KEYNOTE

***Title:* Stream and Watershed Restoration: Guidance for Restoring Riverine Processes and Fish Habitat**

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Abstract:
Billions of dollars are spent annually in North America and Europe to restore rivers and improve fish habitat. Unfortunately, many of these well-intentioned efforts fail to meet their objectives because they ignore watershed processes or do not follow key steps needed to adequately plan, implement and evaluate restoration. Here I provide an overview of the eight key steps needed to plan restoration, assess watershed conditions, identify restoration actions, select and prioritize restoration techniques and monitor and evaluate their success. I provide examples of successful methods, analyses or models used to address each of these key steps. Before assessing conditions or identifying restoration opportunities, it is important to have a clearly defined restoration or recovery goal. Assessment of watershed processes and habitat conditions should include assessment of potential and current rates or conditions and identify the causes of habitat degradation and loss. In selecting appropriate restoration actions, it is important to be aware of whether the actions restore underlying processes or simply improve habitat as well as the longevity, likelihood of success, and whether they ameliorate the impacts of climate change. Several approaches exist for prioritizing restoration actions at a regional, watershed, and reach scale. The most transparent and repeatable approach for prioritizing restoration projects is multi-criteria decision analysis (scoring system) that can incorporate quantitative and qualitative information including scientific and socio-economic data. Monitoring of restoration projects needs to be designed well before the projects are implemented and have clear testable hypotheses and a rigorous study design. Unfortunately, many monitoring programs fail not because of inadequate design, but because of poor implementation, quality control and management – all factors that can usually be overcome by diligent project management. The steps and considerations outlined in this presentation, if followed, should ensure that restoration actions are effective at restoring watershed processes and habitat.

Biography:
Dr. Philip Roni is a Principal Scientist with Cramer Fish Sciences (CFS) and an Affiliate Professor at the University of Washington School of Aquatic and Fishery Sciences. He has more than 25 years of experience as a fisheries research scientist and directs the CFS Northwest science team where he focuses on designing, implementing and publishing definitive studies on watershed restoration. He regularly teaches courses and has published numerous papers on restoration science including the comprehensive books "Stream and Watershed Restoration: a guide to restoring riverine processes and habitat" (2013 Wiley-Blackwell) and "Monitoring Stream and Watershed Restoration" (2005 AFS). Phil received a Presidential Early Career Award (2004) from the US President and a Certificate of Achievement (2012) from the AFS for

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his contributions to restoration science and monitoring and evaluation. He has both an M.S. and a Ph.D. from the University of Washington.

SESSION 1: LINKING ECOSYSTEM COMPONENTS; WHAT ARE THE FACTORS IMPACTING ECOLOGY AND BIOLOGICAL HEALTH?

Title: **Restoring Ecosystem Processes and Resilience in River Systems**

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Abstract:
River systems have been dramatically altered by land-use, climate and hydrologic changes, channelization, fragmentation by dam construction, and water pollution. For example, of Minnesota's 84,705 miles of stream, an estimated 41,628 miles have been channelized, 2,968 miles have been impounded, while thousands of barrier dams and culverts block biotic migrations and recolonization. Similar changes globally have led to catastrophic declines in water quality, stream stability and biodiversity. Freshwater extinction rates far exceed those of other biomes. Biodiversity is an effective indicator of ecosystem health and resilience in river systems since it is dependent on parameters of hydrology, geomorphology, water quality, and connectivity. If allowed, river ecosystems can self-recover from many disturbances but are often unable to recover from past and ongoing human constraints. Many river projects have attempted to address symptomatic issues such as poor habitat or bank erosion with localized, structural solutions. Treatment of symptoms can be costly, temporary and, in some cases, hinder geomorphic and ecosystem processes or create new problems. In contrast, identification of underlying problems, relaxing human constraints to the degree possible, and reestablishing long-term geomorphic and biological processes can yield resilient, self-sustaining river ecosystems. Monitoring over broad spatial and temporal scales is necessary to establish success. Case examples will be presented to illustrate evaluated measures of ecosystem responses to river restoration and suggest strategies towards resilient river ecosystems.

Biography:
Dr. Luther Aadland received his Ph.D. from the University of North Dakota in 1987 and has worked as a river scientist for the Minnesota Department of Natural Resources for the past 31 years. His research and publications have included topics in the habitat and hydrologic requirements of fish and invertebrates, fragmentation effects on biodiversity, ecological responses to restoration, invasive species ecology, and river restoration design and strategies. Of particular interest has been the reconnection and restoration of critical habitat for sturgeon and other imperiled species.

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Luther teaches courses on a variety of topics in fluvial geomorphology, stream ecology, and restoration. His book, *"Reconnecting River: Natural Channel Design in Dam Removal and Fish Passage"* details design approaches, challenges and benefits of project case examples. He has designed numerous river restoration, dam removal, and nature-like fish passage projects on river systems across the United States that have resulted in the return of extirpated fish and mussel species, restored recreational fisheries and improved public safety.

Title: **Trick or Treat: Does Natural Channel Design Work to Improve Stream Ecological Function?**

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***Abstract*:**
Rivers that depart from natural channel forms can limit ecological recovery of aquatic ecosystems and ultimately degrade habitat. Departures include channelization, loss of floodplain connectivity, removal of wood, habitat fragmentation, and altered hydraulic conditions. Monitoring results from fish populations occupying impaired rivers have shown that recovery may require many decades before populations begin to stabilize and even longer before populations show positive signs of recovery. Fish populations occupying degraded river systems may continue to decline without active restoration intervention, such as application of Natural Channel Design (NCD). Uncertainty exists whether application of NCD result in improvements to ecological function that can last over time. In Colorado and Montana, long-term monitoring of NCD projects provide evidence that stream ecological functions have improved, such as increases in fish biomass, density, and species diversity. In addition, NCD project monitoring spanning up to 27 years have shown sustained improvement in fish populations over time. Restoration of full ecological function as compared to reference quality sites has been achieved in NCD project site in Montana but not Colorado.

