegetation to be more vulnerable to state changes during the conservation and release phases and not the exploitation and reorganisation phases as resilience theory currently suggests. Overall, a semi-arid floodplain adaptive cycle as proposed, is a better model to understand the complexity of change in vegetation productivity.

(128) Temporal Variation in Riverine Connectivity: The Impact on Tropical Migratory Shrimp

Jessica Chappell[1], S. Kyle Mckay[2], and Catherine Pringle[1]

[1] Odum School of Ecology, University of Georgia, Environmental Laboratory; [2] U.S. Army Corps of Engineers Research and Development Center

Given dramatic declines in riverine connectivity resulting from dams, managers have recognized the need to balance tradeoffs between ecosystem integrity and socioeconomic needs for freshwater. Watershed connectivity is crucial to the life history of many aquatic organisms such as salmon, eel, and sturgeon. To this end, a variety of connectivity indices have emerged to quantify the effects of dams and other infrastructure on migratory organisms with different life histories. Although rivers are temporally dynamic, connectivity is typically calculated as static through time. Here, we examine the role of intra- and inter-annual variations in connectivity for 9 watersheds in the El Yunque National Forest of eastern Puerto Rico. These tropical rivers host a variety of amphidromous taxa that require both freshwater and estuarine ecosystems to complete their life cycle. Amphidromous species represent a unique challenge for determining connectivity, as movement both upstream and downstream of barriers must be considered. Here we focus on freshwater shrimps (Atyidae, Xiphocarididae, Palaemonidae) given their important roles as consumers and significant impacts on stream ecosystem processes such as algal standing crop accrual and detrital breakdown. Low-head dams, which are associated with water withdrawals, have the potential to block upstream and downstream migration of shrimp during periods of low stream flow. We applied a set of hydrologic models to predict undisturbed hydrologic regimes at each low-head dam. We show declines in riverine connectivity through time in all 9 watersheds has occurred, with the lowest connectivity occurring during droughts. Connectivity also varies annually and is lower in the dry (or winter) season, when low rainfall corresponds with high municipal water use. Using our connectivity models, we then examine alternative water withdrawal schemes and locations. While tradeoffs exist, this analysis demonstrates that current water withdrawal schemes are inefficient and may be improved to better maintain watershed connectivity and municipal water supply. While focused on a particular study system, this analysis demonstrates the inclusion of primary elements for expanding the scope and conservation relevance of watershed connectivity assessments: temporal variability and the importance of balancing tradeoffs.

Keywords: *Atya*, *Xiphocaris*, *Macrobrachium*, passage, movement, riverine connectivity, El Yunque National Forest

(129) Divergent Histories of Degradation in Adjacent Murray River-Connected Wetlands

Peter Gell[1], Giri Kattel[1], Paulo Silva[1], and Atun Zawadzki[2]

[1] Federation University, Mellbourne, Australia; [2] Australian Nuclear Science and Technology Organisation

Floodplain wetlands in the Murray Darling Basin of Australia have been subject to a broad array of stressors since European settlement. This includes change in connection to the main river, increased flux of sediments, nutrients and salts, and changes to the flow and condition of the river itself. The impact of these forces of change can differ between wetlands owing to their varying proximity to the river and the effect of local management of land and water. Analysis of two century long records of change archived in the sediments of two shallow, adjacent floodplain wetlands allows for local and regional scale impacts to be distinguished. Psyche Bend Lagoon (PBL) and Kings Billabong (KB) are adjacent oxbow lakes that lie close to the lower Murray River in north-west Victoria, Australia. Sediment coring and dating revealed both to have continuously accumulated sediment for the past century with PBL now holding 145 cm of sediment and KB 90 cm. Fossil diatom assemblages were analysed in each record to infer changes in water quality, habitat and river connectivity. The basal sediments of each record attest to low salinity, even fresh, conditions in the late C20th. The presence of benthic and epiphytic taxa, and those competitive in low nutrient conditions, indicate clear waters also. While water was pumped into KB for human use in the 1890s peaks in plankton attest to occasional, natural linkage to the main river, probably through flood events. So, prior to river regulation in the 1920s both wetlands were subject to variable connectivity to a river with high quality water. From then however, the conditions of the wetlands departed. River regulation brought permanent river connectivity to KB and the developing irrigation agriculture industry subjected PBL to salinization. The KB record shows a gradual shift to turbid water species attesting to the gradual loss of a macrophyte dominated system to one dominated by phytoplankton. This is supported by the record of preserved cladoceran skeletons which reveals the replacement of a diverse assemblage of littoral taxa with a depauperate pelagic fauna. While some salt tolerant diatoms increased through the KB record, it appears to have been isolated from local salinization impacts. While turbid indicators also increase in the PBL record, interrupted with sporadic peaks in river plankton, the rise in halobiontic taxa is the most prominent feature of change to the lagoon's condition, in response to seepage of saline groundwater and direct release of irrigation return flows, despite occasionally being diluted by overbank river flows. Increases in diatom species that prefer sulphate brines attests to the gypsum-rich dunefields as a source of the salts. The deliberate diversion of the relatively dilute irrigation waters saw PBL rapidly degrade into a firstly hypersaline, then hyperacid, lagoon. Attempts to restore KB by reintroducing a wetting-drying regime have met resistance from residents who overlook the wetland, while efforts to restore PBL appear forlorn due to historic mismanagement. The compromised quality of river source water may put the natural baseline beyond the reach of both attempts.

(130) Landscapes and Timescapes: The Importance of Temporal Connectivity

Michael Reid

University of New England, Riverine Landscapes Research Laboratory, University of New England, Armidale, NSW Australia

The landmark paper by Ward (1989) stressed the importance of longitudinal, lateral and vertical interactions in river systems. Importantly though, Ward also stressed the importance of the temporal dimension. This temporal aspect is often neglected in studies of connectivity in river systems, or considered only in the sense that levels of spatial connectivity vary through time. This limited consideration reflects, perhaps, the conceptual difficulty involved in viewing the temporal dimension in the same way as the 3 spatial dimensions. However, just as a patch position in the landscape affects character, so too does past condition, its position in the timescape. The importance of past condition is widely recognised in the increasing use of benchmarks (be they based on reference sites, reconstructions from palaeo or historical records or theoretical constructions) to aid management and understand human impacts in river systems. However, this paper argues that there is a broader value in understanding past conditions and that this is illustrated through the concept of temporal connectivity. A patch with strong temporal connectivity maintains character through time – it is resilient, possessing features that enable the same basic structure and function to return following disturbance (resources are retained through tight nutrient cycling; biota persist through resistance, dormancy and seed and egg banks). This paper explores the concept of temporal connectivity using specific examples from floodplain river systems to illustrate the system mechanisms and biotic traits that contribute to maintaining ecological character through time.

(131) Effects of Filter-Feeding Asian Carp on Particle Dynamics in Navigation Pools 19 And 20 of the Upper Mississippi River

Amanda Milde[1,2], William Richardson[1], Eric Strauss[2], James Larson[1], Brent Knights[1], and Jon Vallazza[1]

[1] U.S. Geological Survey - Upper Midwest Environmental Sciences Center, La Crosse, WI, USA;
[2] University of WI-La Crosse River Studies Center, La Crosse, WI, USA

Invasive Asian carp are a major threat to native ecosystems because they can affect native food web structures and out-compete native species for resources, ultimately altering native ecosystem functions and services. This has led to heightened concerns about their spread throughout the United States and entrance into the Great Lakes. Native to China, Asian carp were brought to the United States in the 1970s and 1980s to control water quality and algae in aquaculture ponds. Asian carp are voracious filter-feeders consuming phytoplankton and zooplankton, however, little is known about their filter-feeding effects on native food webs in newly invaded natural systems. Large rivers, such as the Upper Mississippi River, provide adequate flow, temperatures, and abundant planktonic food resulting in high rates of growth and reproduction. Our objectives were to: (1) determine seasonal changes in water quality and size distribution and composition of suspended particles and plankton in Navigation Pools 19 and 20 of the Upper Mississippi River across a range of habitat types and carp densities, and (2) characterize the size distribution and composition of particles being ingested by Asian carp to determine variation in prey selection. Water and fish sampling were conducted monthly from May through September of 2013 and 2014. Water quality and nutrient analyses were completed according to standard methods using a Lachat auto analyzer. Particle and Asian carp gut content analyses, including phytoplankton and zooplankton, are currently in progress with a FlowCAM microscope and imaging system. Preliminary results suggest that seasonal high flows may have an effect on nutrient and particle availability among habitats and perhaps on particle food availability for Asian carp. Finally, using spatial patterns of carp distributions, our goal is to determine relationships between carp abundance and particle dynamics. This information will be pertinent to researchers and managers for implementing effective Integrated Pest Management control measures for Asian carp and the management of aquatic systems.

(132) Paddlefish Populations Maintained After a Century of Reduced Connectivity

Jan Hoover[1] and Bryan Cage[2]

[1] US Army Engineer Research & Development Center; [2] University of Mississippi, Oxford, MS, USA

In the early 20th Century, Moon Lake, an 8 km^2 oxbow lake off the Mississippi River in northwest Mississippi, supported important commercial fisheries for Paddlefish (*Polyodon spathula*). Paddlefish were abundant then and harvested for meat, caviar, and oil. In subsequent decades, however, the lake was isolated from the river by levees, and maintained only a tenuous connection to the Yazoo River System, in the Mississippi Delta, through a shallow, narrow, usually stagnant channel 30 km long. Despite this, Paddlefish are still abundant in the lake and unusually massive, frequently exceeding 30 kg. They continue to re-populate the lake in large numbers, sufficient to support a limited state-managed caviar fishery. Telemetry studies in 2014 suggest that the fish exit the lake in spring probably to spawn in the Yazoo River System or in the Mississippi River – more than 482 km away. Captures of Moon Lake tagged fish in the Mississippi Delta and in the Missouri River, support this contention. Ironically, habitat value of Moon Lake for highly migratory Paddlefish may have been preserved by its relative isolation from the river which has protected it, until recently, from competition with invasive species. Now, Asian carp (*Hypophthalmichthys* spp.) are invading the lake, and are reaching record sizes. A Bighead Carp (*H. nobilis*) collected in Feb 2014 was 1316 mm Total Length and 49.7 kg. Impacts of these Asian Carp on the Paddlefish may exceed those of a century of near-isolation.

(137) The Effect of National- Versus Local-Scale Data on Spatial Stream Network Modelling of Aquatic Ecosystems

Murray Scown[1], Michael Mcmanus, and Joseph Flotemersch[2]

[1] University of New England, Armidale, NSW Australia; [2] National Exposure Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH, USA

Modelling and predicting aquatic ecosystem conditions throughout stream networks is becoming a priority for river researchers and managers. Much of the recent research effort has focused on determining the relationships between stream ecosystem variables (e.g., water temperature, nutrients, species assemblages) and drainage basin variables (e.g., land use, topography, soil character), which can influence aquatic ecosystems across a range of scales throughout stream networks. These relationships have traditionally been examined using non-spatial modelling approaches, which do not account for the spatial structure of stream networks, longitudinal connectivity, or directionality of connections along the network. There is evidence to suggest that adopting a spatial stream network (SSN) modelling approach can greatly improve existing non-spatial models. SSN models account for spatial autocorrelation, structure, and directional connectivity in the stream ecosystem variables, which can increase the accuracy of models used to predict stream variables from drainage basin covariates. Critical to SSN modelling is the availability of drainage basin covariate data over large geographic areas, as well as topological stream network data. Such data are available at broad resolutions for the entire conterminous United States (national data), and at finer resolutions for some areas (local data). The advantage of local data for modelling and predicting aquatic ecosystem conditions is that they are generally available at a high enough resolution to account for spatial variability in the stream ecosystems, whereas national data are often more spatially generalised. The disadvantage of local data is that their spatial extent is generally limited to small areas. In order to construct large-scale SSN models throughout the United States, or any country, national data are required where local data are unavailable. This study evaluates SSN models derived from national and local covariate data in the Little Miami River basin, Ohio. The models are compared to determine the effects of using different covariate datasets on the power and accuracy of the SSN model predictions. Results of this study will inform river researchers and managers on the relative value and effectiveness of locally and nationally available datasets for large-scale modelling of stream ecosystem conditions.

(138) A Stream, a Hospital, and a Train: An Urban Restoration Story

Jonathon Kusa[1], James Wisker[2], Michael Hayman[2], and Martin Melchior[1]

[1] Inter-Fluve, Inc., Madison, WI, USA; [2] Minnehaha Creek Watershed District, Minnetonka, MN, USA

Minnehaha Creek Watershed District has been actively engaged in restoration efforts throughout their watershed for over 48 years. Recently, the District has increased their focus on establishing a restored stream corridor along Minnehaha Creek within the City of St. Louis Park and Hopkins. The focus is on restoration of stream ecology and geomorphology, providing pedestrian connections through and across the corridor, and improving stormwater treatment of urban runoff. Prior to restoration efforts, the stream was a ditched channel, straightened, incised, and detached from its floodplains and from the community. A barrier to the community and a receptacle for trash and stormwater sediment and nutrients. Over the last decade, the District has teamed with a local hospital, worked closely with local governmental agencies at the City and County level, and acquired properties along the corridor to advance the restoration of the stream corridor and adjacent properties. The planned development of light rail in the vicinity has further stimulated the District's focus on change within the area. This presentation will provide an overview of how an urban stream has changed and developed over time and how the District is restoring the ecology of a system while leveraging solutions to other urban needs to achieve broader community goals.

(139) The Influences of the Gezhouba and Three Gorges Reservoirs on Eco-Hydrological Conditions for Carps in the Yangtze River, China

Yuankun Wang

Nanjing University, Nanjing, China

To investigate the impacts of dams construction/reservoirs on hydrological regime in the Yangtze River, two of the largest reservoirs on the upper reach, i.e. the Gezhouba reservoir and the Three Gorges reservoir, have been selected as case study sites. By using the Indicators of Hydrologic Alteration and Range of Variability Approach methods, hydrologic alterations of 33 parameters are assessed to demonstrate the influence of these two reservoirs on ecohydrological conditions for carps in the Yangtze River basin. The results show that the impact of Gezhouba reservoir on the hydrological regime is relatively small. Three Gorges reservoir has significantly changed the ecohydrological flow regime downstream with mean hydrological alteration value of 57%. The impacts of reservoirs on hydrological regime downstream are closely associated with the storage capacity of the reservoirs. Hydrological regime alteration greatly influenced carps community population. The results of the current study will be greatly beneficial to the restoration of river ecosystems and ecological operations for Three Gorges reservoir in the Yangtze River characterized by intensified dam construction under a changing environment.

(140) Towards an Evidence-Based Stream Restoration Approach

Juergen Geist

Technical University of Munich, Aquatic Systems Biology

Stream ecosystems are among the most heavily degraded aquatic ecosystems worldwide. In the context of the European Water Framework Directive and the Natura 2000 directive, substantial effort is invested into improving and restoring the habitat quality of streams in Europe, including aspects of water quality, stream bed quality, structural diversity, as well as connectivity. To date, many of the restoration actions are rather based on gut feeling than on scientific evidence. This contribution investigates the success of prominent examples of stream restoration in Europe and proposes a step-wise approach to make restoration more successful in the future. The first example is concerned with the creation of bypass channels around dams which are currently only valued in the context of fish migration. As evident from case studies in Germany, their functions as substitute habitats, e.g. for fish spawning, can be equally important and also need to be considered, particularly in highly fragmented stream ecosystems. A second example addresses a comparison of frequently used techniques of stream substrate restoration in Europe. Interestingly, one of the most heavily used techniques, the loosening of substrate with an excavator, has been shown to be least sustainable, additionally resulting in the strongest adverse effects on downstream habitats compared to all other techniques. As evident from this example, the use of bioindication tools such as the “egg sandwich” can be useful in pre-assessment of restoration success and in the decision on priority areas of restoration. A third example refers to a case study concerning the restoration of fish habitats in heavily modified waterbodies. Using a standardized restoration setup comprising four treatments with nine replicates each, the introduction of dead wood was identified as the measure that resulted in greatest fish aggregation, being at the same time particularly beneficial for juveniles. In summary, the three diverse examples of stream restoration action investigated here all suggest that evidence-based approaches can greatly increase the success in stream habitat restoration and aquatic biodiversity conservation.

