Proceedings of the
MN Lake Superior Watershed Stream Science Symposium

Tuesday, January 7, 2014
Wednesday, January 8, 2014
University of Minnesota Duluth

Photo - Chris J. Benson

This Symposium is funded in part by the Coastal Zone Management Act of 1972, as amended, by the NOAA's Office of Ocean and Coastal Resources Management, in conjunction with Minnesota's Lake Superior Coastal Program.

MN Lake Superior Watershed Stream Science Symposium

Tuesday, January 7, 2014
Wednesday, January 8, 2014
University of Minnesota Duluth

Symposium Sponsors

Acknowledgements

Special thanks to the following organizations that provided funding and in-kind contributions

Minnesota Trout Unlimited, Lake Superior Steelhead Association, The Nature Conservancy, and the McCabe Chapter Izaak Walton League of America

Symposium Planning Committee:

John Jereczek, Minnesota Department of Natural Resources,
Cliff Bentley, Minnesota Department of Natural Resources
Valerie Brady, University of Minnesota Sea Grant,
Jesse Schomberg University of Minnesota Sea Grant,
Brian Fredrickson, Minnesota Pollution Control Agency,
Marty Rye, US Forest Service,
Brian Hill, US Environmental Protection Agency
Carl Haensel, Minnesota Trout Unlimited
Paul Sandstrom, Laurentian Resource Conservation and Development Council

Editor: Paul V. Sandstrom

Published by Laurentian Resource Conservation and Development Council

Interior Photos by June Kallestad, NRRI

Contents

Opening Keynote Speaker MN DNR Commissioner Tom Landwehr

Introduction

The MN Lake Superior Watershed Stream Science Symposium was a significant success. There were 189 registrants representing local, state and federal government, nonprofits, university researchers, and private industry. Attendees traveled to the event from across the Great Lakes states and Canada.

Attendees heard thirty-nine speakers cover topics that ranged from Minnesota's new watershed framework, MN Lake Superior watershed geology, and hydrology to the unique fishery and impacts of climate change. Break out sessions and an interactive online comment gathering process gathered feedback and important ideas from the audience. A panel presentation centered upon funding sources wrapped up the two-day event.

Thirty-six posters illustrating new cutting edge research as well as important findings from completed research were presented. This information added to the wealth of knowledge presented to attendees.

Keynotes:

Day one keynote presentations from state and federal agency heads set the stage for the event by outlining Minnesota's Clean Water fund and the "Roadmap Project", programs to facilitate the states ability to achieve Federal Clean Water Act goals. MN has established benchmarks for water quality with beneficial use classifications, numeric and narrative criteria to protect those uses and nondegradation requirements. The watershed approach paring systematic monitoring, Watershed Restoration and Protection Strategies (WRAPS) with implementation activities delivered through a local implementation framework is the process developed to achieve water quality goals. Discrepancies in funding exist however, that may keep the state from achieving water quality goals in the timeframe desired. The state will need to adapt water quality strategies with respect to a changing climate as well.

Abstracts and Presentation Highlights
Day One

Role of Non-Profits

John Lenczewski*, Minnesota Trout Unlimited
Kris Larson*, Minnesota Land Trust

Abstract: Restoring and protecting trout streams requires a special combination of scientific information, professional expertise, willing landowners, political will and sufficient funding. Due to their unique ability to put these ingredients together, non-profit organizations can play an important role in delivering on state and local goals for watershed protection in the Lake Superior basin. This presentation will explore a few of the strategies used by non-profits such as Minnesota Trout Unlimited and the Minnesota Land Trust to ensure the health of the Lake Superior streams and how scientific data can be helpful in determining priorities and delivering on real-world project implementation.

Presentation Highlights: Non-Profits have a role in water quality implementation strategies working with landowners to engage them in restoration and facilitate protection. Non-Profits work as advocates, secure multiple sources of funding and very efficiently leverage funding. Non-Profits work effectively in the areas government and the private sector has difficulty with.