Biography:
Matt Kondratieff is an Aquatic Research Scientist for Colorado Parks and Wildlife in Fort Collins, CO. He completed his undergraduate work at U.C. Davis, received his Master's from Colorado State University and he worked for three years as a fisheries biologist for Wyoming Game and Fish in Pinedale, WY. Matt has 12 years experience involving the design, construction, and monitoring of natural channel design restoration projects in Colorado. Recent research has focused on the biological response of aquatic organisms to stream habitat restoration treatments. Additional research interests are focused on the influence of in-channel structures, such as whitewater parks and water diversions, on fish populations and fish passage.

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Title: **Stream Restoration: Does Restoring Structure Lead to Function?**

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Abstract:
Efforts are underway globally to improve water quality and other ecosystem services in watersheds impacted by urbanization and agricultural production. Excess nutrients (i.e., nitrogen and phosphorus) create eutrophic conditions that threaten water supply for human consumption as well as ecological health. It has long been recognized that the interfaces between terrestrial and aquatic ecosystems are locations where nutrient processing and removal is maximized. However, these river-floodplain systems are the same environments that are the most severely degraded by human development, including piped water conveyance, river network modifications for flood control, agricultural production and infrastructure placement. Competing uses for land necessitate innovative solutions that maximize biophysical processes to reduce nutrient export. Stream and riparian restoration is one strategy that seeks to do so. Practices enhance channel stability and geomorphic complexity by reconstructing stream channels, planting riparian vegetation and connecting floodplains. The assumption is that the structural changes to mimic natural systems will allow the development of functional equivalencies as well. Our research shows that restoring stream-floodplain connectivity results in greater inputs of sediments and nutrients with subsequent impacts on nutrient biogeochemistry. This was particularly evident downstream of impaired reaches, which highlights the need to optimize placement of practices for maximum impact. We also show that time lags exist in recovery of ecosystem function following stream restoration, particularly related to biologically driven nutrient retention. This is critical for monitoring programs aimed at measuring success and ensuring sufficient time for restoration practices to achieve desired goals.

Biography:
Sara McMillan is an Associate Professor in Agricultural and Biological Engineering at Purdue University. She received her Ph.D. in Environmental Science and Engineering from the University of North Carolina at Chapel Hill and BS in Civil & Environmental Engineering from the University of Iowa. Prior to coming to Purdue, she spent 5 years as a professor at the University of North Carolina at Charlotte and several years working as a professional engineer on the impacts of changing land use and climate on water quality. Her research focuses on linking geomorphic structure with ecological function in restoration projects. She integrates field-based experiments with modeling to mitigate the hydrologic and water quality impacts of human development. Dr. McMillan believes strongly in stakeholder-driven decision making and partners with land owners, regulators, and non-profit agencies to maximize impact of her projects. Her current research focuses on restoration to improve water quality and ecosystem services including projects on green infrastructure, agricultural BMPs, and stream/floodplain restoration.

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KEYNOTE

Title: **Streams without Biology: How Physics Inadvertently Usurped River Restoration**

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Abstract:
The foundations of river restoration science rest comfortably in the fields of geology, hydrology, and engineering. Lane's stream balance equation from the mid-1950s taught us that there is a dynamic equilibrium between the amount of stream flow, the slope of the channel, and the amount and caliber of sediment. The Manning's equation, circa 1890, still influences most stream restoration projects designed today. Inherent in that famous equation are the variables of slope and hydraulic radius, and the ever-confounding roughness coefficient – *n*. Biology, while completely absent in the stream balance equation, makes a cameo appearance in the Manning's equation buried in the roughness factor. Arguably, two of the most influential equations that have shaped contemporary river restoration design left out the power of biology. This would not be a problem if we were designing and implementing river restoration in a Precambrian world -- a world where green algae and fungi are the major biological players -- but in today's environment, biology cannot be ignored.

This talk will provide an overview of, and underpinning science for, the Stream Evolution Triangle (SET) in which biology is included on an equal basis with geology and hydrology as a driver of stream morphology. The SET broadly integrates concepts geology, hydrology, and biology, and includes improved understanding of potential morphological "stream states" at the reach scale following both natural and anthropogenic disturbances. Rather than a deterministic approach, the SET recognizes that similar events can result in various stream morphologies, while dissimilar events can result in a single, dominant stream morphology. The probability of a particular future state is strongly predicated by the relative influence of geology, hydrology, and biology. The SET assumes dynamic morphological evolution through time and recognizes variable rates of change for both spatial and temporal scales, along with numerous potential trajectories.

Having introduced the SET, evidence from completed projects will be presented as case studies for application in innovative stream restoration. Potential utility of the SET in stream restoration planning and design stems from improved understanding and explanation of morphological "stream states", explicitly including the role of biology, which provides insights into appropriate restoration strategies to counter adverse impacts from past disturbance, while building future resilience.

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Biography:
Janine Castro is the Project Leader for the Columbia River Fish and Wildlife Conservation Office (CRFWCO) in Vancouver, Washington. It is the mission of the CRFWCO to assist in determining the status of imperiled natural fish stocks, to evaluate management measures for recovery and assist in the recovery of these stocks, and to prevent future ESA listings. As the Project Leader, Janine provides leadership to a highly diverse technical staff that address a wide variety of fisheries issues, including: (1) fish passage and aquatic habitat restoration, (2) bull trout recovery and lamprey conservation, (3) marking and tagging of nearly 40 million hatchery fish annually to support tribal, recreational, and commercial mark-selective fisheries, (4) mark-recapture studies of wild fish to determine occupancy, distribution, abundance, trends, and population growth rates, and (5) providing analytical support to project design, evaluation, and information management.
Janine provides national and international training on stream restoration, river science, and public speaking for scientists. She has worked for the Fish and Wildlife Service for 18 years and spent the preceding 10 years working for the Natural Resources Conservation Service. Janine is co-founder of Science Talk, one of the five founding members of River Restoration Northwest, adjunct faculty in the Environmental Sciences and Management Department at Portland State University, and the Technical Director for the PSU River Restoration Professional Certificate Program.