Keywords: Stream substrate; connectivity; heavily modified waterbodies; biodiversity conservation; Europe; fish habitat rehabilitation

(141) Ecosystem Metabolism in Off-Channel Habitats of the Middle Mississippi River

Molly Sobotka[1] and Quinton Phelps[2]

[1] Missouri Dept. of Conservation; [2] Missouri Dept. of Conservation & Southeast Missouri State University, Cape Girardeau, MO, USA

Off-channel habitats are frequently considered important areas of increased productivity and as refugia for many species in large rivers. In the Middle Mississippi River off-channel habitats are generally limited to large side channel- island complexes. Productivity in the side channels of the Middle Mississippi River has not been analyzed in contrast to main channel conditions. Continuous hourly dissolved oxygen and temperature data were gathered from areas protected by wing dikes and side channels in the Middle Mississippi River during 2013 and 2015. We used total solar radiation, barometric pressure and wind speed data to model gross primary production (GPP) and community respiration (CR) in approximately weekly increments. We predict that spring floods will create heterogeneous conditions in all areas of the river channel and result in low primary productivity. We further predict that floodplains inundated by spring high water will be highly productive. Results from late summer, fall, and winter of 2013 suggest that wing dike and side channel conditions allow similar rates of primary productivity during intermediate to low water levels. Over the course of the study both areas exhibited periods of positive net ecosystem metabolism (NEM) indicating that autotrophic conditions occur in the Middle Mississippi. However, NEM was more frequently negative, supporting the theory that in large, turbid rivers heterotrophy is the more common state. Initial correlation analysis indicated that light and discharge were the most important drivers of metabolic rates.

Keywords: net ecosystem metabolism, primary productivity, water quality, dissolved oxygen, side channels, Mississippi River

(145) Retrospect on Pool – Scale Drawdown as a Tool for River Restoration

Gretchen Benjamin

The Nature Conservancy

Historically, the Upper Mississippi River (UMR) floodplain was a diverse mosaic of habitats influenced by the seasonal variation of river flows and associated water levels. The river has been altered for human use for hundreds of years including the 1930s construction of 26 locks and dams built to maintain a nine-foot navigation channel. Inundation led to the loss of topographic and bathymetric diversity and associated aquatic vegetation, fish, wildlife and invertebrates. River ecologists realized to bring back the once vibrate aquatic ecosystem they must reestablish river processes and the mosaic of river structure within the floodplain. Since 1986 the federally funded program called Upper Mississippi River Restoration (UMRR) has provided funds to recover over 102,000 acres of structural river floodplain habitat. This represents a significant success for restoration but still missing was the natural seasonal water stages and the associated processes. Reducing water levels at the dam (drawdown) to replicate historic lower summer water levels and induce aquatic plant response became the management target for returning this important aspect of river processes. Working collaboratively the Corps of Engineers, natural resource agencies, conservation organizations, and affected stakeholders were able to reduced water levels for ecosystem benefits while maintaining the channel for commercial navigation. Drawdown demonstrations have been done numerous times in the UMR. In the St. Louis District, this work is known as Environmental Pool Management (EPM) and was first implemented in 1994. Greater flexibility in navigation Pools 24-26 provides more opportunity to reduce water levels with minimal impact to recreation and navigation infrastructure. As spring flood waters subside the Corps of Engineers allows the water level to drop below full pool for at least 30 days. After 20 years of implementation, these demonstrations have produced a reliable response from annual aquatic plants and has been incorporated into the routine operation the pools. In the St. Paul District, the narrow tolerance for pool water levels requires substantially more planning to conduct a drawdown. A total of 3 demonstration drawdowns have been conducted including 1.5 foot reduction at the dam on Pool 8 in 2001 and 2002 and on Pool 5 in 2005 and 2006 as well as a 1 foot drawdown on Pool 6 in 2010. During these drawdowns the acres of exposed substrate on Pool 8 were 1,954, 1,032 acres on Pool 5 and 133 acres on Pool 6. In this river reach, researchers have found that two years of consecutive drawdown for over 45 days produced more robust perennial emergent plants that persistence for years after the Corps of Engineers returns to the routine water level operation. Up to 70 species of moist-soil, perennial emergent and other aquatic species were documented on exposed substrate including rice cutgrass, broadleaf arrowhead, flatsedge, and smartweed. River managers contend that with 20 years of implementation this restoration management tool is ready to shift from demonstration to more routine implementation to allow flexible use to when environmental conditions warrant.

Keywords: Drawdown, Perennial Emergents, Restoration Policy, Dam operations, Upper Mississippi River, Large River Restoration.

(146) 20 Years of Environmental Pool-Level Management in the St. Louis District: Lesson Learned from the Operational Side

Joan Stemler and Brian Johnson

U.S. Army Corps of Engineers, St. Louis District, Saint Louis, MO, USA

The navigation dams within the US Army Corps of Engineers St. Louis District were constructed in the 1930's as components of the Mississippi River Nine-Foot Channel Navigation Project. As mandated by Congress, the dams are regulated for the purpose of creating pools to provide a nine-foot depth navigation channel. Given Congressional authorization, it was not thought that these projects could also be operated to provide environmental benefits.

In 1994, the St. Louis District, at the request of its natural resource partners, including the Missouri Department of Conservation, began an innovative experiment that came to be known as Environmental Pool Management (EPM). These actions involved working within the Corps existing authority to maintain pool drawdowns during the spring and summer for an extended period of time, allowing for the growth of wetland plants. For over 20 years, EPM has been successful in producing thousands of acres of wetland plants. Over that time, our understanding of the relationship between drawdown timing, length, and biological response have grown. EPM has been so successful that it has moved from being considered an experiment to being fully incorporated into the District's routine water control operations.

Close coordination with resource managers in the field has been and remains critical. These team members provide valuable insight into the actual on-site conditions, and often provide the feedback required to ensure a successful vegetative response. As with any natural process, the vegetative response will vary from year to year.

In 2015, like in 1994, the Corps and its environmental partners are continuing to examine ways to improve or expand what can be accomplished. The St. Louis District and its partners have recently begun to look at additional operational changes to determine if greater benefits, including establishment of perennial plants, could be accomplished through more intensive management of pool levels.

Keywords: Environmental Pool Management (EPM); Mississippi River Nine-Foot Navigation Project; Corps of Engineers; water control; drawdown; wetland plants

(147) Fish Responses to Water Levels and Connectivity in River Wetlands of the Central US

James Garvey

Southern Illinois University, Carbondale, IL, USA

In the Mississippi River system, access to shallow-water, vegetated habitat is limited by lack of reliable flooding and barriers such as levees. Native and non-native fishes may rely on these areas for reproduction and as nursery habitats for offspring. In the early 2000s, we evaluated the response of fish to water-level management of shallow areas of Pool 25 of the Mississippi River. The impact of vegetation generated by stable drying and then inundation of the river backwater was combined with a manipulative experiment including vegetated and unvegetated plots. Fish responses were compared to a large habitat restoration project in Swan Lake of the lower Illinois River near Pool 25 and the lower Ohio River, which receives no water-level management. This continental-scale comparison showed that stable variation in water-level and resulting production of moist-soil vegetation are critical for successful recruitment of river fishes with diverse life histories.

(148) Native Freshwater Mussels and Drawdowns: Science to Support Water Level Management

Teresa Newton, Steve Zigler, and Brian Gray

U.S. Geological Survey - Upper Midwest Environmental Sciences Center, La Crosse, WI, USA

Managers in the Upper Mississippi River (UMR) are using reductions in the River's water levels during summer to mimic historical water regimes and rehabilitate habitats for vegetation and other species. Concerns for the unintended effects of these actions on native freshwater mussel populations threatened to halt these projects. Our objective was to characterize the survival and movement of two mussel species in the UMR associated with a water level drawdown. During 2009 (no drawdown) and 2010 (0.3 m summer drawdown), we glued passive integrated transponder tags to 10 *Amblema plicata* and 10 *Lampsilis cardium* at each of 11 sites. Five sites were in shallow areas expected to be minimally affected by the drawdown (reference sites), and six sites were in shallow areas expected to be directly affected by the drawdown (treatment sites). About equal numbers of sites within both the reference and treatment areas had low and high slopes. Tagged mussels were randomly allocated across sites (within years). Recovery of tagged mussels was >88% in 2009 and 2010. Mortality was similar and low (mean, about 5% in both species) among reference sites but was variable and relatively high (means, about 27% in *L. cardium* and about 52% in *A. plicata*) among treatment sites; variation in mortality among treatment sites appeared related to slope. The study found evidence of drawdown associations with net horizontal movements in *A. plicata* but not *L. cardium*. Weekly horizontal movements in both species were significantly correlated with changes in water elevation. We observed significant slope associations related to the drawdown for mortality and net horizontal movement in *A. plicata*. There were strong species-specific differences in the effects of the drawdown on mortality, vertical movement and horizontal movement. These results suggest that *A. plicata* responded to the drawdown by vertical movement into the substratum, whereas *L. cardium* responded by horizontal movement to deeper water. No directionality of movement was observed in either species. Collectively, these data suggest that drawdowns can influence the mortality, movement and behavior of mussels in the UMR. However, more information on spatial and temporal distributions of mussels is needed to better understand the magnitude of these effects. Results from this study are being used by resource managers to better evaluate the effects of this management tool on native mussel assemblages.

(149) Estimation for the Riverbank Collapse Volume with Sandy-Riverbank in the Desert Reach of the Upper Yellow River

Anping Shu, Xing Zhou, Fanghua Li, Guosheng Duan, and Shu Wang

School of Environment, Beijing Normal University, Beijing, China

Yellow River, the second longest river in China, exhibits the characteristics of wandering channel, more river branches and higher sediment concentration. Sandy-riverbank collapse in desert reach is very prominent in the fluvial processes of the upper Yellow River, especially during flood period. The study area has been selected as the lower part of the upper Yellow River from Xiaheyan (Ningxia Province) to Toudaoguai (Inner Mongolia Province), which is called briefly as NM channel and located at the desert region with a total length of 1080km. As a kind of common and prominent sediment disasters, bank collapse affects not only the stability of embankment along rivers, but also the life and safety of people.

Based on the field observations and theoretical analysis for the NM channel, sandy-riverbank collapse can be characterized by the following processes: (1) both wind and water flow forces contribute to the instability of surface particles on slopes; (2)unstable particles fall along a shallow surface, with a small collapse volume at each individual collapse; (3)deposited material was brought into the channel under the action of river flow and the slope angle once again becomes equal to the repose angle; (4)the collapse volumes accumulate at the riverbank under the water level. Thus, calculation of the riverbank collapse volume can be simplified into calculation of the erosion volume by water flowing. On the basis of residual shear stress and using an experimentally determined vertical velocity distribution, a new estimating method has been preliminarily presented for riverbank collapse volume calculation by using measured date from Wuhai observation site, where the Yellow River passes through the Ulan Buh Desert. The results compared favorably with the measured values. Furthermore, the collapse volume calculated by using the estimating method is better verified with the measured data from partial channels at NM channel in 2011-2014. The results above may be used to calculate sandy-riverbank collapse volume in NM channel of the upper Yellow River, which are significant for not only the investigation of desert river dynamics, but also planning and design for riverbank harnessing projects in desert river of the upper Yellow River.

Keywords: The upper Yellow River, Sandy-riverbank, Riverbank collapse volume,Estimating method

(150) A Watershed Integrity Definition and Assessment Approach to Support Strategic Management of Watersheds

Joseph Flotemersch[1], Scott Leibowitz[2], Ryan Hill[2], John Stoddard[2], Martin Thoms[3], Rebecca Tharme[4], and Darren Thornbrugh[2]

[1] U.S. Environmental Protection Agency, Office of Research and Development, 26 W. Martin Luther King Dr., Cincinnati, OH 45268, USA; [2] U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, 200 SW 35th St., Corvallis, OR 97333, USA; [3] University of New England, Armidale, NSW Australia; [4] Riverfutures, Riverway, 48 Middle Row, Cressbrook, Derbyshire, SK17 8SX, UK

Watersheds are spatially explicit landscape units that contain a range of interacting physical, ecological and social attributes. They are social-ecological systems that provide a range of ecosystem services valued by society. Their ability to provide these services depends, in part, on the degree to which they are impaired by human-related activity. An array of indicators is used by government agencies in the United States and elsewhere to assess aquatic water bodies, such as lakes and streams, often in comparison to a reference condition. However, assessments can suffer from the fact that the natural settings of many systems will differ from those sites used to build reference expectations. Additionally, given the ubiquity of human-related alterations across landscapes (e.g., atmospheric deposition of anthropogenically-derived nitrogen), we cannot describe truly unaltered conditions for most, if not all, watersheds. Definitions of 'integrity' have been developed for river ecosystems, but mainly at the reach or site scale and for particular aquatic endpoints, such as fish or macroinvertebrates. However, these scales are inappropriate for entire watersheds. In addition, current assessment of endpoints do not indicate the source of impairment. We define 'watershed integrity' as the capacity of a landscape, contributing surface water to a single location, to support and maintain the full range of ecological processes and functions essential to the long-term sustainability of biodiversity and the watershed resources and services provided to society. To operationalize this definition as an assessment tool, we identified six key functions of unimpaired watersheds. The six key functions are hydrologic regulation, regulation of water chemistry, sediment regulation, hydrologic connectivity, temperature regulation, and habitat provision. This approach can be used to model and map watershed integrity by incorporating risk factors (human-related alterations or stressors) that have been explicitly shown to interfere with and degrade key functions in watersheds. An advantage of this approach is that the index can be readily deconstructed to identify factors influencing index scores, directly supporting the strategic adaptive management of individual components that contribute to watershed integrity. Moreover, the approach can be iteratively applied and improved as new data and information become broadly available, such as data on aquifer resources.

(151) Interaction Effects of Future Land Use and Climate Change on River Fish Assemblages, Habitat Shifts and Related Dispersal

Johannes Radinger, Franz Hölker, and Christian Wolter

Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany

Streams and rivers are among those ecosystems most greatly impacted by human activities and their biodiversity is highly threatened by future changes in land use and climatic conditions. However little is known how these two dominant global drivers interact, whether their interaction effects locally differ in size, direction and extent and whether such interactions amplify or buffer the overall impact on fish assemblages compared to the single independent pressures.

The 1094 km long River Elbe is a major tributary of the North Sea with a catchment of 147,200 km². For the River Elbe catchment we modeled species distributions of 33 fish species using boosted regression trees to uncover the role of single and interacting effects of climate change and land use change. Species-specific models were built for future moderate as well as extreme scenarios to assess synergistic, additive and antagonistic interaction effects on species losses and species gains as well as on α- and β-diversity indices. Moreover, using the GIS-based fish dispersal model FIDIMO we want to provide first insights to which extent potential range shifts caused by changing future conditions can be managed and compensated by species-specific dispersal movements of selected fish species.