Historic Overview of Logging in the Cross River Watershed: 1895-1925

Lee Johnson*, Forest Archaeologist USDA Forest Service, Duluth MN

Abstract: The industrial level harvesting of pine timber from the North Shore of Lake Superior began in the last quarter of the 19th century. Prior to the 1890's, small-scale harvesting of pine for local consumption centered around the newly organized cities of Duluth, Beaver Bay, and Port Arthur in Ontario. The Schroeder Lumber Company consolidated ownership of valuable stands of white and red pine in the upper Cross River watershed near Schroeder in the 1890's and commenced logging operation in 1902. In order to transport raw logs from the woods to the market, the Schroeder Lumber Company harnessed the power of the Cross River through construction of various splash dams, flumes, and water control mechanisms. The Cross River represents one of the few watersheds on Minnesota's North shore were industrial level log drives occurred during the historic logging period (ca. 1880-1925). Schroeder Lumber Company's operations on the Cross River provide a context for the mechanics of log driving and watershed manipulation on Minnesota's North shore in the early 20th century.

Presentation Highlights: Impacts to the Cross River from use to transport logs cut from the watershed during the early 1900's are still evident but have healed over. Significant stands of white pine were removed from areas of the watershed during the late 1800's and early 1900's.

Geologic History of Western Lake Superior Streams

Karen Gran*, Associate Professor of Geological Sciences, University of Minnesota Duluth

Abstract: Streams are constantly evolving. Although much attention focuses on human manipulations of streams and watersheds, stream response to anthropogenic drivers must be understood within the context of stream response to natural drivers. In western Lake Superior, stream geomorphology is controlled by both the geologic setting and the Quaternary glacial history of the area. This talk will review the geologic history of western Lake Superior, back to the time of emplacement of bedrock during the mid-continent rift 1.1 billion years ago up to the most recent glaciation. During the last glaciation, the Superior lob flowed northeast to southwest, scouring the basin now occupied by Lake Superior. The Rainy lobe flowed from the north, scouring the uplands. During times of glacial retreat, large proglacial lakes formed in front of the ice, filling the basin with water. Following the final retreat of glacial ice, isostatic rebound has uplifted the Superior basin. Ice depths were greater in the north, leading to higher rates of isostatic rebound to the north and east, resulting in a general tilting of the basin over time. This tilt continues through today, drowning river mouths in the east and south, while uplifting those on the North Shore.

Presentation Highlights: Minnesota's Lake Superior tributaries are geologically young streams still in the process of adjusting to conditions from the last glaciation. Isostatic rebound along the north shore of Lake Superior continues as the streams actively erode lake laid clay deposits overlain by till. Most North Shore streams are unique with inverted profiles focusing stream power in lower down stream sections close to their confluence with Lake Superior. Hydraulic geometry relationships with the inverted profile streams do not hold the way they do in graded rivers (area/width; width/discharge). Discharge x Slope = Stream Power. Stream power increases as you head towards streams lower reaches. If the stream runs through an area where there is fine-grained till, then slumping along a stream can be expected.
Competent bedrock on LS NS streams can be a large influence on the effects of increasing stream power on slumping and erosion potential.

Diagnostic Geomorphic Methods for Understanding Future Stream Behavior of Lake Superior Streams – What Have We Learned in Two Decades?