SESSION 2: ADDRESSING CHANNEL RESPONSE TO HYDROLOGIC ALTERATION SUSTAINABLY

***Title:* Land Use Change impact on Channels**

Author:
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Abstract:
River width is determined by watershed area, climate and stream type; but changes in land use can cause a doubling of channel size along with a 400% increase in sediment yield as channels evolve. The root causes are an increase in channel discharge resulting from a desynchronization of snowmelt, soil compaction during wet weather logging and changes in watershed roughness largely caused by the loss of mature trees. Channel discharge increases 2 to 3 times over the 1 to 50-year frequency range. Compared with land rebound from glacial melt, land use channel changes occur in mostly a 50-year time span rather than thousands of years and are in the range of 1-ft vertical and 1-ft horizontal per year compared with 1- or 2-mm per year for land rebound adjustments. More frequent and larger storms caused by climate change may also cause channel adjustments especially in narrow valleys with limited floodplains where bridges are a better long-term bet than culverts.

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Biography:
I was a research hydrologist with the USFS, North Central Forest Experiment Station in Grand Rapids starting in 1967 and retiring 35-years later as Chief Research Hydrologist and sometimes Project Leader in 2004. During that time I worked closely with Ken Brooks at the Univ. of MN as an Adjunct Professor from 1974 to 2004. From 2004 until April of 2018 I was a Consulting Hydrologist with Ellen River Partners doing stream restoration primarily in Michigan and Minnesota.

My wife Ellen and I enjoy camping and fishing with family and friends in Minnesota and Colorado and spending time with grand kids and our 2-year old great granddaughter.
She has trained me as a reasonable Quilting Assistant as she, and others craft 30 to 40 quilts a year.

Title: **River Channel Responses to Large Increases in Flows and Sediment Supply**

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Abstract:
Alluvial river channels adjust their width, depth, and slope over time in order to convey the amount of water and sediment supplied from the watershed. Rivers throughout Minnesota have experienced profound changes in flow and sediment supply over the past few decades and are likely to experience further changes in the future. How have rivers responded to these large changes? Why do we observe different responses in different regions? What does this all mean for river policy, management and restoration? We document that flows have increased considerably in many parts of the state due to changes in both climate and artificial drainage. Next, we show that these increases in flow have very different implications in terms of sediment supply throughout the state because sediment rating curves (discharge-suspended sediment relationships) vary considerably throughout Minnesota. We find that the general shape and the steepness of these relationships is primarily dictated by geology and geomorphic history, while vertical offset of the relationships and suspended sediment concentrations of low flows are influenced by land use. This finding should help us prioritize locations where management and restoration actions can do the most good in terms of sediment reductions. Lastly, we document very distinct responses to the increases in flow and sediment supply in different parts of the state. For example, the Le Sueur River contains a very distinct slope break (knick zone) approximately 40 km from the mouth of the river. Above knick zone is low gradient, passively meandering channel. Within the knick zone the channel is relatively high gradient, actively meandering and

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rapidly incising. Thus, the knick zone reach has much stronger response to the increases in flow. Similarly, the Minnesota River between Mankato and Jordan is aggradational and highly dynamic with rapid meander migration rates, frequent channel cutoffs, and has responded to increased flow and sediment supply by increasing channel width considerably. In stark contrast, the Minnesota River between Jordan to Fort Snelling is far less dynamic, with passive meanders and few natural cutoffs because it has a relatively small supply of sediment. The Root River in south-eastern Minnesota has similarly distinct river reaches, but the legacy effects of land use in the watershed manifest themselves in very different ways. Recognizing these differences throughout Minnesota in the morphology of rivers and their responses to increased flow and sediment supply allows us to establish more feasible restoration goals. Some geomorphic settings require that we design for active, dynamic channels. Stable channel design is more appropriate in other settings.

Biography:
Patrick Belmont is an Associate Professor of Hydrology and Geomorphology in the Watershed Sciences Department. His research focuses on how water and sediment move through watersheds. He is driven to understand how landscape systems have evolved over geologic time and evaluate how that landscape context influences modern processes and dynamics. This understanding is useful for predicting how human activities affect terrestrial and riverine processes. The three main thrusts of his research are a) mathematical modeling of hydrology, erosion and river channel change, b) development of water and sediment budgets, and c) spatial analysis with a focus on high-resolution topography data. Dr. Belmont leads a nationally renowned research group, working most prominently in Utah, Idaho, California, and Minnesota and a has strong track record of translating his science into actionable management and policy guidance, working directly with state and county-level agencies, industry and non-profit environmental groups, and state legislators.

***Title:* Has Stormwater Management Been Our Achilles Heel in River Management?**

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Abstract:
Stormwater management techniques have been employed to manage floodwaters since at least the era of the Roman Empire. Techniques have evolved into an intricate network of sewers, curb and gutters, ponds, swales and other infrastructure to route water away from developed areas to receiving water bodies with the preponderance being watercourses. Over the past century, impacts to watercourses from changing landuse practices have become more clearly realized and stormwater management strategies have been modified to address many of the hydrologic concerns. Such strategies have included: peak shaving, targeted velocities and durations to better

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accommodate fish migration and flow release rates at or below critical shear stress thresholds of bed and bank media to reduce channel erosion have become common place.