The results revealed, that the catchment-wide average species richness is predicted to increase by 0.7, 1.4 and 2.5 fish species in the moderate climate change scenario, in the moderate land use change scenario and in the combined scenarios, respectively by 2050. For 56-85% of the catchment significant changes in species richness were predicted. In up to 11% of the catchment these changes in richness are associated with substantial changes in species composition (Sørensen similarity < 0.5 compared to baseline conditions). Antagonistic interaction was the dominating effect on species losses and gains found in up to 75% of the catchment. In contrast, synergistic and additive effects were detected for only up to 20 % and 16% of the catchment, respectively. Interestingly, the size of the joint interaction effect was negatively spatially correlated with the size of single independent effects of land use and climate change.

Concluding, in this study we evaluate (i) how potential species assemblages will change under future land use and climate conditions and provide evidence that (ii) land use and climate change effects are highly interacting (antagonistic, synergistic and additive) causing (iii) species composition shifts which are highly spatially variable in size and characteristic within a single major European catchment.

Keywords: fish distribution modelling; river fish diversity; climate change; land use change; interaction effects; fish dispersal; FIDIMO

(157) A Methodology for Modeling Hydrology, Water Quality, and Habitat Outcomes Using Alternative Landscape Scenarios

Megan McGuire

US Army Corps of Engineers

The 10 million acre Minnesota River Basin has been highly altered by agriculture, development, and changing climate patterns. Increased subsurface drainage, large drainage ditches, and increased impervious surface area have greatly increased base flow in the Minnesota River and its tributaries, which has drastically increased the sediment and nutrient loads, negatively impacting navigation and habitat in the Mississippi River and the Gulf of Mexico. The State of Minnesota's Sediment Reduction Strategy calls for an 80-90% reduction in the baseline sediment load of approximately 1,200,000 tons per year. Within the Minnesota River Watershed, many tributary rivers and lakes are impaired for a variety of water quality standards. The Army Corps of Engineers is working with the States of Minnesota, South Dakota, Iowa, and many local government and non-profit organizations to envision alternative futures for the basin by modeling the effects of alternative landscape scenarios on hydrology, water quality, habitat, and agricultural production. Five alternative landscapes were developed using spatial rules inspired by Nassauer et al. (2007) based on several GIS layers including NLCD, SSURGO, and NWI. Unlike the Nassauer approach, which used hand-digitizing, this study developed automated spatial rules that were programmed in ArcGIS. The study has developed a replicable methodology for other watershed investigations to use in the development of alternative future scenarios for modeling applications. The five alternative landscapes we developed are: 1) Existing Conditions, 2) Pre-European Settlement, 3) Increased Agricultural Commodity Production, 4) Improved Water Quality and Reduced Downstream Flooding, and 5) Enhanced Biodiversity. Each alternative landscape is based on a unique set of rules that reflect distinctly different landscape objectives. The alternative landscapes intentionally present extreme case studies that bracket the range of potential future scenarios and explore a wide range of hydrologic, water quality, habitat, and economic outcomes. We are also engaging with stakeholders to develop locally-preferred hybrid scenarios that incorporate features intermediate to the extreme scenarios. Landscape outcomes will be modeled using several technical models including the hydrologic model Gridded Surface Subsurface Hydrologic Analysis (GSSHA). For our study, the GSSHA model was built at multiple nested scales to help determine scaling relationships that can be applied throughout the basin. The same alternative landscapes will be run through several habitat evaluation models: the FWS Habitat and Population Evaluation Team (HAPET) models for ducks and grassland birds and the Midwest Fish Habitat Partnership models for fish habitat condition. These spatially-explicit hydrologic and habitat models are highly influenced by extent and distribution of land cover. The same alternative landscape methodology could be applied to other hydrologic and habitat models to meet the needs of individual studies. The methodology to develop the alternative landscapes will be described along with their use in multiple technical models to estimate potential outcomes for hydrology, water quality, habitat, and agriculture. Although the model runs are not complete, the alternative landscape methodology should prove useful to other large river researchers and will provoke discussion on modeling future scenarios for agricultural watersheds.

Joan Iverson Nassauer, et. al. (2007) Alternative Scenarios for Future Iowa Agricultural Landscapes

(158) "Cross-Feeding" Across a Big River Floodplain Evaluated by Simulation Modeling

Clifford Ochs[1] and F. Douglas Shields[2]

[1] University of Mississippi, Oxford, MS, USA; [2] Shields Engineering, LLC

Cross-feeding refers to a symbiosis in which the products of one organism are the substrates of a second organism, and vice versa. Here, we use the term metaphorically to describe the interactive and highly dynamic relationship between the main channel and connected floodplain backwaters of the Lower Mississippi River. In the main channel pelagic autotrophic production is light-limited and algal biomass concentration does not vary substantially by season. In contrast, supported by nutrients that wash into hundreds of connected lakes and wetlands during the annual spring flood, backwaters autotrophic production is seasonally intense, with increases of algal biomass concentration by nearly two orders of magnitude. Some of this backwaters production, in the form of algae and other organisms, is exported to the main channel as the river elevation drops in summer and fall. Hence, "cross-feeding": In exchange for seasonal import of dissolved nutrients from the river to backwater lakes and wetlands, there is seasonal export of biological production to the river from backwaters. Based on empirical data collected in 2006-2009, we quantitatively modeled the respective roles that backwaters and the main channel play in this relationship. Model drivers were variables used to evaluate river-backwaters hydrologic connection strength including river elevation, nutrient exchanges, numbers and volume of backwaters, and their hydraulic residence time. Based on model output, we assess the potential strength of cross-feeding for backwaters biological production, exchanges of nutrients and organic matter with the river, as well as backwaters nutrient sequestration.

Keywords: Lower Mississippi River; Phytoplankton; Connectivity

(159) Lagrangian River Drifters Reveal Dissolved Oxygen Dynamics in a Large River

Scott Ensign[1], John Gardner[2], Martin Doyle[2], and Ryan Neve[1]

[1] Planktos Instruments, Morehead City, NC, USA; [2] Duke University, Durham, NC, USA

Lagrangian drifters were used to characterize dissolved oxygen and light regimes in a low gradient alluvial river during low (68 cubic meters per second) and high (225 cubic meters per second) discharge. Drifter measurements were compared with data from a stationary sensor at the drifters' splash-point. During low flow, a neutrally-buoyant, subsurface drifter (average, minimum, and maximum depth of the drifter was 1.4, 0.4, and 4.9 m) traveled 42 km in a 24 hr period. The same drifter traveled 16 km in a 6 hour period (average, minimum, and maximum depth was 3.4, 0.4, and 7.2 m) during high discharge before becoming snagged on the bottom. A floating drifter traveled 15 km in a 5 hr period during high discharge before becoming trapped in a debris jam. The surface drifter recorded more variable dissolved oxygen (mean= 10.4 mg per L, standard deviation = 0.3 mg per L) than the subsurface drifter traveling beneath it (standard deviation = 0.2 mg per L). The more variable oxygen concentration at the surface may have resulted from the surface drifter consistently travel close to the river bank and frequently contacting large floating debris jams. Presumably, high rates of respiration within these debris jams created heterogeneous dissolved oxygen concentrations near the river bank that became fully mixed within the thalweg where the subsurface drifter sampled. The stationary sensor at the head of the study reach recorded a diurnal dissolved oxygen fluctuation of 0.8 mg per L during high discharge, a pattern that was also apparent in the drifter data. No diurnal change occurred during low flow. By replicating the vertical mixing of planktonic organisms, the neutrally-buoyant subsurface drifter was able to measure the cumulative light exposure during transport. Despite a 2 m deep euphotic zone during high discharge, cumulative light exposure was vastly greater during low discharge when the euphotic zone was 1 m deep but maximum depth was 3 m. These Lagrangian data provided insights on dissolved oxygen dynamics and an understanding of ecosystem productivity that expanded the measurement boundaries of fixed-station sampling methods. In particular, the drifter data revealed spatial and temporal heterogeneity in dissolved oxygen and light that would have remained hidden from fixed-station or boat-based measurements. Finally, the ability of neutrally-buoyant drifters to replicate the vertical and horizontal mixing of organisms in large rivers offers a novel platform for field-based studies to quantify organisms exposure regimes to light, temperature, travel time, water chemistry, and hydraulic conditions.

(160) Quantifying the Effects of Envioronmental Variables on the Composition and Activity of Denitrifhying Microbial Communities

Abigail Tomasek[1], Miki Hondzo[1], Jessica Kozarek[1], and Michael Sadowsky[2]

[1] St. Anthony Falls Laboratory, University of Minnesota, Minneapolis, MN, USA; [2] BioTechnology Institute, University of Minnesota, Minneapolis, MN, USA

Human activities, largely from agriculture, have increased the amount of global reactive nitrogen in the environment. Fertilizer application in the Upper Midwest delivers high concentrations of nitrate, a highly mobile form of nitrogen with negative ecological and health implications, to surface waters. The extensive tile drainage network in the area, allowing nitrate to flow directly to surface waters, exacerbates this problem. High nitrate concentrations in the Mississippi River have been shown to be the predominate cause of the dead zone in the Gulf of Mexico. In aquatic environments, complete denitrification can be viewed as a nitrate sink, converting nitrate into inert nitrogen gas that is released to the atmosphere. Denitrification hot spots, or small areas of enhanced denitrification activity, and hot moments frequently account for a high percentage of overall denitrification in streams and floodplains. This research aims to identify and quantify parameters that enhance denitrification hot spots. Investigated parameters include the influence of carbon type and concentration, moisture content, water velocity, and flooding frequency and duration. Results will be presented from flume, field, and a controllable outdoor experimental stream experiments. Three field sites in a small, agriculturally dominated watershed in Southern Minnesota were visited 3 times over a field season to determine temporal variability in denitrification. Two of these sites were targeted for a cross-sectional sampling to determine the variability of denitrification across a channel. The experimental stream was used to determine the effect of flooding on denitrification. Flume experiments were used to determine the effect of sediment carbon content and water velocity on denitrification. The denitrification potential of each sediment sample was determined using the denitrification enzyme activity (DEA) assay and the abundance of denitrifying genes was quantified using qPCR. A subset of the samples was submitted for metagenomic analysis to investigate the microbial communities associated with areas of high denitrification activity. Integrating the denitrification potential with the quantity of denitrifying genes provides insight into the effect of environmental variables on both the composition and activity of microbial communities and provides a microbial processed based understanding for sustainable surface water management to promote denitrification.

(161) Changes in Sediment Nitrogen Dynamics as a Result of Water Level Manipulaitons in the Upper Mississippi River (Naviagation Pool 8) and Lower Illinois River (Swan Lake)

William Richardson[1], Jennifer Cavanaugh[1,2], Lynn Bartsch[1], and Eric Strauss[1,3]

[1] U S Geological Upper Midwest Environmental Science Center, La Crosse WI, USA; [2] Natural Resource Conservation Service, Davis, CA, USA; [3] University of Wisconsin – La Crosse River Studies Center, La Crosse ,WI, USA

Intentional water level reductions, or "drawdowns," are being used more frequently in large rivers to improve vegetation growth and wildlife habitat. Such drawdowns could have significant effects on sediment nutrient biogeochemistry mainly due to changes in sediment oxygen dynamics. We selected two areas of the Upper Mississippi River system (Navigation Pool 8 and Swan Lake) to examine the effects of water level drawdown on Nitrogen (N) dynamics. Navigation Pool 8 underwent summer drawdowns in 2001 and 2002, and in Pool 8; we determined the effects of sediment drying and rewetting resulting from water level drawdown on (1) patterns of sediment nitrification (conversion of ammonium to nitrate) and denitrification (conversion of nitrate to nitrogen gas) and (2) concentrations of sediment total N, nitrate (NO_3^--N), and ammonium (NH_4^+-N) and sediment moisture and bulk density. We examined these variables in 20 backwater sites before, during, and after the water level drawdown to observe changes resulting from desiccation and re-wetting of sediments on a 10-site "drying" transect that dried during the drawdown and from another 10-site reference transect that remained inundated. During the dry period, pore water NO_3^- concentrations and denitrification increased on the drying transect whereas nitrification and exchangeable NH 4^+ concentrations decreased. Sediment NH_4^+ concentrations (pore-water) decreased significantly in Pool 8 during periods of desiccation, while sediment $NO_3^-$and rates of denitrification increased, although there was no reduction in total sediment N. Increased aeration in the drying transect allowed NO_3^- produced via nitrification to persist, resulting in higher concentrations of available NO_3^-, which subsequently enhanced denitrification. The reduction in sediment NH $_4^+$ in Pool 8 was likely a result of increased plant growth (deep-rooted deeper-rooted *Sagittaria* and *Nelumbo*) and N assimilation, which is then re-deposited back to the sediment surface upon plant senescence, resulting in a net gain of surficial sediment N.

We also examined sediment N concentration and sediment moisture and bulk density in three areas of Swan Lake, IL, a semi-isolated backwater on the lower Illinois River managed to promote water fowl production using drawdowns. Portions of upper Swan Lake have been drawndown since the 1970s, while lower regions have been since 1999 and the lowest portions since 2003. Sediment NH_4^+ concentrations in areas that have dried annually in Swan Lake were lower, but not significantly so, in sediments that remained wet.

The Swan Lake study suggested that longterm drawdowns do not result in a significant long term reduction in sediment N. Combined, these results indicate that water level drawdowns are probably not an effective means of removing nitrogen from the Upper Mississippi River system. Fundamentally, in order for N reduction to occur via denitrification, nitrate-laden water must have

contact with carbon-rich, anoxic sediments to promote denitrification. Clearly this is not the case during a drawdown where sediments dry with extended exposure to air.

Keywords: nitrogen; denitrification; nitrification; porewater; nitrate; ammonium; drawdown; Upper Mississippi River; Illinois River;

(162) Pool-Scale Growing Season Drawdowns Enhance Aquatic Vegetation Communities on the Upper Mississippi River

Kevin Kenow

U.S. Geological Survey - Upper Midwest Environmental Sciences Center, La Crosse, WI, USA

The Upper Mississippi River (UMR) was transformed into a series of shallow navigation pools to facilitate commercial navigation in the 1930s. These pools initially supported a diverse complex of wetland habitats. Over time, habitat quality in these pools was degraded and large expanses of open water with little vegetation developed that were less beneficial to desired fish and wildlife.

In an effort to enhance aquatic plant production and habitat diversity on the UMR, the U.S. Army Corps of Engineers St. Paul District conducted summer-time water level reductions (drawdowns) of Navigation Pools 5 (2005 and 2006), 6 (2010), and 8 (2001 and 2002) of the UMR. The water level reductions were expected to improve conditions for seed germination and growing conditions for emergent and submersed aquatic vegetation (SAV). The composition and viability of the seed banks from drawdown areas was determined experimentally using a seedling emergence method. We assessed vegetation response to the drawdowns through (1) interpretation of high-resolution aerial photography, (2) field measures of the distribution of SAV, and (3) field measures of the composition and productivity of emergent perennial and moist soil vegetation on exposed substrates.

Timing of seedling germination varied among species and has implications for scheduling drawdowns to promote establishment of desired species. A wide variety (>70 taxa) of moist soil, emergent, rooted floating aquatic, shrub, and tree species colonized substrates exposed during the drawdowns. This vegetation response correlated well with seed bank results. Exposed substrates were dominated by both emergent and moist soil annual species the first year followed by a shift from plant community dominated by annuals to one dominated by perennials. Pool-wide drawdowns likely contributed to increases in deep and shallow marsh annual, submersed aquatic, and shallow marsh perennial plant communities. While increases in SAV were documented, it is difficult to attribute this response solely to drawdown effects when system-wide variability in growth is considered. Long-term persistence of emergent perennial and rooted-floating aquatic plant beds reestablished as a result of the drawdowns is addressed.