Faith A. Fitzpatrick*, U.S. Geological Survey, Wisconsin Water Science Center

Abstract: Geomorphic studies of Lake Superior streams started in about 1993 from questions posed by fisheries biologists at the Wisconsin Department of Natural Resources to the U.S. Geological Survey: Are erosion and sedimentation rates in Bayfield Peninsula streams natural or human accelerated? If human accelerated, what can be done to alleviate the problems and improve habitat? Sedimentation problems noted in river mouth areas pointed to a need to look upstream for understanding the longitudinal connections between past and present watershed hydrological processes and present and future trajectories of channel behavior. A multi-disciplinary, diagnostic, geomorphic analysis approach was used that included the following: documenting historical and pre-Euro-American settlement channel changes, mapping glacial landforms and bedrock outcrops, constructing historical and modern sediment budgets, describing valley alluviation, and simulating historical land-use effects by testing watershed hydrological models. This led to the determination that erosion and sedimentation rates in Bayfield Peninsula streams were elevated above natural rates and helped guide managers on where to locate future rehabilitation and protection activities. This diagnostic approach has been used for informed prediction of future geomorphic responses to watershed hydrological disturbances and has been used for answering a variety of management questions related to stream rehabilitation and contaminant fate and transport.
Contact Information: Faith A. Fitzpatrick, U.S. Geological Survey – Wisconsin Water Science Center, 8505 Research Way, Middleton, WI 53562, USA
Phone: 608.821.3818, Fax: 608.828.3817, Email: fafitzpa@usgs.gov

Presentation Highlights: Glacial landforms across the Lake Superior Watershed have produced geomorphic diversity among stream systems. Stream network position, valley type, geologic setting, land cover, and history are important factors in predicting future behavior.

Human disturbance has accentuated ongoing geomorphic processes. History affects the present stream condition; channels have been cut off from their floodplains in two ways, channel incision and overbank sedimentation (flume-like). "Slowing the flow" from uplands and within the channel is important towards maintaining channel stability. Natural channel restoration that reconnects the channel to its floodplain and riparian wetlands will benefit both the biological and hydrologic stream characteristics. The large wood supply in the channel system is missing as are the geomorphic and hydrologic benefits produced by large wood. Knowing past and present stream behavior throughout a watershed helps to determine future management, protection, and rehabilitation strategies.

An Isotopic Approach to North Shore Lake Superior Watershed Management

Joe Magner* and Lu Zhang
Dept. of Bioproducts & Biosystems Engineering
University of Minnesota
Lee Engel
Minnesota Pollution Control Agency

Abstract: The stable isotopes of hydrogen and oxygen offer watershed managers a tool to better understand hydrologic storage and pathway movement. Isotope data was collected over several years from varying tributaries along the North Shore Lake Superior, selected arrowhead lakes and specifically in the Cross River watershed in 2012. Results offer hydrologic insight related to sources of runoff and hydraulic residence time. Data collected from tributaries discharging to Lake Superior suggest a general south to north pattern of isotopic signatures that are dynamic and change with season. Headwater lakes provide the most important storage of precipitation and sustain baseflow in most tributaries, including the Cross River. Subsurface storage is relatively small due to limited aquifer extent. Lake hydraulic residence time is directly influenced by location in the watershed, contributing drainage area and lake volume. The mega-storm of June 2012 illustrated a relatively small amount of storage in the Cross River. The new precipitation overwhelmed the watershed pre-event isotopic signature and shifted all measured sites toward the storm isotopic signature. These data point to the need for comprehensive intentional watershed management of North Shore Lake Superior streams and lakes.

Presentation Highlights: Plotting the relationship of stable hydrogen and oxygen isotope ratios produces a global meteoric waterline or local meteoric water line. Minnesota's local meteoric water line can be used to determine precipitations travel

path to stream water or hydrologic residence time. Temperature drives isotopic ratios. An increase in temperature will create an increase in isotopic composition. A meteoric water line is also present due to elevation changes. A seasonal isotopic signature also exists. Evaporation causes fractionation of isotopes. Transpiration creates a different signal (fractionation) In June 2012, a large rain event displaced water in systems. The isotopic signature was altered. After effect from the large amount of water displaced indicates wetland and soil storage. During wet years water moves through the system faster. Climate change will change hydraulic residence time (and possibly biology) Isotope measurements are an easy and inexpensive way to estimate hydraulic residence time and can help guide watershed management decisions. The samples cost only about $10 to run.