The current and past strategies to manage altered flows have afforded little attention to managing the continuum of bed material transport which represents half of Lane's balance in maintaining channel stability for any given watercourse. The presence of oversized channels, oversized infrastructure (e.g. culverts), sediment detention ponds (including forebays), on- and off-line stormwater management ponds, enhanced routing, bridge spans to convey regulatory flood flows rather than spans to maintain riparian corridor stability further exacerbate the sediment transport continuum – Stoke's Law remains valid and channels continue to degrade and exacerbate ongoing maintenance. This becomes a particularly challenging obstacle when a proponent may be contemplating either a river restoration or rehabilitation initiative. With both flow and sediment regimes irrevocably altered from landuse change, rehabilitation offers greater opportunities for design success, however, this approach in many cases may need to alter both the historical geomorphic alignment and ecological targets of a given watercourse.

If proponent's expectations are to undertake river restoration approaches to perpetuate historical channel alignments and ecological targets, stormwater management strategies need to be notably reconstituted to include the continuum of bed material transport. Fortunately, low impact development (LID) initiatives are beginning to take hold in North America which may be the first step along this pathway continuum. It is an axiomatic notion in the fields of surface water chemistry and contaminant hydrogeology that the most effective ways to mitigate contamination are to first remove the sources of the contamination and then address the residual plume effects. A similar analogy should apply in stormwater management where rain harvesters could be installed in combination with depressional storage at the lot scale of all new (and eventually matured) developments which would remove the first one to two inches of precipitation while not interrupting the continuum of upland washload transport. Stream and river corridors could then be configured (notably larger floodplains) to accommodate the lower frequency higher magnitude flood events while maintaining sediment continuity. Such approaches would further decrease the need for other infrastructure (such as ponds) within a development envelop offsetting costs of LID investments. This presentation will summarize many of the pitfalls in current stormwater best management practices, effects upon river channels (which are applicable to urban and rural watercourses) and mitigative strategies to re-establish the bed material continuum.

Biography:
Dr. Bill Annable, PhD, PhD, PEng, PE, PGeo, is an Associate Professor of Civil and Environmental Engineering at the University of Waterloo in Ontario, Canada. Bill has been researching the hydraulic, sediment transport, morphologic and eco-hydraulic characteristics and linkages of rivers across North American and Europe for the past 25 years. His principle areas of research focus on investigating the effects of hydromodification due to land-use change on both urban and rural settings and the bio-physical linkages between aquatic communities and their physical habitat conditions (including hydraulics, sediment transport, and groundwater / surface water interaction). In addition to theoretical and applied research, Dr. Annable has also been

designing, monitoring and supervising the construction of river rehabilitation projects across North America totaling over 3,000 km of rivers studied and over 200km of river channels rehabilitated. Bill has also been investigating with colleagues the eco-hydraulic linkages of domesticated watersheds in Switzerland and Italy to assist with developing rehabilitation strategies to effectively rehabilitate watercourses historically effected by hydropeaking schemes.

KEYNOTE

***Title:* Restoring Ecological & Geomorphic Function on the Heartrock Ranch, Idaho**

Author:

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Abstract:

A large-scale restoration following the Natural Channel Design approach was implemented in 2011 near Sun Valley, Idaho, with primary goals of establishing cold-water fisheries and enhancing river stability (i.e., transporting sediment and streamflows) and hydrological connectivity (longitudinal, lateral, vertical, and temporal). Assessments related to both ecological and geomorphic functioning at multiple spatial scales were conducted to direct the restoration by identifying limiting factors for various species and their habitats, including large mammals, eagles, heron, waterfowl, songbirds, and aquatic organisms. A downstream reference reach on Willow Creek was used to represent the physical and biological potential of the impaired river system.

Assessment results indicate that heavy, season-long livestock grazing, poor irrigation practices, and direct channel impacts were responsible for numerous impairments, including:

- Incised channels with disconnected floodplains
- Lack of sediment transport capacity due to overwide and shallow channel
- Poor pool quality
- Limited instream wood, undercut banks, and woody vegetation
- Invasion of fine sediments generated from accelerated streambank erosion
- No off-channel features for habitat complexity or diversity for terrestrial and aquatic species
- Poor invertebrate habitat, spawning habitat, and gravels
- Elevated water temperatures
- Limited holding cover and habitat for juvenile and adult fish species during low and high flows

The restoration involved constructing 13 miles of stream channels on previously abandoned surfaces to reconnect channel/floodplain exchanges, transport sediment, and regain an instream flow regime with a new water management plan. Oxbow lakes, emergent wetlands, and off-channel food plots were created, and the toe wood structure was implemented on newly constructed channels and for portions of the braided Big Wood River to introduce instream wood

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and reduce excess sediment from streambank erosion. A screened gravel substrate without fines from the excavation of the oxbows was placed on constructed glides for spawning material, and a separate mixture of cobble and gravel was placed in the created riffle, pool, and run bed features. Invasive riparian species were eliminated, and native riparian vegetation was re-established on previously overgrazed lands.

Monitoring results show that average stream discharge increased even during low precipitation years, residual pool depth increased (< 0.18 m to > 0.9 m), spawning substrates increased in size (0.11 mm to 19 mm), and estimated egg-to-fry trout survival increased from less than 20% to more 90% based on the Fredle indices. Invertebrate indices of restoration effectiveness were "positive", and fish diversity increased from three to seven species in the restored spring creeks, which matched species diversity in the post-restoration reference reach. For the two restored streams, redd counts increased dramatically (7 to 161 and from 17 to 143). Likewise, the electrofishing catch-per-unit-effort for wild trout increased dramatically (0.013 to 1.166 trout/m and 0.029 to 0.222 trout/m) for the two spring creeks as part of the larger community-level response. According to ranch accounts, the restoration and aquifer recharge approach increased hay production and reduced labor needs by converting flood irrigation to sub-irrigation.