Keywords: Drawdown; habitat restoration; Upper Mississippi River; vegetation response; water level management

(163) The Value of Inventory Monitoring Data for Detection of a Response to Drawdowns on the Upper Mississippi River

Ruth Nissen

Wisconsin Department of Natural Resources, Mississippi River Team, La Crosse, WI, USA

The U.S. Army Corps of Engineers- St. Paul District (USACE) conducted experimental water level reductions during the summer growing season on Navigation Pool 8 of the Upper Mississippi River (UMR) in 2001 and 2002 to improve conditions for the growth of aquatic vegetation, while simultaneously continuing to provide a safe navigation channel for commercial navigation. An ambitious detailed monitoring plan was developed by the multi-agency Water Level Management Task Force for the Pool 8 drawdowns to evaluate the vegetative response to a pool-scale drawdown, assess the effects of drawdown on physical, chemical, and biological parameters, evaluate effects on channel maintenance requirements, and effects on river uses such as recreation, commercial navigation and cultural resources. The monitoring was a multi-agency effort depending on funding and personnel from the USACE, U.S. Geological Survey- Upper Midwest Environmental Sciences Center (UMESC), U.S Fish and Wildlife Service- Upper Mississippi River National Wildlife and Fish Refuge (Refuge), Wisconsin Department of Natural Resources (WDNR), and Minnesota Department of Natural Resources (MDNR). The biological component included two avenues of monitoring: 1) existing monitoring programs; and 2) new studies specifically designed to assess response to the drawdowns. Not all biological monitoring tasks were initiated or finished to completion due to biological reasons or funding and staff constraints. Monitoring summaries were completed for fisheries, mussels, shorebirds, waterfowl, avian botulism, waterfowl hunter surveys, and contaminant availability. Generated products included agency reports and peer-reviewed publications. Based on the experience gained from monitoring effects of the Pool 8 drawdowns, monitoring task recommendations were modified for subsequent drawdowns in other pools. This adaptive process has continued as new hypotheses and expanded data collection have been recommended that could further assess the effect of drawdowns on fisheries, shorebirds, and waterfowl. New methods of data collection and analyses of existing data continue to be explored to gain further insight on the biological effects of drawdowns on the Upper Mississippi River.

(164) Pool-Scale Drawdowns on the Upper Mississippi River – WHA

Tim Schlagenhaft[1] and Gretchen Benjamin[2]

[1] The Audubon Society; [2] The Nature Conservancy

Pool-scale drawdowns on the Upper Mississippi River have been successful in restoring emergent aquatic vegetation and have had a positive effect on fish and wildlife. While much is known about drawdown effects, there remain several important unanswered questions including optimum extent (depth), duration (length of time), and frequency of drawdown. In addition, effects on fish, mussels, shorebirds, waterfowl, and other wildlife need to be better understood to inform management decisions. Also, implementing drawdowns has been time consuming and challenging, often taking 4-5 years to plan and conduct individual pool drawdowns. Challenges include accommodating commercial navigation and recreational boating needs, covering costs of supplemental dredging, and working within U.S. Army Corps of Engineers operating policies. The Water Level Management Task Force is working to learn more about the effects of drawdowns and to shorten the time-frame for drawdown planning and implementation. An adaptive management strategy was developed by the Task Force to address unanswered questions, and a process to make drawdowns routine and operational is being pursued. This presentation will detail these strategies to improve our knowledge about drawdown effects and make drawdown implementation more efficient.

Keywords: Upper Mississippi River, water level management, drawdowns, adaptive management

(165) Challenges and Advantages to Restoration of Floodplain Ecosystems: Lessons Learned from Restoration of Sites Invaded by Reed Canarygrass in the Upper Mississippi River System

Meredith Thomsen[1], Carrie Reinhardt Adams[2], Nathan De Jager[3], and Eileen Kirsch[3]

[1] University of Wisconsin-La Crosse River Studies Center, La Crosse, WI, USA; [2] University of Florida, Gainesville, FL, USA; [3] U.S. Geological Survey - Upper Midwest Environmental Sciences Center, U.S. Geological Survey - Upper Midwest Environmental Sciences Center, La Crosse, WI, USA

The restoration of invaded floodplain ecosystems is notoriously difficult, often requiring managers to address multiple biotic and abiotic processes and to work across jurisdictional boundaries. In some systems, the natural flooding regime and riverbed morphology are so dramatically altered that restoration must first focus on hydrogeomorphology before plant community composition can be addressed. The Upper Mississippi River offers a contrasting case study in this regard. Although it is impounded by a series of dams that increase summer-time water levels, significantly affecting many ecosystem characteristics, these dams do not prevent seasonal flooding and hence the floodplain remains highly connected to the river. In some ways this connectivity hinders the restoration of forest sites invaded by *Phalaris arundinacea*, an aggressive invader of North American temperate wetlands. For example, the flood-pulse introduces a significant stochastic element to every project. When crossed with the topographic heterogeneity of floodplain environments, the result is the almost guaranteed failure of vegetation management actions in some years and/or some areas of a given site. The effects of hydrology on site conditions and plant performance are complex, making it difficult to tell whether flood duration, timing, or depth is the most important in determining restoration success. Even where young trees become established, episodic flood-related mortality and intense herbivory by white-tailed deer can open the door to re-invasion by *Phalaris*. In other ways, however, the natural characteristics of a floodplain system promote forest restoration. Reliably dry periods of the year provide a window of opportunity for the application of restoration treatments. Native floodplain plant species include many which are fast-growing and disturbance-adapted and thus benefit from the high nutrient availability of floodplain soils. The natural heterogeneity of floodplain habitats creates some areas where natives may have a competitive advantage, for example where forest trees shade plants in canopy gaps. Native propagules are widely distributed by floodwaters and can survive for long periods in the soil seedbank. Furthermore, the dominance of the flood-pulse means that once native cover is re-established there may be a rapid return to pre-invasion ecosystem function, in contrast to other systems where invasion has a longer legacy. We seek restoration approaches that capitalize on the advantageous characteristics of the floodplain. For example, by applying restoration treatments across elevation gradients we can improve the chances that they are effective within some portion of a site during a given year. Alternatively, by promoting the rapid height growth of native tree species we can increase the likelihood that they get out of the reach of competition, flooding, and browsing, preventing subsequent re-invasion of the site. Designing projects using the idea of applied nucleation, in which effort is focused on establishing small areas of restored vegetation rather than on treating entire sites, is another way we could hedge our bets. Finally, the development of mechanisms by which land managers could decide

which projects to pursue in a given year based on forecasted flood durations might allow us to avoid some costly failures.

(166) Effect of Sediment Load on Vegetation Colonization in Midstream Riparian Zone

Takashi Asaeda and Kelum Sanjaya

Institute of Environmental Science and Technology, Saitama University, Saitama, Japan

Stony areas are a typical landscape of the midstream riparian area providing a unique habitat for miscellaneous pioneering species. Flooding is a crucial course to preserve the stony surface, where deposition and erosion ensue concurrently while changing the landscape of riparian zone by washing off trees and herbs. Erosion and deposition play a vital role in nutrient dynamic in rivers. Further, the sediment plays an important role in determining the river morphology other than the nutrient dynamics. Invasive woody species (*Robinia pseudoacasia*, *Alianthus altissimia*, etc.) and herb species (*Sicyos angulatus*, *Solidago canadensis*, etc.) are extremely dominant in riparian zones of Japanese rivers, although the reason is unknown. Thus, the objective of the current study was to assess the possible consequences of the sediment accumulation and attrition in riparian area on the basis of remote sensing and a numerical model. Past aerial images were assessed to identify eroded and deposited locations after floods in middle reach of Hii River, Japan. Arc Gis 9.3 software was used for georeferncing and processing the images. After analyzing continuous images before and after flood erosion and deposition, the number of years for herbs appearance in deposited and eroded locations was estimated separately. The colonization of herb was delayed after the flood in average ~1.3 years at the eroded sites and ~2.4 years at the sediment-deposited sites. Herb colonization takes longer time in the deposited locations than in the eroded locations. The colonization of herb requires a sufficient amount of nutrients and seeds beforehand. When, compare the eroded sites where the underlying sediments are exposed after flushing off the surface sediments, deposited sites are consisted of cleansed fresh sediments with low in nutrients, hence the colonization is delayed. A Dynamic models was built to understand the soil nitrogen budget and vegetation colonization on river sediment bars. The model consists of modules for recruitment and later growth of trees, herb biomass based on the edaphic condition, and the nutrient budget of the riparian soil, associated with flood characteristics. The model was applied to three rivers to simulate tree and herb coverage of the riparian area for 20 to 50 years and they were fairly agreed with the observed results. Then, simulation was conducted for assumed magnitude of flood with 2 year, 5year and 10 year intervals for 10 year period for different fractions of deposited and eroded areas. The vegetation coverage substantially reduces with increasing deposited area fraction; nevertheless, the increase of eroded area did not show a change of vegetation coverage. Other than the deposition, high inundation frequency was given low vegetation coverage and low inundation frequency was wise versa. On the other hand, the simulated results reasonably agreed with the observed nutrient contents in the sediment, indicating that nutrient limitation in the deposited area resist for vegetation invasion. Therefore, it suggests that the deposition of cleansed wash sediment substantially delay the vegetation colonization over erosion in riparian area.

Keywords: Invasive species; Flood disturbance; Deposition and erosion; Model application; Aerial photographs

(167) Modelling and Application of River Ecological Model

Yoshihisa Akamatsu

Yamaguchi University, Yamaguchi, Yamaguchi Prefecture, Japan

Ecological models based on mass balance are useful methods to understand the mechanisms maintaining an aquatic ecosystem. Such ecological models for aquatic ecosystems are typically designed to be applied to enclosed water bodies such as bays and lakes. These models usually consist of a surface flow model, a biological model, a heat-balance model and a mass-balance model. However, these models are difficult to apply for rivers, since various boundary conditions are indispensable for a long-term transient calculation and river bed variation is need to be taken into account.

In this study, the ecosystem model is developed to know the material balance in the river ecosystem, which consists of one-dimensional unsteady flow, one-dimensional calculation of bed variation, heat balance, water quality and biological model. This water quality model deals with particulate organic carbon (POC), dissolved organic carbon (DOC), ammonia nitrogen (NH_4-N), nitrite (NO_2-N), nitrate (NO_3-N), orthophosphate (PO_4-P) and dissolved oxygen (DO). In the biological model, attached algae, zooplankton, phytoplankton, benthic animal and fish are taken into account.

The ecological model is applied for Saba River, Yamaguchi Prefecture, Japan. Calculation area is a section of 4～23km from river mouth. Field observations were conducted in this section in order to verify the reproducibility of this model. Water discharge, water temperature and dissolved oxygen were monitored at upstream and downstream boundaries from 1st, January to 31th, December, 2013. Water sampling and fish, benthic animal, attached algae sampling were conducted at four points at 11th, March, 16th, June, 19th, August, 23th, October and 27th, December. For each water sample, the following parameters were measured: dissolved organic carbon (DOC); and nutrients (orthophosphate (PO_4-P), total phosphorus (T-P), ammonia (NH_4-N), nitrate (NO_3-N), nitrite (NO_2-N), and total nitrogen (T-N)). For organism samples, dry weights are measured.

The temporal variations of water level, water temperature, dissolved oxygen and the amount of attached algae obtained from this model during the ordinary flow show a good agreement with the observed results. During the flood, the observed riverbed deformation was a little smaller than the calculated. However, it is enough to evaluate the influence of sediment transport on the habitat of fish, aquatic animal and attached alga. These results reveal that this model is useful to predict the variation of material balance in the river ecosystem due to the climate change and the river crossing structure such as weir and dam.

(168) Assessment of Geomorphic Impacts of Riparian Vegetation Removal on the Colorado River

Gigi Richard

Colorado Mesa University, Grand Junction, CO, USA

The introduction of tamarisk (*Tamarix* spp.) to the riparian zones adjacent to the Colorado River and many of its tributaries in the southwestern US has contributed to increased stability of the river channels. The increased stabilization and salinization of riparian zones and increased total water consumption of tamarisk stands create a significant impact in the Colorado River drainage basin on the main stem and many tributaries. Tamarisk impacts on the Colorado River and its tributaries have led to removal efforts and the release of the tamarisk leaf beetle (*Diorhabda carinulata*) as a biological control agent. Bank erosion following high flows in 2011 in areas where vegetation removal had occurred suggests that recent efforts at removal of tamarisk could contribute to increased bank erosion and increased channel mobility.

The purpose of this study is to assess changes in channel mobility following tamarisk removal along a 51-km reach of the Colorado River in western Colorado via GIS analysis of repeat aerial photos of the channel and side channels in areas where removal has been accomplished and field surveying of cross sections in three reaches of the Colorado River where tamarisk removal occurred in January 2015, with the intention of continued annual monitoring to measure future cross-section geometry changes.

Baseline field surveying of river cross sections was accomplished prior to and immediately following riparian vegetation removal. A total of twenty cross sections in three one-kilometer study reaches were surveyed with survey-grade GPS to map the pre-removal channel bathymetry. Topographic survey of the riparian zones will be accomplished with aerial LIDAR following removal of invasive riparian vegetation. The removal sites will be resurveyed following the next near-bankfull streamflow to assess changes in channel morphology.

Changes in the historic channel for the entire 51-km reach were measured by digitizing the non-vegetated active channel in GIS, including the main channel and side channels. Areas of significant channel change were identified and classified as removal areas, non-removal areas, or adjacent to removal areas. The size of the eroded areas, including total area, length of bankline where erosion occurred and width of the erosion into the bank, were compared between removal and non-removal sites. Initial results do not indicate significant difference in sizes of eroded areas in reaches where vegetation removal had occurred versus sites where riparian vegetation was not removed.

Poster Presentations

(P001) Change of DO and Turbidity During the First Flush in Urban Streams and their Effects on Fish

Bomchul Kim and Doohee Won

[1] Dept. Environmental Science, Kangwon National University

In urban streams organic ooze can accumulate at the bottom of sewer or ditches. When it rains water flow velocity increase and the organic ooze or sediments are resuspended to be discharged into main channel of streams. Consequently turbidity and BOD can increase in the early phase of a rain runoff which can be called the first flush effect. Automatic data logging sensors were installed at two urban streams in Seoul, Korea (the Mokgamchon Stream and the Tanchon Stream) and the fluctuations of DO and turbidity were monitored. During the first flush period turbidity increased drastically to over 1,000 NTU. At one stream site DO depletion occurred at the time of turbidity increase. Fish survival test using a cage showed that the water quality during the early phase of rain runoff is not suitable for fish survival. But fish is living in the streams and we need more information in order to explain the dilemma of fish survival in streams of occasional DO depletion.