Effects of Climate Change on Watersheds of Grand Portage Indian Reservation, a Case Study in Climate Change Adaptation Planning

Seth Moore*, PhD, Director of Biology and Environment Grand Portage Band of Chippewa

Abstract: The Grand Portage Indian Reservation is located in extreme north eastern Minnesota along the border of Ontario and on the shore of Lake Superior. Grand Portage Natural Resources Management Department has been researching the effects of climate change on waterbodies and watersheds on the reservation. Climate change effects on water temperatures and fisheries have been observed. Some observed effects of climate change include loss of cold-water obligate species like brook trout in inland lakes. The Grand Portage Band of Chippewa have developed a Climate Change Adaptation Plan to address projected impacts to the reservation lands and waters. Implementation of the plan has begun and results of some adaptation strategies will be discussed.

Presentation Highlights: The average August air temperature in Grand Portage has increased 2 degrees C. since 1960. Lake and stream temperatures have also risen during that time period. The Grand Portage Band has developed a climate change plan with strategic planning for resource management. Trout Lake provided an example to implement the plan. Brook trout are no longer abundant in Trout Lake, with their decline coinciding over years of increasing summer water temperature. An adaptation management strategy to introduce a warm water fish assemblage of yellow perch and walleye was successful. However fish consumption advisories for mercury in the perch and walleye were unintended consequences. The Climate Change Adaptation Plan will be maintained as a living document to develop a community and ecosystem health framework.

Large Woody Habitat

Eric Merten*, Wartburg College

Abstract: Wood is critical to the ecology of lotic systems, and influences every ecological process that occurs there. Wood appears to be relatively sparse in north shore streams; possible reasons include reduced recruitment due to forest harvest, decreased retention due to relatively small piece size and flashy hydrology (both exacerbated by forest management), increased rates of breakage and decay, or intentional removal and chucking by humans. Wildfires may lead to reduced wood recruitment as well. I will discuss results from studies addressing several of these processes, with some implications for biota.

Presentation Highlights: The terminology "woody habitat" is more appropriate than woody debris. In-stream wood provides:

- Fish habitat.
- Plunge pools
- Lateral migration
- Invertebrate substrate
- Leaf litter retention
- Transient storage
- Hyporheic recharge
- Shade

Eric's research project tagged over 1000 pieces of wood in 12 streams. They measured all aspects that may affect movement; elevations relative to peak flows, size, length, core density, position – pitch and position relative to flow. One year later revisited and located wood. They found 0.20 pieces of wood per meter in the 12 north shore streams. This standing stock of wood in streams is larger than some (0.08 in Maine), about the same as others (0.20 in Ontario), and less than most published values (1.5 in Argentina, 0.56 in New Zealand, and 0.57 in Washington). Natural causes of occurrence and movement of wood in stream include recruitment of wood, transport factors including; burial, effective depth, length ratio in relation to channel width, bracing, and root wad presence.

Management options recommended are to manage the riparian forest for large mature trees. Mature trees produce more wood in the stream. Large size woody habitat in the stream requires large trees.

The Status of Migratory Fish Populations in North Shore Streams

Josh Blankenheim*, Lake Superior Anadromous Specialist
MN Dept. of Natural Resources

Abstract: The fish communities in the anadromous reaches of Minnesota's North Shore streams have changed considerably since the 1800s. Brook trout were

historically the only salmonid present in North Shore streams, but development, overfishing, and introductions of other salmonids have resulted in vastly different fish communities today. North Shore tributaries currently support naturalized populations of coho, Chinook, and pink salmon, steelhead, and brown trout, as well as reduced populations of native brook trout. Management of the fish community has evolved through the decades and the current goal is focused on rehabilitation of self-sustaining wild and naturalized migratory fish populations with emphasis on steelhead and brook trout. Progress has been made as is evidenced by an increase in the abundance of steelhead and a shift in the size distribution of brook trout to larger fish. However, all salmonid species face limiting factors in Minnesota's North Shore streams including erratic flow regimes, warm water temperatures, lack of suitable spawning and nursery habitat, and reduced stream connectivity. Future management of salmonids in North Shore streams must include a strong emphasis on watershed management.