Biography:
Hydrologist/Geomorphologist, P.H., Ph.D., Principal of Wildland Hydrology in Fort Collins, Colorado, with field experience in river work spanning 50 years. Dave has designed and implemented over 70 large-scale river restoration projects. Dave developed a stream classification system, the BANCS streambank erosion model, the FLOWSED/POWERSED sediment transport models, the *WARSSS* methodology for cumulative watershed assessments, and a geomorphic approach to river restoration using a Natural Channel Design methodology. Dave utilizes his extensive experience to conduct short courses in watershed management, river morphology, restoration, and wildland hydrology applications. Dave has also authored two textbooks and over 70 reports and articles in research journals, symposia, and federal agency manuals.

KEYNOTE

Title: **The Yellow River Initiative - An Introduction to the Kankakee River Problem and Plan**

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Abstract:
The Kankakee River Basin is one of the most extensively modified watersheds in Indiana. Since 1977 the Kankakee River Basin Commission (KRBC) has struggled to balance drainage with

sediment loss, flooding, and a long, increasing list of competing uses. The never-ending cycle of dredging and clearing the river has become increasingly unsustainable, and the politics of an interstate river basin more difficult. The KRBC has never tried to manage the basin in a vacuum; the Kankakee may be the most studied watershed in Indiana, but the questions have changed. For the last two decades, a growing body of work has demonstrated that rivers need to be managed as systems. The "patch here and dredge there" strategy doesn't work. It simply moves the problem. The KRBC has come to realize this paradigm shift. They have fought with budgets and eroding sand dunes longer than anyone, and there is more sand than money. The KRBC has now asked the question: "is there a better way to manage this river system?" There are no easy answers, but the KRBC with the help and support of the Indiana Silver Jackets is trying to come up with ways to better manage the Kankakee River basin. In this presentation, we will discuss the most recent efforts of the KRBC to lay out and initiate, with the help of Indiana Silver Jackets, a new path to better understand and address the challenges facing the Kankakee River system – the Everglades of the North.

Biography:
Robert Barr is a research scientist (fluvial geomorphology and hydrology) at the Center for Earth and Environmental Science at IUPUI. His primary research focus is on understanding the physical processes and form necessary to achieve and maintain healthy stream systems in a changing landscape. Bob has participated in numerous large-scale stream assessments, including the Yellow and Maumee Rivers in northern Indiana, Eagle Creek and White Lick Creek in Central Indiana, and several small streams in the Toiyabe and Toquima Mountain Ranges of north-central Nevada. Bob's current projects include the Indiana Fluvial Hazard Mitigation Program, the School Branch National Water Quality Initiative, the Kankakee River Basin Restoration Initiative, and the Indiana Silver Jackets low head dam initiative. In addition to his academic research interests, Bob has served as a consulting hydrologist and fluvial geomorphologist for over 12 years.

SESSION 3: SEDIMENT IN RIVERS; INCORPORATING PROCESS UNDERSTANDING IN RESTORATION DESIGN

Title: **Regional Sediment Data and Regional Curves: Increasing Confidence in Designs through Competence, Capacity and Support**

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Abstract:
Excess sediment in the stream corridor contributes to many issues in the watershed including public water supplies, flooding, aquatic habitat, and impoundments/receiving waters. Raising the awareness of the amount of sediment entering the stream systems from stream bank erosion is not only a water quality issue, but a key component in the assessment and proposed solutions to address this natural resource concern.
Field practitioners of natural channel design must incorporate two major data resources into the process of assessment and design.
Field practitioners need local hydro-physiographic data to correlate regional curve data for use in validating bankfull and sediment data as well as channel competence and capacity for design alternatives evaluation. Collecting and analyzing sediment data using USGS field techniques allows the development of regional sediment curves. The sediment curves in conjunction with regional curve discharge data can be used in the development of dimensionless sediment curve data for use in assessment and design. RIVERMorph™ software is an excellent tool for incorporating this data and evaluating existing cross sections for competence and capacity as well as proposed cross sections. Utilizing regional curve data and sediment data to design appropriate width/depth ratios are vital components of successful stream restoration and/or stabilization projects.

Biography:
Alan is the president of Streamwalker Consulting, LLC (formed in 2005) and is currently assisting Resource Institute, Inc as a consulting agent. As a consulting agent with Resource Institute, Alan assists with project management activities.

Prior to his retirement from USDA-NRCS (Natural Resources Conservation Service) in January 2017; Alan served 6 years as the Assistant State Conservationist for Field Operations in Waynesville, NC. His major duties included: providing supervision, guidance, and assistance to the 33 western counties in North Carolina as well as supervising the district conservationists at the field office level, serving as a supervisor to the area support staff and coordinating a well-balanced resource conservation program to meet the objectives of customers in western NC. He was instrumental in forming a pilot project with federal, state and a non-profit partner to accelerate EQIP assistance in western North Carolina. This project was the Western NC Stream Initiative that used a non-profit partner who worked with SWCD's using state funds to assist with engineering, permitting and construction oversight for stream projects. Through FY2018 this partnership has leveraged over 24 million (federal 7 state funds involving over 200,000 feet of streams in western NC.

Alan completed Level 4 of the Rosgen courses in 1998 and has served as a field assistant for Levels 1,2, & 3 Rosgen stream courses held in North Carolina since the late 1990's. Alan has an interest in stream dynamics and is also involved in stream restoration/stabilization projects using the natural channel design approach.

Alan spent two summers as a as student-trainee in McDowell and Rutherford Counties and served as a soil conservationist in Yadkin, Sampson and Duplin Counties and prior to serving 11 years as the District Conservationist in two locations; Alexander and Alamance Counties. Prior

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to becoming the ASTC-FO he served 14 years as the Area Resource Conservationist in Waynesville, NC.