Keywords; urban stream, DO depletion, turbidity, fist flush, fish survival

(P002) Connectivity and Export of Fish Biomass to the Lower Missouri River from A Managed Floodplain Wetland

Meagan Montgomery and David Galat

University of Southern Illinois, Carbondale, IL, USA

Connectivity to facilitate recruitment of fishes to large rivers from floodplain spawning and nursery areas depends on overlap of rises in river stage and temperature, predictability of connecting flow pulses, rate of their rise and fall, and duration of connection and area of floodplain inundated. Restoration projects are being undertaken along the lower Missouri River (LMOR), Missouri, to mitigate past channelization and levee construction that severed river-floodplain connectivity and denied riverine fishes access to adjacent seasonally-flooded wetlands. Two actively managed wetland pools were constructed for fish spawning and nursery at Eagle Bluffs Conservation Area (EBCA) as part of the Missouri River Recovery Program. Pools were built with water-control structures designed to allow controlled passage experiments on ingress and egress of riverine fishes. Our objective was to estimate biomass export of the total fish assemblage and of individual fishes from EBCA to the Missouri River following periods of managed wetland inundation and isolation. The flood pulse initiating lateral connectivity differed between the 2007-2008 study years. There was one major flood pulse in spring 2007; whereas, multiple flood pulses of smaller magnitude and duration occurred in spring 2008 followed by a larger flood pulse in summer. The major 2007 flood pulse overtopped the pool levees inundating much of EBCA and preventing an accurate estimate of fish import for 2007. Over 60 species, a mixture of native and invasive fishes, used the pools during study years. Five ingress and 2 egress events occurred in 2008 resulting in 4,640 individuals and 4,100 kg biomass from 33 taxa entering and 3.3 million individuals and 45,600 kg biomass from 41 taxa exiting the pool. Net 2008 export to LMOR was 139,000 fish/ha and 1960 kg/ha. Numerically dominant native fishes entering were shortnose gar (33%), gizzard shad (11%) and bigmouth buffalo (8%). Orangespotted sunfish (32%) gizzard shad (20%) and mosquitofish (13%) were most abundant native fishes exiting. Common carp was the most abundant invasive entering (30%); whereas bighead carp (8%), common carp (7%) and silver carp (6%) were most abundant invasives exiting. Bigmouth buffalo (22%) and shortnose (21%) dominated native fish biomass entering with common carp biomass slightly more (52%) than these combined. Shortnose gar (29%), and gizzard shad (10%) contributed the most native fish biomass exiting but were far exceeded by the combined biomass of invasive Asian carps (55%). This is one of the few studies to quantify fish biomass export to a large river and the importance of floodplain wetlands to annual large river fish recruitment. Results show how river-floodplain connections, especially those associated with large flood pulses, benefit recruitment of both favored native species and invasive Asian carps. Such knowledge can guide management and conservation efforts to promote or regulate targeted fish species.

Keywords: river-floodplain connectivity; Missouri River Recovery Program (MRRP); actively managed wetlands, fish recruitment, fish biomass import/export; invasive fishes

(P003) Connectivity May increase Growth of Largemouth Bass in the Upper Illinois River

Cassidy Miles, Jason DeBoer, Mark Fritts, and Andrew Casper

Illinois River Biological Station, Illinois Natural History Survey, University of Illinois-Urbana Champaign, Urbana, IL, USA

Knowing how climate affects aquatic ecosystems is important for conservation and management of fish populations. We can use annual growth increments from fish otoliths to understand effects of environmental factors on individual fish growth. We collected Largemouth Bass (LMB) Micropterus salmoides using pulsed-DC electrofishing in the Dresden Reach of the Upper Illinois River during Spring 2014, assigned ages to each fish, and back-calculated lengths-at-age from otolith growth increments. We modeled incremental growth as a function of age and several age-corrected environmental factors (e.g., river stage height, discharge, weather). Our environmental factors were auto-correlated, thus we only used a single environmental factor in each model, and used AICc to rank our models. Length increased with age and appeared to asymptote at age 6, whereas growth decreased with age. Age explained 77% of the variation in growth; however, each of the models containing age and an age-corrected environmental factor had a lower AICc than the age-only model. The two models containing maximum and minimum stage height had a combined AICc weight of 0.96. The parameter estimates for stage height were positive, indicating greater LMB growth occurred in years with greater stage height. We postulate greater stage height could allow for: (1) reconnection to seasonally isolated backwaters, which offer (a) greater access to energetically beneficial prey and (b) refugia from energetically expensive river flows, (2) increased availability of and access to flooded terrestrial habitat, and (3) inflow of floodplain nutrients into main-channel riverine habitats, which benefits LMB that remain in the main channels.

(P004) Estimating Trends in River Water Temperature Using Water Temperature Measurements from Haphazard Times and Dates

Eric Eager[1] and Brian Gray[2]

[1] University of Wisconsin - La Crosse River Studies Center, La Crosse, WI, USA [2] US Geological Survey Upper Midwest Environmental Sciences Center, La Crosse, WI, USA

Interest in the effects of climate change has led to multiple recent studies of trends in river and stream water temperature. Such trends, when present, may affect biotic processes and community composition. A challenge to the estimation of trends in river water temperature is that legacy water temperature datasets are often comprised of spot measurements taken at haphazard times during daylight. Such datasets may also derive from dates that have themselves been selected haphazardly. Given that water temperature typically varies diurnally and seasonally, trends in measured water temperature from spot measurements may reflect actual trends, artifactual trends induced from trends in time or date of sampling, or combinations thereof. Of course, contributions from such artifactual trends will bias estimates of actual trends in water temperature. Our efforts to minimize such bias have, to date, focused on cases where one to many water temperature measurements at haphazard times and dates were obtained on at least some days within an approximately two-week sampling interval per year. The proposed method—that of multilevel or hierarchical regression—yields effectively unbiased estimators of temperature trend: Using simulated data, biases in trend estimates over 20 yr of 50% and 100% from consistent changes in haphazard time and haphazard date were both shrunk to 2% with the proposed method. The use of the proposed method with water temperature data from summer from the Illinois River, USA, where mean time of sampling decreased by 2 h (from 1200 to 1000 h) over a 17 yr period, yielded a trend estimate that was 31% larger when adjusted for time of sampling. We are beginning work on the potentially more challenging problem of estimating temperature trends.

(P005) Hydrologic Analysis of Floodplain Connectivity for Ecological Understanding and Management

Alison A. Whipple[1] and Joshua H. Viers[2]

[1] Center for Watershed Sciences, University of California, Davis, CA, USA [2] School of Engineering, University of California, Merced, CA, USA

A river's flow regime, particularly its flood regime, interacts with the surrounding landscape to drive important physical and ecological processes within riparian and floodplain communities. This connectivity is naturally dynamic and complex in space and time, contributing to high biological diversity and productivity. In many river systems, particularly lowland alluvial rivers, floodplain processes and functions have been substantially altered by water management, land use, and hydroclimatic change induced by climate warming. We describe a floodplain inundation regime using concepts and metrics similar to those used to define natural flow regimes to better understand the frequency and variability of physical conditions supporting biological communities. This research moves beyond flood frequency analysis to include flood event attributes that distinguish characteristic flood types via statistical cluster analysis. Floods are identified based on floodplain activation thresholds and characterized using metrics of ecological relevance from the natural flow regime paradigm, such as magnitude, duration, timing, rate of change, as well as other metrics, such as those pertaining to the shape of the hydrograph. Using these hydrologic metrics within cluster analysis allows for the characterization of meaningful flood types inundating floodplains, and thus an assessment of type frequency on both inter- and intra-annual bases. This analysis is applied to the Cosumnes River, the only major undammed river on the west slope of California's Sierra Nevada, and its record of over 100 years of continuous daily streamflow measurements. The lower Cosumnes River is also one of the few locations within California's Central Valley where floods are allowed to regularly access their floodplains and where several conservation and restoration efforts are present or underway. Research outcomes can be used both to understand historical and current conditions within the floodplain and to improve interpretation of future water, land use, as well as restoration impacts. Overall, this research directly informs understanding of ecologically relevant aspects of the Cosumnes River flow regime, provides insights for flow management and restoration efforts, and demonstrates the utility of applying these methods to other floodplain systems within California and globally.

(P006) Hydrologic Partitioning and Vegetation Response in Selected Moist Zone Catchments of Ethiopia: Analyzing Spatiotemporal Variability

Fasil Worku

Analysis relating spatiotemporal variability of hydrologic budget with that of catchment-vegetation is one of the avenues to explore vegetation response to climate variability and the resulting impact on water resources dynamics. Here the spatiotemporal variations of hydrologic budget and Normalized Difference Vegetation Index (NDVI) in six moist zone catchments of Ethiopia during 2000-2006 were analyzed and their relationship explored. It was found that the fraction of precipitation potentially available to catchment-vegetation (Wetting; W) ranged from 0.73 to 0.96, meaning up to 27% of precipitation was not available to vegetations. Strong and significant correlation was observed between Humidity Index (HuI) and W (with Pearson's r = 0.91), making HuI a good indicator of catchment wetness, and thus soil moisture condition. Horton Index (HI) (a.k.a. catchment-vegetation water use factor) ranged from 0.42 to 0.92, leaving up to 58% of wetting not consumed by vegetation in some catchments, and in others this unused fraction was as low as 8%. Although HI showed strong inter-catchment variation, it was relatively constant from year-to-year and can be considered a catchment characteristic. However, HI alone is not sufficient to indicate whether vegetation growth is limited by moisture availability, as NDVI of 0.77 was observed in a catchment with lowest HI and NDVI of 0.56 was observed in another catchment with highest HI. Moreover, inter-regional variability in the timing of observed lag between monthly precipitation and NDVI peaks was noticed. Our results demonstrate that catchments within the same climate zone exhibit variable hydrologic partitioning and vegetation response behavior.

Keywords: Catchment-vegetation; Hydrologic Partitioning; Moist Zone; Spatiotemporal Variation

(P007) Modeling Spatial Relationships between the invasive Snail *Bithynia tentaculata* and Submersed Aquatic Vegetation Using Long-Term Monitoring Data

Alicia Weeks[1], Nathan De Jager[2], and Roger Haro[1]

[1] University of Wisconsin-La Crosse River Studies Center, La Crosse, WI, USA [2] U.S. Geological Survey Upper Midwest Environmental Sciences Center, La Crosse, WI, USA

Bithynia tentaculata is an invasive gastropod (the faucet snail) that was first reported in Lake Michigan in 1871 and has since rapidly spread through the Nation's waters. This invasion has been extremely problematic in the upper Mississippi River (UMR), specifically Pools 7 and 8 as these areas lie along the continental avian flyway. As an intermediate host for several exotic trematode parasites, *B. tentaculata* is linked to regular regional waterfowl mortality events. Due to the wide distribution of waterfowl in this region, the best attempt to control the spread of these parasites will be to control the population of *B. tentaculata*. This study was designed in order to predict the distribution of *B. tentaculata* relative to submersed aquatic vegetation in an attempt to identify potential locations with higher risks of transmission (i.e., areas providing greater waterfowl nesting and food resources). A stratified, random sampling design and rake score method were used to survey vegetation densities. Distribution maps were created for select vegetation species including *Vallisneria americana*, *Ceratophyllum demersum* and *Elodea canadensis* in Pool 8 of the UMR. Moran's I spatial autocorrelation statistics were generated to determine the degree and scale of patchiness of *B. tentaculata* and vegetation, as well as the degree of spatial correlation between *B. tentaculata* and vegetation. For each macrophyte species, the spatial correlation with *B. tentaculata* declined as the distance between sampling locations increased, suggesting a patched distribution. However, the scale of patchiness of *B. tentaculata* was finer than for vegetation patterns, suggesting that *B. tentaculata* is more locally concentrated than the distribution of potential macrophyte habitats. The preference of vegetation species was examined using an electivity index. The results suggest that *V. americana*, *E. canadensis*, and *C. demersum* are among the most preferred. The macrophytes *Potamogeton crispus* and *Potamogeton zosteriformis* were avoided by *B. tentaculata*.

Keywords: Invasive species, faucet snail, *Bithynia tentaculata*, Upper Mississippi River, aquatic macrophytes

(P008) Reintroduction and Recovery Activities for the Federally Endangered Higgins Eye (*Lampsilis higginsii*) on the Upper Mississippi River

Aaron McFarlane and Dan Kelner

U.S. Army Corps of Engineers

Since 2000, conservation measures have been used by the U.S. Army Corps of Engineers in collaboration with the Upper Mississippi River (UMR) Mussel Coordination Team to conserve the Federally-Endangered Higgins eye (*Lampsilis higginsii*). One goal is the establishment of new and viable populations of Higgins eye in areas of the UMR and tributaries protected from heavy colonization of invasive zebra mussels (*Dreissena polymorpha*). Conservation activities have included: 1) evaluation and selection of relocation/reintroduction sites; 2) genetics studies; 3) propagation via glochidia-inoculated fish released into the wild or used for cage culture in the wild; 4) relocating naturally propagated adults and artificially propagated juveniles; and 5) monitoring. Ten reintroduction sites in the UMR and its tributaries were selected based on factors including the Higgins eye's historic range, risk of zebra mussels, existing mussel community, presence of suitable host fish, and water quality. Propagation efforts followed, using nearly 400 donor females of three genetically-unique strains. Reintroduction accomplishments to date include: nearly 500 adult Higgins eye relocated from waters heavily infested with zebra mussels to UMR Pools 2 and 3; over 44,000 sub-adult Higgins eye propagated in closed-bottom cages and placed in the wild; and an estimated potential 4.5 million juveniles transformed on free-released fish or fish in open-bottom cages. Initial monitoring efforts have suggested reintroduction efforts have been successful. Marked, relocated Higgins eye have been recaptured in surveys in UMR Pools 2 and 3. Adult Higgins eye and even new recruits have been discovered during monitoring at sub-adult reintroduction sites, indicating that reintroduced individuals have successfully reproduced. Adult Higgins eye have been discovered in UMR tributaries where they had been locally extirpated, indicating that glochidia on free-released, inoculated fish have successfully transformed. Monitoring is planned to continue to determine if reintroduced populations remain viable.

(P009) River Studies and Leadership Certificate: An Inter-University Collaboration With the River Management Society

Gigi Richard

Colorado Mesa University

The River Management Society (RMS) is taking an active role in cultivating a future generation of river leaders and professionals who possess a basic foundation of knowledge, skills, and experience in river-based management, science, policy, conservation, education, and recreation. To this end, RMS has initially partnered with five universities to create a River Studies and Leadership Certificate. This certificate is designed for undergraduate students and is being offered at Prescott College, Colorado Mesa University, Utah State University, University of Utah and University of Idaho. Including coursework (six courses) and a professional experience component, the certificate is designed to train and empower students to address real world challenges facing our nation's rivers. All students undertaking the certificate program are required to study basic river science, Geographic Information Systems, and swiftwater rescue. Students must also choose one of the following three emphasis areas: river science; river-based policy/management; or river-based recreation, education and tourism. As students complete the certificate they are encouraged to use RMS as a source for their river studies and professional networking, and will get a special invitation to attend a River Management Society Symposium or sponsored-conference. Students will be required to share aspects of their river studies with the RMS community by a presentation at the annual RMS Symposium or by publishing an article in the RMS Quarterly Journal. The River Studies and Leadership Certificate will equip students to become informed river professionals and stakeholders, help them to make sustainable decisions about future uses, research, and management of our nation's river systems, and integrate them into the RMS community.

(P010) Suspended Sediment Yield in A Brazilian Subtropical Watershed

Fabiano Oliveira

Federal University of Parana, Curitiba, Brazil

Studies of the hydrossedimentological behaviour of rivers in several environments of the planet, under different climatic, geological, biogeographical and socio-economic conditions indicate that concentrations of suspended sediments in fluvial systems vary in time and space, as well as in different approach scales. Few studies regarding suspended sediment dynamics are focused in brazilian subtropical environments. The need to understand the heavy and increasing aggradation of the Babitonga Bay in the last decades stimulated an investigation of the suspended sediment dynamics and transport in the main river that flow into the bay. The study aimed to analyze the variation of suspended sediment yield at different points of the Cubatão River and its main tributary, the Quiriri River, located in Santa Catarina State, southern Brazil. The 490 km^2 watershed includes three different environments: the coastal plain, the scarps of the Serra do Mar mountain range and the Atlantic Plateau. The diversity of structural and morphological features have strong influence both on river dynamics, in the rain distribution pattern and in the vegetation distribution, which ranges from mangrove forests to bush fields in the higher altitudes. Discharge, turbidity and suspended sediment concentration were monitored monthly over a period of 36 months at three different points along the Cubatão River, located in the plateau (point 1), at the base of the escarpments (point 2) and in the coastal plain (point 3), as well as at one point in its main tributary located just before their confluence (point 4). Extra daily and hourly monitoring was accomplished during some main rainy events. Results indicate a clear distinct hydrological and hydrossedimentological behavior within the watershed, with substantially different suspended sediment yield patterns. Suspended sediment concentration may proportionally decrease or increase with discharge variation at the different monitoring points. On the other hand, general suspended sediment yield per unit area decreases from the plateau to the coastal plain. Differences in suspended sediment concentrations at the monitoring points can be related not only to relief structure and pluviometric distribution, but also to land use characteristics.