Presentation Highlights: Brook trout are the only native salmonid to Minnesota's North Shore streams. Historically brook trout were abundant. Introduced species found in North shore streams now include; brown trout, steelhead, pink salmon (accidental release), coho salmon, Chinook salmon, several strains of rainbow trout, and Atlantic salmon. Brown trout, coho and Chinook salmon are successfully reproducing in other states. Minnesota practices intense management with steelhead, and brook trout. Most North Shore streams have steelhead present. The steelhead fishery experienced a decline from the 1970s to 1990s from a peak in the 1940s through the 1960s. Rehabilitation actions for steelhead have been with barrier modification, habitat structures, stocking, evaluation using fish traps, regulation changes (now catch and release only), and easements. The steelhead catch rate has been increasing since the 1990s. Brook Trout – there was a stocking effort in the 1970s and 1980s but with low success. There are about 30 streams surveyed every 5 years. Regulations now include a one fish bag limit with 20" limit.

Limiting factors affecting the fishery:

- Access; Minnesota has only 180 miles of accessible habitat below barriers for migratory fish. About 45% of this habitat is in the Knife watershed.
- Flow; Low flow during dry summer months and ice accumulation in winter requiring deep pools to overwinter.
- Temperature; Lower parts of rivers get warm/stressful and at times lethal, the North Shore streams lack groundwater to keep temperatures cool.
- Connectivity – there are unlinked culverts
- Limited spawning habitat

Steelheads from the Knife River that leave the river at age 1 have a 4% return rate as adults. If they leave at age 2 the return rate increases to 12%.

Role of Beaver in Riverine Management

Marty Rye*, Forest Hydrologist, Superior National Forest

Abstract: Beaver are a natural and important component of the riverine environment. They provide an important energy source that alters the physical, biological, and chemical characteristics of a riverine corridor. Their activity is considered an important natural disturbance dynamic. Beaver population numbers, density, and presence vary greatly over time and space. Their activity can interfere with human service demands of a riverine system, especially when riverine systems are managed for service optimization. A truly sustainable or restored system must include beaver. Management of beaver has always occurred and will need to continue. It will need to come in the form of population control, mitigation of undesirable effects, modification of service expectations and accommodation of natural disturbance dynamics.

Presentation Highlights: Beaver are a mid-successional species that don't do well in coniferous dominated stands. Beaver are an energy source and bring that to the rivers by building dams. Beavers introduce hydraulic complexity to aquatic ecosystems. Dam failures result in a flood surge downstream. Fine sediment drops out into the beaver pond, so below the beaver dam, the sediment will be coarser. Planform complexity will increase from beaver presence, even after the beaver leaves. The hydrologic setting is important for understanding the impacts to streams caused by beaver dams. Beaver dams are leaky; water will leak through the dam, underneath, or to the outside. Hydrologists need to consider the soil make-up (bedrock/solid pack clay vs. a silty-loamy soil) of the river and floodplain to understand the true influence from the beaver dam to flow and flood conditions. The largest impact from beaver dams is on smaller runoff events impacting flow volume. Dams can actually help to increase baseflow because of water leakage behind the dam. A pulse of beaver dam wood can cause local resorting and impact the morphology of the stream downstream.

Beaver dams trap leaf litter and nutrients, all of which impacts nutrient cycles. Many fish, e.g. wild and stock trout, are able to negotiate beaver dams moving upstream and downstream. Much time and money is spent to keep beavers out of culverts to reduce road damage. Beaver dams impair fish migration. Impacts on temperature in marginal coldwater systems may be an important consideration with respect to fish interaction. Beaver change riparian vegetation by browsing and raising the water table creating wet meadows that can be sustained for a very long time. Research is needed on beaver impacts to:

- Discharge, Temperature, Physical Habitat, Water Chemistry, Biota, and Riparia.
- Beaver impacts need to be considered in the planning and design of Watershed Management Plans, Human Infrastructure, and Resource Management including Fisheries and Fishing.