Alan was born and raised on a beef cattle, tomatoes and tobacco farm in Haywood County, North Carolina. He attended the University of Tennessee in Knoxville where he was a member of the Alpha Gamma Rho fraternity and graduated with a Bachelor of Science Degree in Plant and Soil Science in 1983.

Alan's interests are the University of Tennessee Athletics (especially football), college football, fly-fishing, golf and about anything out doors.

***Title:* Stream Channel Succession and Sediment Dynamics: Black Vermillion River, KS**

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Abstract:
The Black Vermillion River drains approximately 410 square miles in northeastern Kansas. The drainage basin of the Black Vermillion River lies within Ecoregion 47: Western Corn Belt Plains. Surface materials are dominated by alluvium and glacial drift/till. Conversion from native, warm-season tallgrass prairie to agricultural production caused significant impacts to the river channel and riparian landscape. Major channelization shortened the river by nearly 16 miles from pre-settlement dimensions; this shortening combined with the construction of numerous flow-through structures/dams have produced dramatic changes in discharge and sediment dynamics.

In 2007, nine monitored stream reaches were established within three main tributaries of the Black Vermillion River of northeast Kansas. Each reach was surveyed and assessed for channel stability. Subsequent surveys (2008-2010) were conducted along with monitoring of streambank erosion, bed scour, and sediment size/distribution shifts. Surveys allowed for geomorphic characterization, quantification of stability, and identification of stream successional sequence. This work allowed correlation of stream 'state' and in-channel sediment contributions, as well as prediction of future erosion rates based upon progression of stream succession.

This presentation recounts our predictions of channel succession on the Black Vermillion River and the coincident sediment yield associated with establishment of a stable channel form at current bed elevations. Calculations assume that a stable channel and floodplain at current bed elevation is the most acceptable design solution in this tillage agriculture dominated landscape.

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Use of natural channel design parameters allows for the prediction of stable channel form and sediment yields associated with channel succession. Our measured erosion rates and basin-specific bank erosion curves (Sass and Keane, 2012) allow prediction of the time frame for stream channel succession. Such understanding is critical in determining not only how but when to most effectively mitigate the myriad of instability consequences.
This work was supported by USDA CREES 406 Integrated Program (Grant#KS600399).

Biography:
Tim Keane, PhD, is Professor of Landscape Architecture and Commerce Bank Distinguished Graduate Faculty at Kansas State University where he has served since 1984. His teaching has been repeatedly recognized with multiple departmental "Teacher of the Year" awards, two college level "McElwee Teaching Awards" and three endowed "Jarvis Chairs in Landscape Architecture" recognizing his teaching and service. Keane's research, which focuses on fluvial geomorphology, stream channel stability and sediment transport, and urban storm water management, has been acknowledged through national awards from the USDA and the Council of Educators in Landscape Architecture (CELA). Keane was awarded the inaugural Mary Jarvis Scholar of Distinction faculty chair in Landscape Architecture (2010-2013). Keane's research has been funded by state, federal and private agencies including the Kansas Conservation Commission, KDHE, USDA, NSF and the Apache Foundation. Dr. Keane was one of the founders of the College of Architecture, Planning and Design's interdisciplinary doctoral program and has chaired three candidates to successful completion in the newly minted program.

***Title:* Sediment Sources, Baseline Sediment-Transport Rates and the Effectiveness of Restoration Measures for Reducing Loads to Receiving Waters**

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Abstract:
The impact of erosion, transport and delivery of sediment to receiving-water bodies is the focus of worldwide attention in efforts to protect drinking water, aquatic and marine resources, and maintain reservoir capacity for water supply, flood control and power generation. To adopt effective sediment-control measures to protect receiving waters, it is not sufficient to only know the magnitude of the sediment load, but also the major contributing sources. Potential sediment sources may include: uplands (from overland flow and mass movements) including gullies, dirt roads, fields and channels (bed and banks). There has long been an overemphasis on the role of uplands and fields on sediment erosion and delivery at the expense of channel processes (e.g. Chesapeake Bay, the Great Barrier Reef). This is largely due to institutional inertia that produces a reliance on watershed models to predict sediment loads, notwithstanding that these models cannot account for one of the most important sources today; streambanks.

A series of studies from the Chesapeake Bay Watershed show that streambank sediments may account for 47-95% (mean of 71%) of sediment yields. In contrast, based on watershed modeling, EPA suggests that only 30% is derived from streambanks. For example, in southern Queensland, Australia, watershed modeling showed that 60% of the suspended load delivered to the Great Barrier Reef from the Burnett River was emanating from uplands, while just 8% of the 2.76 million tonnes/y was generated from streambanks. A subsequent, detailed study of streambank erosion, however, showed by both empirical and modeling approaches that streambank erosion accounted for between 44% and 73% of the average, annual-suspended load. The locus of sediment erosion has shifted from the uplands to the channel systems as soil-conservation measures improved and rivers adjusted to influxes of agricultural sediment and other anthropogenic activities. These periods of instability are marked by increases in sediment-transport rates. Contributions from channel sources, particularly streambanks can typically be in excess of 50% of the total suspended-sediment load. Transport rates from stable or re-equilibrated systems, however, are used to determine baseline or "reference" transport rates. Examples from various ecoregions are provided and range over several orders of magnitude.
It is, therefore, critical to use the appropriate analytic tools if one hopes to be able to accurately determine magnitudes of sediment delivery from various sources, and to determine effective sediment-reduction strategies. For streambanks, the dynamic version of the Bank-Stability and Toe-Erosion Model (BSTEM) is used to simulate bank erosion over extended flow periods. Used in combination with observations of the longitudinal extent of failing banks, unit loadings (per m of channel length) are extrapolated to determine bank-generated sediment loads. Predictions of important load reductions along with the effectiveness and cost-effectiveness of a range of restoration measures slope are quantified by comparing erosion rates for the same flow series under "existing" and various restoration strategies. These may include direct modification or protection of banks, riparian plantings, changes in flow regime or grade control. Examples are provided from the U.S., Australia and New Zealand.