Keywords: Suspended Sediment; Watershed; Land Use; Cubatão River.

(P011) The Influence of Levee Setback Scenarios on Flood Wave Attenuation

Jourdan Adair, Mark Stone, and Colin Byrne

University of New Mexico, Albuquerque, NM, USA

Human modification of natural systems has long been a byproduct of nature's dynamism combined with society's desire for predictability. While river engineering projects certainly impact the environment, natural systems are also subject to stress associated with climate change and increasing populations. The effects of these stressors on the world's already limited water supply are evident in the alteration of hydrologic processes. One such process, particularly in the southwest, is the transition from reliance on snowpack to peaky monsoonal events, making levee evaluations an integral part of flood risk analysis. A function of both bank storage and connectivity to the floodplain, flood wave attenuation (i.e., the dispersion and reduction of peak flow downstream) is an important aspect of flood routing. The objective of this study is to investigate the influence of levee setback scenarios on flood wave attenuation. The area of interest is the San Acacia reach of the Middle Rio Grande, stretching from the San Acacia Diversion Dam to Socorro, New Mexico. Three scenarios have been developed and modeled along the reach: 1) historic conditions, 2) existing conditions, and 3) restoration potential. Historic conditions are used to capture the original levee positions, demonstrating the most extreme case of lateral constraint, while existing conditions represent two recently implemented levee setback projects. As for future management considerations, the third scenario introduces potential restoration such as bank lowering to further restore connectivity. Two-dimensional (2D) models are being developed for each scenario using D-Flow Flexible Mesh (D-Flow FM) from Deltares. An advantage of this model is the ability to create a multi-resolution mesh with higher resolution in areas of particular interest (e.g., restoration sites) while maintaining a coarse mesh in areas of lesser interest. Evaluating these various scenarios with D-Flow FM 2D modeling allows us to illustrate how attenuation responds to levees, and the implications of the results on flood risk reduction.

Keywords: hydrodynamic modeling; flood wave attenuation; levee setback; Middle Rio Grande; river engineering

(P012) Freshwater mussels provide multi-decadal insights into the environmental history of large rivers

Andrea K. Fritts, Mark W. Fritts, Jason A. DeBore, and Andrew F. Casper

Illinois River Biological Station, Illinois Natural History Survey, University of Illinois-Urbana Champaign, Urbana, IL, USA

The shells of freshwater mussels can provide a unique opportunity to examine the impact of historical changes in aquatic ecosystems. Mussels deposit annual growth rings in their calcareous shells, much like tree growth rings, so that shells from archeological and museum collections can serve as records of long-term environmental change over the past 1000 years. We used sclerochronology techniques to evaluate changes in age-and-growth patterns in two mussel species collected from the Illinois River near Havana, IL from 1894-2013. This is a period that encompasses numerous large scale changes both positive and negative such as commercial fishing, expansion of navigation, eutrophication and sedimentation, as well as the initiation of the Clean Water Act and millions of dollars in ecosystem restoration efforts. Von Bertalanffy analyses indicated that modern animals are growing at a 50% greater rate and reaching a maximum size that is 20 mm larger than their 1894 counterparts. By constructing a historical biochronology response to environmental changes, we can better understand the dynamics of aquatic systems and the recovery rate after substantial perturbations and restoration efforts.

(P013) Aquatic Vegetation and Fish Community Response to Floodplain Lake Restoration, 2007-2014

Todd D. VanMiddlesworth and Andrew F. Casper

Illinois River Biological Station, Illinois Natural History Survey, University of Illinois-Urbana Champaign, Urbana, IL, USA

The restored floodplain sustains a diverse (11 species) and abundant native submersed aquatic vegetation (SAV) community that is otherwise difficult to find within the Illinois River Valley today. As the diversity and plant density increased since restoration, so has the species richness and biomass of native fishes. Native aquatic vegetation and fish species remained dominant in our collections while non-native species were present during 2014. Non-native aquatic vegetation and fish species will continue to be monitored closely.

(P015) Changes in Sediment Nitrogen Dynamics as a Result of Water Level Manipulations in the Upper Mississippi River (Navigation Pool 8) and Lower Illinois River (Swan Lake)

William Richardson[1], Jennifer Cavanaugh[2], Lynn Bartch[1], and Eric Strauss[3]

[1] U S Geological Survey, Upper Midwest Environmental Science Center, [2] Natural Resources Conservation Service, [3] University of Wisconsin-La Crosse River Studies Center

Intentional water level reductions, or "drawdowns," are being used more frequently in large rivers to improve vegetation growth and wildlife habitat. Such drawdowns could have significant effects on sediment nutrient biogeochemistry mainly due to changes in sediment oxygen dynamics. We selected two areas of the Upper Mississippi River system (Navigation Pool 8 and Swan Lake) to examine the effects of water level drawdown on Nitrogen (N) dynamics. Navigation Pool 8 underwent summer drawdowns in 2001 and 2002, and in Pool 8; we determined the effects of sediment drying and rewetting resulting from water level drawdown on (1) patterns of sediment nitrification (conversion of ammonium to nitrate) and denitrification (conversion of nitrate to nitrogen gas) and (2) concentrations of sediment total N, nitrate (NO_3^--N), and ammonium (NH_4^+-N) and sediment moisture and bulk density. We examined these variables in 20 backwater sites before, during, and after the water level drawdown to observe changes resulting from desiccation and re-wetting of sediments on a 10-site "drying" transect that dried during the drawdown and from another 10-site reference transect that remained inundated. During the dry period, pore water NO_3^- concentrations and denitrification increased on the drying transect whereas nitrification and exchangeable NH_4^+ concentrations decreased. Sediment NH_4^+ concentrations (pore-water) decreased significantly in Pool 8 during periods of desiccation, while sediment NO_3^- and rates of denitrification increased, although there was no reduction in total sediment N. Increased aeration in the drying transect allowed NO_3^- produced via nitrification to persist, resulting in higher concentrations of available NO_3^-, which subsequently enhanced denitrification. The reduction in sediment NH_4^+ in Pool 8 was likely a result of increased plant growth (deep-rooted deeper-rooted Sagittaria and Nelumbo) and N assimilation, which is then re-deposited back to the sediment surface upon plant senescence, resulting in a net gain of surficial sediment N.

We also examined sediment N concentration and sediment moisture and bulk density in three areas of Swan Lake, IL, a semi-isolated backwater on the lower Illinois River managed to promote water fowl production using drawdowns. Portions of upper Swan Lake have been drawndown since the 1970s, while lower regions have been since 1999 and the lowest portions since 2003. Sediment NH_4^+ concentrations in areas that have dried annually in Swan Lake were lower, but not significantly so, in sediments that remained wet.

The Swan Lake study suggested that longterm drawdowns do not result in a significant long term reduction in sediment N. Combined, these results indicate that water level drawdowns are probably not an effective means of removing nitrogen from the Upper Mississippi River system. Fundamentally, in order for N reduction to occur via denitrification, nitrate-laden water must have contact with carbon-rich, anoxic sediments to promote denitrification. Clearly this is not the case during a drawdown where sediments dry with extended exposure to air.

Keywords: nitrogen; denitrification; nitrification; porewater; nitrate; ammonium; drawdown; Upper Mississippi River; Illinois River

(P016) Community Responses to Hydrologic Disturbance Following A Legacy of Longitudinal Disconnection

Karen Baumann, Eric Scholl, Heidi Rantala, and Matt Whiles

Southern Illinois University, Carbondale, IL, USA

With the number of stream restorations projects increasing, there is a need for ecological studies and data to guide these efforts. The Cache River watershed in southern Illinois was divided into the upper (UCR) and lower (LCR) Cache River sub-watersheds as a result of the Post Creek Cutoff, a diversion ditch constructed in 1915 for agricultural and logging purposes. The LCR is now disconnected from its headwaters and suffers from reduced flow, hypoxia, and sedimentation. Resource managers are exploring scenarios for partial reconnection of the two segments in order to increase base flow in the LCR during dry summer months. Understanding how riverine communities respond to variable hydrologic conditions will allow for more effective restoration planning and monitoring. Southern Illinois experienced a large flood in 2011 and exceptional drought in 2012. We examined macroinvertebrate communities in the UCR and LCR during the summer months from 2010 through 2013. Community composition differed significantly between the UCR and LCR, as well as among years ($p=0.001$ for both). Temporal patterns in the UCR were primarily driven by chironomid midges, Elmidae (riffle beetles), Polycentropodidae (trumpet-net and tube-making caddisflies), and *Stenacron*, a heptageniid mayfly. Declines in the biomass of these taxa in the UCR were associated with flooding and drought ($p<0.05$). Patterns in LCR community structure were driven by more tolerant taxa such as Chironomidae, Oligochaeta, and *Caenis*, a small tolerant mayfly. Temporal patterns of these taxa in the LCR were non-significant among years, partly due to high variability among sampling sites and months. Mean individual body size in the UCR was highest overall in 2011 ($p=0.001$). Body size in the LCR was marginally correlated with monthly discharge in June of all years ($p=0.076$). Shannon Diversity in the UCR was highest in 2012 and lowest in 2011 and 2013 ($p<0.0001$), largely due to the addition of small-bodied lentic taxa like zooplankton during low flow. LCR diversity did not change across years ($p>0.05$). Responses to hydrologic extremes indicate that the UCR responds to disturbance events more like a typical river, while patterns in the LCR are clouded by high spatial variability due to low connectivity among study sites resulting from a century of impaired flow. Restored flow in the LCR could affect the food quality (larger-bodied invertebrates) available to higher trophic levels during early summer and should also boost diversity of more sensitive lotic taxa.

(P017) Community Structure and Diets of Fishes Are Influenced By Implementation of Rock Weirs

Sophia Bonjour, Heidi Rantala, Micah Bennett, and Matt Whiles

Southern Illinois University, Carbondale, IL, USA

Newbury rock weirs have been used as a restoration practice for channel stabilization in many Midwestern rivers. The upper Cache River has experienced channel incision and bank erosion as a result of an increased gradient through the creation of a diversion ditch in 1915. Weirs, or constructed riffles, were implemented to mitigate the erosional process. Previous research in the Cache River found that weirs benefitted aquatic macroinvertebrate and riparian bird communities by enhancing habitat heterogeneity and insect emergence production. Based on prior studies, we hypothesized that fishes would also benefit from weirs through enhanced habitat heterogeneity and changes in food availability. We collected fishes using hand nets, seines, and electroshocking at weir and non-weir sites in the upper Cache River. We flushed guts of larger individuals streamside, while smaller specimens were preserved whole and later dissected. Gut contents of both were identified, enumerated, and measured to calculate biomass using length-mass regression. Fish communities differed significantly between weir and non-weir habitats (global $R=0.63$, $p<0.05$), with more benthic-feeding fishes collected at weirs. Non-weir fish assemblages were characterized by higher abundance of? surface feeding taxa. Fishes from weir sites had more diverse diets and more prey biomass in guts (global $R=0.54$, $p=0.001$ for both), although total abundance of prey in guts did not differ between habitat types. Differences in biomass of gut contents were driven by invertebrate taxa that are found primarily on weir habitats in this stream, such as filter feeding insects. Fishes from both habitats selected for larger-bodied Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa and against Chironomidae larvae. Invertivorous fishes in non-weir habitats consumed significantly more chironomids than invertivores from weirs, which consumed significantly more EPT taxa ($p<0.05$). Results support predictions developed during prior studies and further demonstrate positive ecological responses to restoration practices in the Cache River. Further research will examine dissolved oxygen concentration and stream metabolism across weirs to quantify physicochemical changes for these structures.

Keywords: Cache River, Newbury rock weirs, restoration, fishes, community structure, diets, macroinvertebrates

(P018) Fish Passage Facilities in China: Design Practice and Challenges

Xian Wang, Wen Xiong, Ye Qiao, and Yiqun Hou

Institute of Hydroecology, Ministry of Water Resources and Chinese Academy of Sciences

In recent years, with the rapid economic development and the acceleration of exploring hydro-power resources in China, the obstruction effect of hydro-projects on fish population have appeared gradually. As the Chinese government and society demonstrated increasing concern about ecological protection, there are impressing demands for building fish passage facilities. For the past few years, China put much effort on the research and design of fish passage facilities, however, there are still difficulties and challenges existing in relevant design and building process. This presentation analyzes the practices related to the research and design of fish passage facilities in China, as well as challenges encountered such as high dams and cascades dams, and then proposes corresponding possible solution to those issues in terms of policy, planning, technology, research and management.

(P019) Historical and Emerging Contaminants in the Mixed Agricultural and Urban Use Catfish Creek Watershed, Iowa, USA

Wade Gibson and Adam Hoffman

University of Dubuque, Dubuque, IA, USA

Human activities impact watersheds and waterways on a scale that varies both temporally and spatially. Historically, water quality studies have primarily focused on nutrient loading, such as nitrogen and phosphorus, but recent research has focused on emerging contaminants, such as pharmaceutical and personal care products (PPCPs) and their ever-increasing presence in our waterways. Previous studies have examined the prevalence of PPCPs in surface freshwater around the country. However, temporal and spatial studies of PPCPs in systems of varying land use patterns are lacking. Sites in the Catfish Creek Watershed in Iowa with varying land use (urban and agricultural) were sampled for select PPCPs. Water samples were filtered and kept on ice prior to analysis. In addition to PPCPs, metals and nutrient concentrations were also analyzed. Past research has found that all five branches of Catfish Creek, a tributary of the Mississippi River, exceed recommended water quality criteria for nitrogen, phosphorus, and sediment; however no studies have examined PPCP concentrations in this watershed.

Metals analyzed in this study were arsenic, lead, mercury, manganese, and cadmium. Across sites and sampling events, five pharmaceuticals were tested for including acetaminophen, caffeine, sulfadimethoxine, trilocarbon, and triclosan. These chemicals were chosen due to their high risk quotient (RQ). As chronic pharmaceutical toxicity data is limited, a common method of assessing environmental risk is by calculating a RQ, which is a ratio of the measured or predicted pharmaceutical environmental concentration and the measured or predicted concentration at which no adverse effect on aquatic ecosystem function is to be expected. In addition to RQ analysis, regression analysis was also used to compare the spatial variation in PPCP concentrations. In high concentrations PPCPs can impact aquatic organisms, thus affecting the entire ecosystem. Implications regarding the impacts of PPCPs, nutrient, and metals on the plant, animal, and human communities in and along the river will be discussed.

Keywords: Pharmaceuticals and Personal Care Products (PPCPs); nutrient contamination; heavy metal contamination; water quality; Catfish Creek Watershed.