Stream Temperatures: Are Our Trout Comfortably Cold?

Deserae Hendrickson*, Duluth Area Fisheries Supervisor, MN DNR

Abstract: Temperatures in trout streams tributary to Lake Superior can be extremely variable, on a number of scales. This presentation looks at stream temperatures from the trout's perspective, in several watershed areas in the Duluth Management Area including the Nemadji watershed, Duluth urban streams and North Shore streams up to the Split Rock River. Factors influencing stream temperatures and their suitability to sustain trout will also be highlighted.

Presentation Highlights: Brook Trout are stressed between 20 and 25 degrees C, lethal temperature at 25 degrees. There is a wide range of variability in stream reaches. The water temperature can range 10 degrees from a given air temperature. The more baseflow there is the more the more resistant the stream will be to warming. An open landscape promotes fast runoff versus sustained baseflow. Rainfall on hot impervious surfaces such as blacktop and rooftops heat runoff water. Dams holding water in place can increase temperature. Tisher Creek temperature is 5 to 10 degrees higher near the Hartley Park dam compared to sites above and below. Beaver dams affected 5 sites by increasing temp, 3 sites stayed the same, 2 sites decreased temp.

Beaver dams alter flow and riparian vegetation. Riparian management – shade is essential in northeast Minnesota to block radiant warming from the sun. Humans influence through forest harvest and clearing. Winter low flow impact the incubation of trout eggs, which require constant flow and oxygen. Snow acts as an insulator on the ice. When there is less snow the ice forms deeper and can freeze out areas of a stream. This is happening more often. Lethal or high stress temperatures are observed in the main stem and lower sections of most Minnesota Lake Superior tributaries. Duluth streams have widespread lethal temperature observations with a few hotspots.

The North Shore streams have hot spots resulting in trout stress primarily below beaver dams. Widespread lethal temperatures are observed on occasion. Lake Superior north shore streams are often on the thermal edge. Watershed and riparian management is critical to cool temperatures.

Managing Stream Connectivity on the Superior National Forest

Jason T. Butcher*, USDA Forest Service, Superior National Forest

Abstract: Maintaining and increasing stream connectivity is one of the most important goals in managing aquatic ecosystems. Connectivity in streams has important implications to biological communities, in-stream and floodplain physical properties, water quality, natural disturbance regimes, and overall watershed health. Aquatic organism passage is a primary component of stream connectivity in areas where streams are crossed by roads, dams, or other infrastructure. The three million acre Superior National Forest (SNF), located in northeastern Minnesota, has approximately 3,400 miles of streams that are crossed over 1,600 times by roads. The SNF uses an interdisciplinary program to assess, prioritize, implement, and evaluate restoration activities that improve stream connectivity. Restoration activities include removing crossings and roads from floodplains, dam removals, and riparian enhancement projects. Crossing improvement projects on the forest range in scale from small culverts to bridges and occur in a variety of aquatic settings from low gradient wetland streams to high gradient rivers. We present a review of the various aspects of the program, including project design rationale, for consideration in watershed management of Lake Superior tributaries.

Presentation Highlights: The Stream Connectivity Conceptual Framework is 4-dimensional: lateral- across the banks through the floodplain, longitudinal- upstream and down, vertical- through groundwater and geologic setting, and over time. Transportation infrastructure (crossings and culverts) and dams (impoundments) interrupt connectivity resulting in longitudinal organism barriers. Barriers reduce organism access to key habitats- spawning, foraging, nursery, and thermal refuge. Barriers increase fragmentation resulting in smaller more isolated populations that are more vulnerable to catastrophic events. Fragmentation restricts organism gene flow and recolonization.

Most conventional stream crossings (culverts) have destabilized natural stream channels trapping wood and sediment upstream while concentrating stream flow and energy downstream. Conventional crossings do not easily pass woody debris. Large woody debris moving through a stream system is important for nutrients, habitat and hydrologic function. Unstable stream channels downstream result in perched culverts hindering or blocking aquatic organism passage. Winter ice accumulation can block culverts resulting in damaged infrastructure. Culverts that don't appropriately drain can cause flooding and drown out riparian floodplain vegetation.