Biography:
Dr. Andrew Simon is a Principal and Senior Geomorphologist at Cardno in Oxford, Mississippi. He has 38 years of research experience, 16 years with the U.S. Geological Survey and 16 years at the USDA-ARS, National Sedimentation Laboratory. His process-based research has been in in mechanistic analysis of unstable-channel systems, streambank erosion, cohesive-sediment entrainment, the role of riparian vegetation, "reference" sediment-transport rates for TMDLs, and river restoration. He is the author of more than 100 technical publications, has edited several books and journals and is the senior developer of the Bank-Stability and Toe-Erosion Model (BSTEM). His Cardno team recently collaborated with the Corps of Engineers to integrate that model into HEC-RAS. His field research has taken him to Australia, New Zealand, Europe, Asia and across North America. Dr. Simon is also a Special Professor in the School of Geography at the University of Nottingham, UK.

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SESSION 4: STREAM RESTORATION; ADAPTIVE IMPLEMENTATION AND MANAGEMENT

***Title:* Applied Research Efforts to Improve the Design, Implementation and Management of Ecological Restoration in North Carolina**

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Abstract:
Stream restoration is "big business" with over a billion dollars spent annually on restoration projects across the US. North Carolina is recognized as a national leader in stream restoration innovation, design and implementation. The rise of restoration in N.C. was in part due to the leadership, creativity and innovation afforded by the formation of the NC State University Stream Restoration Program (SRP) in the late 90's. A partnership of the Biological & Agricultural Engineering Department and NC Sea Grant, the SRP is a team of faculty, staff, and students working to improve water quality and aquatic ecology through research, demonstration projects, and education. Following two decades of developing, testing, demonstrating and evaluating natural channel design focused restoration practices, the SRP now focuses heavily on evaluating the ecological performance and functional uplift and the metrics and tools for gauging these outcomes. The SRP also offers a series of River Course workshops with 4-6 short courses a year attended by more than 200 restoration professionals and a biennial stream conference, EcoStream, which attracts 350-400 participants. Since inception, the SRP has provided training and education to more than 6000 professionals in stream assessment, design, construction, modeling and monitoring.

Commonly stated goals for stream restoration include enhancing water quality, improving aquatic habitat, stabilizing stream banks, establishing native riparian vegetation and enhancing floodplain function. Many funding agencies have realized the need to document and quantify functional performance of restoration efforts. The SRP has partnered with state and federal agencies, local governments and non-profit organizations to develop research projects focused on evaluating the ecological benefits, including water quality for restoration efforts and to identify new and innovative practices to maximize these ecological benefits. This presentation will feature several of these efforts.

SRP assessed 157 restored, impaired and reference streams during 2006-2012 using several rapid assessment tools. Macroinvertebrates were collected from 85 of the restored streams and watershed assessment was conducted for a selection of streams. Morphological design data and

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site-specific landscape factors were also compiled for 79 of the restored streams. Statistical analysis revealed that macroinvertebrate metrics correlated with stream assessment variables and as expected, watershed condition variables improved correlation in most cases. In addition, restored streams were found to have morphologic conditions similar to reference streams, but exhibit greater variability in aquatic habitat and bedform. Larger (wider) streams in steeper valleys with larger substrate and un-developed watersheds have higher numbers of pollution intolerant EPT taxa. Also, greater floodplain widths correlate with higher EPT taxa.

In partnership with the NC Division of Mitigation Services, NC's in-lieu fee mitigation program, and the Environmental Defense Fund, SRP is currently evaluating functional uplift and physical and morphological adjustment of stream restoration projects in the Piedmont region of NC. In addition, to assist the state's Department of Environmental Quality in developing proposed nutrient crediting protocols for stream restoration projects, the SRP has conducted data collection, analysis and technical advice to evaluate the three mechanisms of nutrient reduction currently being considered (i.e. streambank erosion, hyporheic exchange and increased floodplain connectivity) in order to develop nutrient crediting criteria that are based on sound science.

Biography:
Barbara Doll is an Extension Specialist for North Carolina Sea Grant and an Extension Assistant Professor in the Biological & Agricultural Engineering Department at NC State University Barbara holds a Ph.D. in Biological and Agricultural Engineering and is a licensed professional engineer who joined Sea Grant in 1992 to work on water quality issues. Sea Grant is a federal/state program that promotes the wise use of coastal resources. Much of Barbara's current research and outreach focuses on ecological restoration, reducing the impacts of nonpoint source pollution and assessing the effectiveness of restoration practices. She has developed and implemented several innovative stream restoration projects including the multi-million dollar, three-phase project to restore Rocky Branch, a creek that runs a mile through the North Carolina State University campus and is a tributary to the Neuse River.

Barbara currently serves as the principal investigator for more than $1.2 million in grant funding which supports outreach and research projects focused on evaluating the performance of stream restoration efforts, developing new techniques for ecological restoration, stormwater management and assisting communities with water quantity and quality challenges. She manages a team of engineers and graduate students who are funded by these projects. Barbara has authored a number of publications on stream restoration and stormwater runoff, including publishing in professional journals such as the Journal of the American Water Resources Association and WATER.

Prior to joining Sea Grant, Doll worked as a staff engineer for Soil and Material Engineers in Raleigh, N.C. and as a research assistant in the Civil Engineering department at NC State.