(P020) Hydrologically Mediated Regulation of Zooplankton Communities in Patches within a River Mosaic

Jarod Sackreiter[1], Michael Delong[2], and William Richardson[3]

[1] University of Mississippi, Oxford, MS, USA, [2] Winona State University, Winona, MN, USA, [3] U S Geological Survey, Upper Midwest Environmental Science Center

A wide range of biotic and abiotic factors have the potential to influence zooplankton community structure within hydrologically variable aquatic habitats of a large floodplain river. An especially important driver of planktonic community structure are meso- (local) and macro-scale (regional) hydrological patterns and covarying water quality variables, which create spatial and temporal differences in zooplankton community composition. The objective of this study was to identify factors that regulate community structure of crustacean and rotifer zooplankton in different hydrogeomorphic zones across a riverine landscape. Samples of planktonic rotifers and crustaceans were taken in May – September of 2009, 2010, and 2011. Rotifers were collected by passing 8-L of water through a 38 -µm sieve. Crustacean samples were collected with vertical tows using a 64-µm mesh plankton net. Standard physico-chemical measures were taken with each set of samples. Daily discharge data from the U.S. Geological Survey gage at Winona, MN were used to determine change in discharge from the day samples were collected to 7, 14, 21, and 28 d prior to sampling. Multivariate analysis identified turbidity as a key determinant of zooplankton community structure. Rotifer densities increased with greater turbidity. Densities of crustacean zooplankton, however, were greatest at intermediate levels of turbidity. Taxa richness of rotifers also increased with turbidity. Community composition was also influenced by changes in discharge prior to sampling events. Densities of rotifers and crustacean zooplankton were low when there was a marked increase in discharge during the period prior to sampling. Differences in zooplankton densities across sites were most pronounced when there was little change in discharge over the period prior to sampling, suggesting that backwater sites were establishing distinctive attributes with prolonged stability and hydrological retention. The patterns in rotifer and crustacean zooplankton densities and number of taxa suggest that a combination of abiotic and biotic factors linked to hydrological conditions regulate community structure. Abiotic factors govern community structure when hydrological connectivity of backwaters is high. Increased abundance of microcrustaceans, including predaceous species, and declines in rotifer abundance, was associated with increasing hydrological retention. As hydrological retention further increases, crustacean zooplankton abundance and diversity declines, potentially as a result of greater susceptibility to predation by visually–feeding zooplanktivorous fishes. This study, therefore, suggests that connectivity and its effect on hydrological retention plays an important role in determining abiotic and biotic influences on zooplankton community structure with the level of response differing among connected slackwater patches within the riverine landscape.

Keywords: zooplankton, hydrology, community, regulation, abiotic controls, biotic controls

(P021) Laja River Basin, Chile: Finding Potential Water Management Solutions Through an International, Interdisciplinary Water Resources Course

Scott Fennema[1], Mauricio Quiroz Jara[2], Keegan Hicks[3], Jaun Ignacio[4], Karen Trebitz[1], Jan Boll[1], Jerry Long[1], Brian Kennedy[1], Diego Caamano[4], and Ricardo Barra[2]

[1] University of Idaho, Moscow, ID, USA; [2] Facultad de Ciencias Ambientales y Centro EULA - Chile, Universidad de Concepción, Concepción, Chili; [3] University of Waterloo, Waterloo, ONT, Canada; [4] Catholica University of Chile, Concepcion, Chile

Faculty from the University of Idaho's Waters of the West program and from the University of Concepción, and Catholica University of Chile, Concepción, jointly organized a unique international, interdisciplinary water resources course. The course is part of the University of Idaho NSF funded IGERT (Integrative Graduate Education and Research Traineeship) program. PhD students from the US, Canada and Chile participated in the course. One case study in the course focused on management regimes for the Laja River Basin in Chile as a case study. The Laja Basin's relatively clean, low nutrient waters provide hydroelectric power, irrigation water, municipal water, and important ecosystem services within the basin, and dilute effluents and contaminants in the larger Biobío River into which it flows. The Biobío system, including the Laja River, accounts for nearly 20 percent of the nation's power and provides drinking water for more than a million residents. Extended drought, coupled with the current water management regime that dates to 1958 on Laja Lake, have resulted in record low lake levels, and conflicts especially among hydroelectric power producers, irrigators, and municipal needs. Projected climate change scenarios for the Laja Basin are a precipitation decrease of 2.5 mm/year and a temperature increase of 0.2-0.4 °C per decade. Chile's annual population growth is approximately 0.9 percent, but energy consumption is projected to increase by 6 to 7 percent by 2020, which will further stress the basin's water resources. Students from the various countries representing different disciplines and cultures, integrated disciplinary perceptions, lectures, readings, and international perspectives and developed optimization strategies for the Laja System. This presentation highlights the cultural and societal experience provided to the students and four optimization strategies proposed for improving integrated water management of the Laja system.

Keywords: Water Resource Management; International Collaboration; Interdisciplinary Research; Climate Change; Water Sustainability

(P022) Large Wood Increases the Autochthonous Base of the Macroinvertebrate Assemblage in a Lowland River, as Demonstrated by Combined Fatty Acid and Stable Isotope Analysis

Matthew Cashman[1], Francesa Pilotto[2], Gemma Harvey[3], Geraldene Wharton[1], and Martin Pusch[2]

[1] Queen Mary University of London, London, UK; [2] Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin

As large wood (LW) may profoundly modify the hydromorphology of river ecosystems, we tested if wood may also influence the availability of food resources and the trophic base of the benthic macroinvertebrate assemblage. To do so, we quantified the contribution of trophic resources to the diet of the macroinvertebrate assemblage colonizing the surface of LW logs, sediments surrounding LW, and control sediments away from LW. In addition, a secondary objective of this study was to compare and contrast two methodologies for determining food webs, and the macroinvertebrate assemblage trophic base was examined through both stable isotope analysis (SIA) and fatty acid (FA) biomarkers.

SIA analysis showed that the macroinvertebrate food web was mostly sustained by seston exported from a lake 1 km upstream, highlighting a high degree of lake-river coupling. However, the presence of wood shifted the trophic base from being predominantly supported by seston to a combined contribution by seston and local autochthonous production growing on wood. The macroinvertebrate biomass sustained by local autochthonous production was lowest in control sediments, increased 1.4 fold in sediments surrounding wood, and 4.3 fold on the wood surface. While the contribution of terrestrial material to the macroinvertebrate assemblage increased 85% around wood, it was a relatively unimportant part of the diet, supporting less than 10% of total biomass.

FA did not effectively detect seston but differentiated between allochthonous and autochthonous components of the trophic base. In addition, it demonstrated the higher nutritional value of autochthonous primary producers, and detected taxa-specific diet changes in several consumers that were not detected by stable isotopes. When paired with stable isotope results, FA suggested that many seston-feeding consumers preferentially fed on the autochthonous fraction of seston. However, due to trophic modification of some fatty acids in consumers, fatty acids results were mainly qualitative, and were not yet able to produce reliable quantitative results.

The joint use of SIA and FA in this study was complementary, particularly for addressing the mix of allochthonous and autochthonous resources from lacustrine and riverine origins. We suggest the use of fatty acids in conjunction with stable isotopes in order to resolve a complex mix of similar trophic resources in freshwater food webs.

Our study suggests that the presence of LW in the river channel decreases lake-river coupling by providing alternative basal resources, primarily through its role as a hard substrate to increase local autochthonous productivity. River management that would limit the availability of wood in river channels would likely limit ecosystem productivity through decreasing the availability of high quality food resources.

(P023) Mismatches in Water Quality Data and Public Perceptions of Rivers

Danelle Larson, Robert Edsall, James Stoutenborough, and Martin Ventura

Idaho State University, Pocatello, ID, USA

The Portneuf River basin in southeastern Idaho has multiple river sections that vary by land and water uses, aesthetics, and recreation potential, as indicated by several water quality-monitoring stations.

We asked the public to sketch on a map the river locations they believed were at greatest risk of water quality pollution, flooding, and human health due to water contact. Additionally, we asked them to identify their favorite locations for fishing, biking, and swimming. We also asked respondents to choose from a list of options to identify the primary source of water quality contamination for the river. We digitized each sketch map to create "hotspot maps" and compared the map results against the questionnaire and basin-wide water chemistry data.

The 102 public respondents indicated that the concrete channel running through the city of Pocatello posed the greatest flood risk and was the primary source of water quality degradation. The water chemistry dataset suggested that the primary source of water quality change was upstream of the city due to water diversion for agriculture (i.e., reduced discharge) – not the concrete channel. Further, the public preferred to recreate in river locations with the greatest Escherichia coli concentrations, but did not express health concern.

These social-ecological analyses suggested that public perception of river health and ideal locations for recreation may not match measured water quality data. This study emphasizes the to further study of people's perception of rivers and provide local river education.

(P024) Mississippi River Basin Acoustic Telemetry Databases

Marybeth Brey

U.S. Geological Survey

Acoustic telemetry networks are routinely used to monitor the movement of many fish species in large rivers. Most recently, invasive Silver Carp (*Hypophthalmichthys molitrix*) and Bighead Carp (*H. nobilis*)(Asian Carp; AC) have been the fish of interest in the Mississippi River Basin (MRB). For nearly 10 years, AC have been tagged, tracked, and monitored by multiple agencies throughout the MRB, and vast amounts of detection data have been generated. Large telemetry datasets are often difficult to use, manage, and archive. In addition, because fish move through state and federal boundaries, close collaborations with multiple states, federal agencies, and universities are necessary for complete tracking data and successful monitoring and management of mobile fishes. To better manage these data and enhance assessments of fish movement related to river conditions, we have developed a fish telemetry database with visualization tools for the Mississippi River Basin. Currently, this database includes over 1,500 AC tagged with Vemco® acoustic transmitters from Southern Illinois University (SIU), the U.S. Fish and Wildlife Service, and the U.S. Army Corps of Engineers and is supplemented with temperature data from SIU and river gaging station data from the U.S. Geological Survey (USGS). The goal is to expand this database to include all acoustically tagged fish within the MRB. Users can monitor fish movement related to environmental variables (e.g., discharge, temperature, or turbidity), archive or download detection data, calculate movement parameters (e.g., net distance moved or average distance per month), or visualize fish movements over time. This type of tool will provide a central location for acoustic telemetry data and an additional way to facilitate management of invasive species within the Mississippi River Basin.

(P025) Reach- and Catchment-Scale Determinants of the Distribution of Freshwater Mussels in A Tributary of the West Branch Susquehanna River

Sean Reese, Benjamin Hayes, and Jessica Newlin

Watershed Sciences and Engineering Program, Bucknell University Center for Sustainability and the Environment, Civil and Environmental Engineering, Bucknell University, Lewisburg, PA, USA

We investigated the diversity and distribution of freshwater mussels at ten selected sites in Buffalo Creek, a fifth order (Straher) stream when it enters the West Branch of the Susquehanna River watershed. A goal of this work is to relate mussel assemblages and individual taxa to reach- and catchment-scale variables and to monitor the effects of eel introduction in Buffalo Creek. We chose five sites downstream, and five upstream of the eel introduction site over an area of four river miles with simultaneous collection of habitat observations and water chemistry parameters for each site. Additional variables such as reach geomorphology, regional geology, groundwater exchange, land use history (e.g., logging and agriculture), and present-day land cover were quantified for the selected study sites.

Five mussel species have been found in Buffalo Creek, with *Elliptio complanata* being the most dominant species. *E*. *complanata*, typically the most widespread mussel in the Atlantic drainage, is suffering a serious reduction in recruitment, likely due to the loss of Amerian eel from West Branch of the Susquehanna River basin as a result of construction of large hydroelectric and low-head recreational dams on the middle and lower Susquehanna River. Despite efforts to introduce eels in Buffalo Creek, these barriers remain a dominant factor in the diversity and distribution of mussels in the both the river and the tributaries.

In addition to large barriers in the overall river system, smaller reach- and catchment-scale differences in habitat, water quality, geomorphic and land use characteristics appear to influence the results of the mussel surveys. Habitats in Buffalo Creek exhibit instability due to sedimentation from agriculture and urban areas and erosion of legacy sediments. From the upper to middle to lower Buffalo Creek catchment, the number of individual mussels, number of species, diversity index, and relative abundance of unionids all decline substantially. Higher densities of mussels are found in forested upstream reaches with more favorable habitat consisting of loose gravel/cobble substrates, low suspended sediment loads, and forested riparian corridor. The richest mussel assemblages were associated with sites with the highest overall habitat quality, greater flow stability, less fine substratum, and lower specific conductance.

(P026) Research on Swimming Behavior for Fish Passage in China

Yiqun Hou, Wen Xiong, Ye Qiao, and Xiang Wang

Institute of Hydroecology, Ministry of Water Resources and Chinese Academy of Sciences

Fish passages design must be based on understanding the swimming ability and behavior of the target species. In China, there have been increasing needs of building fish passage facilities after 2010, but the knowledge of swimming performance and fish behavior was far from enough to design fish passages. In recent years, critical swimming speed and critical burst swimming speed of Chinese native fish have been widely tested, but the measurement of sustained swimming speed, prolonged swimming speed and time endurance based on fixed velocity tests are still relatively rare, mainly because of the procedure take a long time. Generally, performance data of critical burst swimming speed helps to determine the maximum flow velocity in the fish passes, 80% critical swimming speed is often considered as the maximum sustained speed and used as average velocity in the designing of fishway pools. In addition, the relationships between oxygen consumption and swimming speed have been studied for some fish species. The tail beat frequency, amplitude and stride length were often observed during critical swimming speed tests. This presentation will introduce the recent studies of swimming ability for Chinese native carps, velocity criteria on performance data, and in turn defines optimal pass dimensions, slope, and frequency of resting pools.

(P027) Response of the Fish Egg Community to Re-operation in Flow Regime from Three Gorges Reservoir Based on Sampling Conducted from 2011 to 2012, China

Yang Qihong[1], Ye Qiao[2], Zhang Lin[1], Wang Jiasheng[1], and Zeng Yue[1]

[1] Changjiang River Scientific Research Institute; [2] Institute of Hydroecology, Ministry of Water Resources and Chinese Academy of Sciences

The flow regime is a critical factor in the sustained ecological integrity of flowing water systems. The Yangtze River is the most important river in China. The Three Gorges Reservoir greatly changed the flow regime of the Yangtze River, resulting in decreasing of fish population dramatically since the Three Gorges Reservoir was impoundment in 2003, particularly those of the four major Chinese carps (FMCC): black carp, grass carp, silver carp, and bighead carp. Flood pulse and empirical fish research were initiated in 2011, as a pioneering way to protect FMCC resources in the Three Gorges Reservoir. When water temperature was greater than 18˚C, re-operation was implemented, and the time of the floods lasted for four to five days. This study investigated the impacts of flow regulation and re-operation on fish spawning, particularly for the FMCC, and validated the environmental factors that promote spawning of the FMCC.

The FMCC egg biomass was assessed by density (number•1000 m-3). the FMCC egg mean density ranged from 0.29 to 17.05 ind•1000 m-3 among the eight floods. For the re-operation and regulation floods on occasions D and A (during the flow rise and the flood decrease), N total number of individuals ($F=7.01$, $p=0.01$) was significantly different, as was S species richness ($F=4.58$, $p=0.04$). A significant difference in FMCC egg density was observed among eight floods between 2011 and 2012 in different occasion, and the FMCC mean egg density during the re-operation flood was nearly four times than that of the regulation flood. Fish egg number and Pielou's evenness index were different among the eight floods (N, $F=2.63$, $p=0.05$; J', $F=2.80$, $p=0.04$;). In egg community, nine species contributed 50.41% to the difference in community composition between re-operation and regulation floods on occasions D and A, particularly two species with sticky egg, Parabramis pekinensis and Hemiculter leucisculus (Basilewsky). The grass carp contribution to the difference between the re-operation and the regulation floods on the second rank was 6.12%, however, it was almost equal in the re-operation and regulation floods. The abundances of silver carp, black carp and bighead carp, during the re-operation were two to fourfold greater than that during the regulation floods. A difference in community composition was observed between re-operation and regulation, indicating that the re-operation schedule was sufficient to change the egg community composition. The egg community was significantly correlated with four environmental factors, i.e. water transparency, change in daily water discharge, and change in daily water level.

(P028) Suspended and Benthic Sediment Interaction with the Water Column Along River Continua

John Gardner and Martin Doyle

Duke University

Benthic and suspended sediments play an important role in all aquatic ecosystems. They provide habitat for micro and macrofauna, facilitate biogeochemical reactions, and influence light availability and thus primary productivity. An important physical characteristic of an aquatic system is the surface area of the sediment-water interface. Small streams have a high benthic sediment-water contact surface area relative to the water volume compared to large rivers, and therefore are often considered biogeochemical “hotspots”. However, the role of suspended materials in rivers, has received little attention. We assessed the potential for benthic and suspended sediment interaction with surface water using a river continuum framework along large US rivers. Hydraulic geometry, sediment rating curves, and flow frequency analysis together with assumptions regarding median grain size, shape, and riverbed porosity were used to calculate the ratio of suspended sediment to benthic sediment-water contact surface area within a control volume (Suspended Sediment Surface Area: Benthic Surface Area, SSSA:BSA). Discharge was normalized at all sites using flow duration analysis (discharge that is exceeded 1, 10, 20…100 % of the time). We estimated where in the river continuum does suspended sediment-water contact exceed benthic (SSSA:BSA >1), and how frequently does this occur. Along the Yellowstone River from the most upstream site to the outlet, the SSSA:BSA was described by a power function of basin area. Longitudinal patterns and magnitude of the SSSA:BSA were sensitive to suspended and benthic median particle sizes, discharge, and penetration depth into bed sediments. Assuming a uniform bed grain size of 1 mm, suspended size 0.1 mm, and penetration depth equal to 0.5 mm, all sites along the Yellowstone River exceeded a SSSA:BSA of 1. However, a SSSA:BSA >1 occurred 100% of the time at the outlet of the Yellowstone but only 2% of the time, during extreme discharge events, at the most upstream site.

(P029) The Fourth Upper Mississippi River – Restoration, Monitoring, and Research

Marvin Hubbell

U.S. Army Corps of Engineers, Rock Island District

As described in the book, The River We Have Wrought by John Anfinson, the establishment of the Upper Mississippi River Restoration Program (UMRR) "…emerged from the largest battle between navigation interest and environmental organizations in the upper river's history." And, declaration of the Upper Mississippi River System (UMRS) as both a nationally significant ecosystem and a nationally significant navigation system was a means for Congress to "…direct the parties to divide the (financial) pie" on the UMRS.

The Water Resource Development Act (WRDA) of 1986 was the legislative vehicle that established these two unique designations. Creation of UMRR (previously referred to as the Environmental Management Program) made it the first comprehensive large river ecosystem restoration, monitoring, and research program in the United States and ushered in what John Anfinson refers to as the "fourth upper Mississippi River…". Declaration of the UMRS as both a nationally significant ecosystem and a nationally significant navigation system makes it the only large river system in the United States to receive such a designation.

The political climate that created UMRR lead to a provision in WRDA1986 that directed the Corps of Engineers to consult with the natural resource agencies from the five states, the Department of Interior, and other federal agencies in the implementation of UMRR. The result was creation of a Coordinating Committee, development of a working relationship with nine other UMRS groups, and working relationships with numerous NGO's and the public. This regional partnership has evolved into a highly effective regional entity, and to date, UMRR has invested more than $510,000,000 in restoration and scientific efforts in the five state region. In addition, state and federal partners have contributed more than $32,000,000 in support of the UMRR.

Not only did UMRR pioneer environmental restoration for this and other larger river systems, it is truly unique in that it combines the ability to design and construct large and small scale river rehabilitation projects with the ability to monitor and research key environmental attributes of the UMRS. Both Program elements have increased our understanding of the river and have helped refine restoration techniques.

UMRR's authorized boundary covers 1,200 miles of navigable rivers within the UMRS, including 2.7 million acres of floodplain, and is helping to restore and protect the world's 3rd largest watershed. Since 1986, UMRR has benefitted approximately 102,000 acres of critical habitat through the completion of 55 habitat rehabilitation projects. In addition, UMRR has collected data on key environmental attributes of the river in six key pools within UMRS.

This presentation will highlight the vision, key efforts and future direction of the UMRR and working relationship with navigation interest to manage the UMRS as both a nationally significant ecosystem and a nationally significant navigation system

Key Words: Large River Restoration, Mississippi River, River Policy, Large River Monitoring

(P030) The Importance of Ecosystem Services within Riverine Landscapes

David Gilvear[1], Andy Large[2], and Michael Stewardson[3]

[1] Plymouth University, Plymouth, UK; [2] Newcastle University, Newcastle upon Tyne, UK [3] University of Melbourne, Melbourne, Australia

The importance of ecosystem services within riverine landscapes has been recognised for some time, but specific identification of the role they can play in management represents a more recent challenge. Despite significant advances in our understanding of rivers and how they are impacted by human interventions, there has been surprisingly little research into how we can best categorise river ecosystem services and expand societal understanding of how multiple benefits e.g. towards community resilience can accrue from healthier fluvial systems. In this paper we summarise some of the recent advances made in river ecosystem service science, critique conceptual approaches, classification schemes and terminologies, and recommend ways of progressing the science towards impact.

Central here is the space-time continuum that we propose as the basis of a conceptual framework for riverine ecosystem service assessment. Recognising that the strong downstream directionality ('cascade') of ecosystem service flows provides both opportunities and challenges, we adopt a river network perspective for conceptualising riverine ecosystem services across whole catchments. The spatial 'cascade' of ecosystem services through the river network is rarely a direct transfer because ecosystem processes within the river network modify and offset potential benefits by affecting the downstream transport, transformation and retention of water, sediments, energy, nutrients, contaminants and other material. There needs to be full consideration of both 'supply' reaches and 'demand centres' (including socio-cultural considerations) in ecosystems service assessments, and to address this we present a methodology for identifying and mapping "hot-spots" of ecosystem service delivery. The approach takes into account the fact that ecosystem services very seasonally and annually, as well as during flood and drought and that ecosystem services are dynamic entities particularly dependent upon flow. The concept of transient ecosystem services and "hot-moments" of provision is introduced.

By providing this overview of the nature of the problem, and suggesting ways in which we should (begin to) move forward, we intend that these concepts be presented as a start-point for discussion by an ISRS working group on river ecosystem services.

(P031) The Mobilization of Lead from A Lead Shot Contamination to A Resident Macroinvertebrate In A Riparian Wetland and Its Effect on Macroinvertebrate Diversity

Suzanne Ryan, Gretchen Gerrish, Colin Belby, Roger Haro, and Carmen Rivera

University of Wisconsin-La Crosse River Studies Center, La Crosse, WI, USA

Lead contamination in wetland environments is common due to the use of lead shot to hunt waterfowl and the use of lead fishing tackle. In order to properly manage these contaminations, it is important to understand the ultimate fate of lead at these sites. Heavy metals are readily taken up by plants and animals in aquatic environments and are transferred to higher trophic levels. They can also be exported to terrestrial environments along with nutrient subsidies that take place through the normal, seasonal life cycle movements of aquatic insects. Our study looks at how lead (Pb) is mobilizing into the invertebrate population of an urban, riparian wetland from a zone of heavy lead contamination (lead sediment concentrations up to 26,000 ppm), the ultimate fate of the lead that is accumulated by resident macroinvertebrates and what effect, if any, the contamination has on the biodiversity of the macroinvertebrate population.

(P032) Water Management in a Changing Climate: Balancing Complex Water Demands for Equity and Sustainability in the Biobío Basin, Chile

Javiera Aguayo[1], Ricardo Barra[1], Gustavo Diaz Garrido[1], Shana Hirsch[2], and Oscar Parra[1], Jason Walters[2], Natasha Wingerter[2], and Marjorie Zapata Muñoz[1]

[1] Universidad de Concepción, Concepción, Chili; [2] University of Idaho, Moscow, ID, USA

Water resource managers must prioritize complex water demands within a limited framework, which often includes impairing river connectivity in order to maximize the benefit of socio-economically beneficial water needs. In January 2015, an interdisciplinary group of PhD students in the Water Resources program at the University of Idaho traveled to Chile to collaborate with a similar group of Chilean university students in the European Union-Latin American (EULA) Center for the Environment/Faculty of Environmental Sciences. With the aim of developing a proposal for the management of water resources with a localized but interdisciplinary focus, the students reviewed the drivers of management decisions in the Biobío River Basin from within the socio-economic, political, legal, cultural, and ecological contexts of Chile, both current and historical. A conceptual model developed for this analysis illustrated three major competing priorities for water within the Biobío River Basin system (hydropower, irrigation, and river ecosystem function). These beneficial uses were chosen as the main focus of the model as they demonstrate clearly conflicting values for water decision-making. With climate change in mind, the binational group considered future management options that optimized the individual potential of hydropower, irrigation, and ecosystem function and weighed the benefits and impacts of each approach.

The Biobío River Basin is the most important hydrological system in Chile, and also one of the most disturbed by human impacts. The primary ecosystem services provided by the watercourse are hydropower and irrigation, and their prioritized use results in impacts to river ecology and the fragmentation of habitats. Drinking water is also an important beneficial use of the river, but quality and quantity requirements are met through the maintenance of higher flows for the primary services. While economic development of the Biobío River Basin has increased, little value has been placed on native biological diversity as compared to the preferable introduction of non-native species. As the river and surrounding watershed becomes homogenized through these human induced changes, loss of natural river network connectivity occurs, impairing ecosystem function and resilience to climate change. Additionally, there is a conflictual relationship between hydropower and irrigation. Water for hydropower is considered a non-consumptive use in Chile, is not subject to the same water rights market system, and can be stored without any concern for downstream consumptive-use rights holders. Furthermore, dam operators prefer to store summer flows to meet winter energy demand peaks, while irrigators require the most water during the warmer months. This tension between dam operators and irrigators may increase in intensity as climate change results in lower overall precipitation and less snowmelt flows during the planting season. Ultimately, both reforms to the existing water governance regime and a more extensive adoption of holistic and adaptive approaches were suggested in order to manage the Biobío Basin effectively through future climate change scenarios. By analyzing the trade-offs between hydroelectric power generation, irrigation, and ecological services, this analysis demonstrated

the ways in which holistic watershed analysis and planning are essential to recognizing emerging issues of equity and sustainability within a changing climate.

(P033) Invasion of *Pueraria lobata* and *Sicyos angulatus* in River Floodplains

Harun Or Rashid and Takashi Asaeda

Department of Environmental Science, Saitama University, Saitama City, Japan

Frequent flooding often wash away vegetation and top soil of the floodplains and set it to a condition of primary plant succession. Primary succession in such habitats starts with perennial plants with rhizomes or other complex structures. In last few decades, the typical environments of all almost all rivers floodplains have been intervened by human activities. Many pioneering and native plant species have been reported to be replaced or outcolonized by exotic and often invasive plants. A large number of these invasive species are lianas. These invasive species due to their huge biomass turnover and other characters like symbiotic nitrogen fixation enrich the extant infertile soil with nutrients and soil moisture. As a result, river floodplains become intensely vegetated. *Pueraria lobata* and *Sicyos angulatus* are two vine species notable for their interference in fallow land and arable land, respectively. However, these species intruded in many Japanese rivers and reportedly outcolonized pioneering species like *Miscanthus sacchariflorus*. Their control or eradication became a serious issue at this moment. But before initiation of a control program of any invasive species, it is important to find its biology and responses to environmental factors. In this study, we examined the differences in habitat soil characteristics of these taxa to provide insight into possible mechanisms of succession and competition. Plant and soil samples were collected and above- and belowground dry mass was measured in plants collected from two locations with different soil characteristics along the Tama River, Japan. Allelopathic properties of these plants and habitat soils were assayed in the laboratory. *P. lobata* was found to have allelopathic capacity, whereas we did not find such properties in *S. angulatus*. Though both species are highly invasive, they possess different characters in terms of drymass allocation and response to soil nutrient concentrations. The dry mass of *S. angulatus* was higher in soils with high nutrient levels. *P. lobata*, though it produced more dry mass in nutrient-rich soil, also grew well on nutrient-limited soils. Dry and nutrient-poor habitats produced higher amounts of belowground dry mass in *P. lobata* than habitats with higher soil moisture contents and nutrient levels. The plant organs showed the highest accumulation of TN and TP in leaves, followed by the roots and stems. Neither of the species had significant correlation between tissue nutrients and available soil nutrients.

Keywords: Allelopathy; edaphic factors; *Pueraria lobata*; river floodplain; *Sicyos angulatus*

(P034) Tracking the Status of Free-Flowing Rivers: Creating a Global Registry

Thieme, M.L.[1] G. Grill[2], B. Lehner[2], D. Tickner[3], B. Geenen[4], Suresh Babu[5], Marc Goichot[6], Jonathan Higgins[7], C. Reidy Liermann[8], Cheng Lin[9], Michael McClain[10], Jian-Hua Meng[11], Mark Mulligan[12], Christer Nilsson[13], Paulo Petry[7], Leonardo Saenz[14], Sergio Salinas[15], James Snider[16], Klement Tockner[17], Paula Valdujo[18], and Christiane Zarfl[19]

[1] WWF-US; [2] McGill University; [3] WWF-UK; [4] WWF-Netherlands; [5] WWF-India; [6] WWF-Mekong Programme; [7] The Nature Conservancy; [8] University of Wisconsin-Madison; [9] WWF-China; [10] UNESCO-IHE; [11] WWF-Germany; [12] King's College London; [13] Umea University; [14] Conservation International; [15] WWF-Mexico; [16] WWF-Canada; [17] Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB); [18] WWF-Brazil; [19] University of Tuebingen

Free-flowing rivers are the freshwater equivalent of terrestrial wilderness areas. In comparison, they harbor a large proportion of our global biodiversity in a relatively small habitat space, making them more vulnerable to anthropogenic pressures than their terrestrial counterparts. In particular, new hydropower development on large, free-flowing rivers threaten to accelerate the decline of freshwater species. Yet, no global registry of free-flowing rivers exists to underpin monitoring of their status over time and to help catalyze protection of those of highest conservation value. In order to address this gap, we will produce an updated global inventory to identify those rivers that remain free-flowing and provide a registry that will allow tracking of the connectivity status of rivers over time. We convened representatives of major NGOs and academic institutions, reached consensus on a draft definition and agreed that the methodology would address river fragmentation and flow regulation from large and medium-sized dams (longitudinal connectivity), road density and human population in the floodplain (lateral connectivity), flood regulation effects on floodplains (lateral connectivity), and water abstraction effects on intermittency (temporal connectivity). A set of relevant global geospatial datasets will be compiled and linked to a high-resolution river network comprised of approximately 8 million river reaches. Each reach of river will be evaluated for its "free-flowing" status based on the level of disturbance to its connectivity components. The draft methods will be tested for robustness both at global scale and in several smaller-scale geographies. At a minimum, methods will be tested in the Tapajos Basin (Brazil) and the Upper Ganga (India) and comparisons will be made with results from other existing inventories. The resulting global inventory is intended to inform research and conservation planning, and will provide a new global indicator for monitoring purposes, river health assessments, and river impact studies.