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River Restoration 2018
PROTECTING & RESTORING RIVERS IN THE FACE OF UNCERTAINTY
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Title: **Adaptive Management: Using Geomorphic Stream Stage and Transition and Departure Conditions to Plan and Generate Restoration**

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Abstract:
Understanding stage, transition, and channel evolution is a fundamental necessity in developing restoration practices considered to be natural channel restoration. Developing alternative restoration that operates within the natural range of physical variability based on models or analytical equations alone are at high risk of not meeting physical stability, biological objectives and diversity. Avoiding visits to the field involving critical measures of dimension pattern, profile and sediment studies to identify stable morphological stream types and the departure therein will inevitably have consequences. Adaptive management in river restoration is most completely served with this planning paradigm intact. Validation of the current stable analog, aka reference reach, in the similar hydrophysiographic region and fluvial landscape-valley type is essential.

Throughout the Pacific Northwest and the Intermountain West structural practices instead of geomorphic system and channel evolution based designs are still popular. In some areas in the West, such as the Pacific Northwest a structure name has driven design instead of natural stable dimensions, pattern, and profile associated with the type and distribution of sediment load. In many instances success and even objectives have become a moving target instead of identifying and serving the principle objectives stated on permits and funding documentation. Impacts on water quality are potentially a concern.

This paper discusses both river restoration successes and failures due to the consequences of not completing an analysis of stage, transition, channel evolution and departure analysis. In some instances extreme wood structures have been designed without the consideration of riparian vegetation plan and practice. In other instances, even when bank stability was stated as a design objective, extreme lateral recession occurred next to structures and it was acceptable because it was considered a natural process. In other instances, lack of consideration of the socio-economic landscape was not considered in the planning process. Channel evolution, stage of adjustments, and identification of a stable morphological geomorphic stream type within the given hydrophysiographic region with valley landscape types are essential to base line adaptive management and riparian ecological stage and transition. These are pre-requisites for appropriate and robust natural channel restoration.

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Biography:
Barry works in Portland, OR as the National Fluvial Geomorphologist on the Water Quality and Quantity Technology Development Team. He has served for 39 years in various positions with the NRCS including: stream geomorphologist, watershed planner-geomorphologist, soil conservationist and also in Pullman, WA as an NRCS-PhD Graduate Studies student in fluvial geomorphologist while providing technical assistance to USDA-NRCS. Thirty-six of his 39 years of total federal career service, has been with the NRCS. Previous to 1991 most of his NRCS (SCS) work was at field office positions such as soil conservationist, supervisory soil conservationist, team leader, watershed hydrologist, and hydrologic unit (watershed) project coordinator in the Western United States. Barry completed and received his Ph.D. (NRCS Graduate Studies Program) in fluvial geomorphology at Washington State University. He has been a Certified Professional in Erosion and Sediment Control (CPESC #514) for twenty-eight years. Barry's principle expertise is geomorphic river restoration: training, analysis, planning, design, and implementation. He has analyzed, planned, designed and constructed numerous river restoration projects and completed recommendations on streams, including watershed-based fluvial, wood uses in rivers, and streambank erosion studies. He has completed over 1.5 million acres of sedimentation studies in the Western United States. Barry has walked and classified over 1300 miles of streams. He teaches introductory, advanced fluvial geomorphology and geomorphic natural channel design for USDA-NRCS. He is a trainer and lecturer at universities, professional societies, and state sponsored courses. He is a technical paper contributing author of related materials: National Engineering Handbook- Natural Channel Design 654, NEH 653, Stream Corridor Restoration: Principle, Processes, and Practices, Technical Notes, Utah Farmer Stockman, Stream Notes, Rural Technology Initiatives, SVAP 2.0 and so forth. Barry has completed in-depth statistical analysis and management recommendations of fluvial geomorphology impacting rare and endangered species in riparian corridors. He is a fly angler and a BSA Silver Beaver.

***Title:* The Growing & Evolving Benefits of Stream Restoration – From Resiliency to Stormwater BMP – How Will the Industry Continue to Adapt?**

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Abstract:
Stream restoration continues to grow in popularity across the United States. The very practice of stream restoration relies on adaptive management to ultimately implement projects and set streams on the trajectory of sustainability. Interestingly, the profession in general and the funding sources used to pay for stream restoration are also undergoing an adaptive management process. Historically mitigation and/or fisheries enhancement were the key drivers funding stream restoration projects. Now in many areas across the US, the need for resilient

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communities and water quality enhancements through the TMDL program have resulted in significant funding sources for stream restoration projects.

This talk will explore the ever-evolving field of stream restoration and the adaptive management that the profession is currently under from multiple perspectives. Specifically, the evolution of funding sources for restoration implementation will be discussed and examples of key drivers for funding stream restoration in different parts of the country will be explored as well as the applicability of these funding approaches to other areas. Specific examples of the benefits of stream restoration from a resiliency and TMDL reduction perspective will be provided. The adaptive management of the profession will also be discussed. Are we evolving to a profession that will be licensed or will we be continuing on the current path? Are schools of thought for restoration converging or diverging? How are the benefits of stream restoration evolving? These questions will be explored from a practitioner's perspective.

Biography:
George Athanasakes has a diverse background which includes civil engineering, stream restoration, and watershed planning. George has served as the Principal-in-Charge, Project Manager and/or Design Engineer on over 100 stream restoration projects incorporating a variety of restoration techniques. George's services are often retained to consult on stream restoration projects throughout the United States. In addition, he has helped to bring innovation to the field of stream restoration by leading the development of the RIVERMorph software, which is the industry standard for stream restoration software throughout the United States and internationally.

George serves as the Ecosystem Restoration Services Leader for Stantec and is responsible for leading Ecosystem Restoration for the firm throughout the United States. George holds Bachelors of Science and Masters of Engineering Degrees from the University of Louisville. He is also a Registered Professional Engineer in several states.

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