Cross River Channel Survey: Present Day Effects of Historical Logging Structures

Brad Hansen*, University of Minnesota
Karen Gran University of Duluth
John Nieber University of Minnesota

Abstract: During the historical logging period between 1895 and 1905 the Cross River was used to transport logs to Lake Superior. It was one of the few successful

attempts to drive logs down a North Shore stream. Because the river did not produce enough flow to easily drive logs, the Schroeder Lumber Company built a series of dams and other logging related structures designed to move logs down river to Lake Superior. Today six dams and a number of other logging related structures still exist in some form. The two main questions this research project addressed were:

1. Did the historical use of driving logs to Lake Superior cause any long lasting changes to the river channel?
2. What impact do the existing structures have on the river channel?

The three main components of the project were: LIDAR analysis of geomorphology, watershed modeling and a walking survey of the channel. The conclusions of the research were:

- The Cross River channel was not altered significantly by driving logs to Lake Superior
- Present day dams have a minor local influence on floodplain continuity.

Presentation Highlights: The Cross River was modified in the late 1800's to facilitate the transport of logs. There were several dams constructed to store and produce flow pulses to drive logs downstream. Research work was completed that concluded no significant channel modifications have resulted from the dams and log driving.

Tom Landwehr: Wrap Up Day One

-The north shore streams are a unique resource. The geology, climate, and biota are something to be protected.

-From Duluth to Grand Portage the streams change. Each stream is unique.

-The sound data presented here is critical to management. Long, ongoing research is critical.

-Biology should inform political decisions we make so we can have these resources in the future.

-We face a great challenge in how we talk about adaptation and mitigation for climate change?

-Conservation dollars need to be spent wisely. This research is so important. Past conservation decisions that were wise at the time we now know better.

Abstracts and Presentation Highlights
Day Two

Effects of Forest Harvesting on Flows in the Cross River; a Look with the HMS Model

John L. Nieber*, Professor, Department of Bioproducts and Biosystems Engineering, University of Minnesota
Nick Grewe, LimnoTech Inc.

Abstract: The harvesting of timber in the watersheds along the north shore of Lake Superior probably increase the magnitude of runoff generated for north shore streams. As a case in point, an analysis of the generation of runoff for the Cross River and the potential effect of timber harvesting in that watershed in the early part of the last century was undertaken. This hydrologic analysis was conducted in concert with a geomorphic assessment of the Cross River channel to determine the possible effects of historical timber harvesting and log-drives down the river on the character of the river channel. For the hydrologic analysis the HEC-HMS model was applied to the Cross River watershed with a historical large rainfall event that occurred July 21, 1909. The rainfall event consisted of 5.2 inches of rain in 24 hours, a greater than 100-year storm for the area. During the time period of logging in the Cross River watershed approximately 39% of the area had been logged. Taking these conditions into account in the assignment of curve number parameters to the subwatersheds, the peak runoff generated from this storm event is predicted by the model to be increased 57% over the peak flow generated from either pre-timber or current (recovered) conditions.

Presentation Highlights: A hydrologic analysis modeling the impact of a catastrophic rainfall event during the time period of logging in the Cross River watershed predicted the storm event peak flow to be 57% higher than the peak flow generated from either pre-timber or current (recovered) conditions. This hydrologic analysis was conducted in concert with a geomorphic assessment of the Cross River channel to determine the possible effects of historical timber harvesting and log-drives down the river on the character of the river channel.

Assessing Cumulative Watershed Stressors: Using LIDAR to Assess the Amount of Open Lands and Young Forest Associated with In-Channel Erosion for North Shore Tributaries

Tom Hollenhorst*, U.S. Environmental Protection Agency, Office of Research and Development, Mid Continent Ecology Division, Duluth, MN
John Jereczek, MN DNR Lake Superior Habitat Coordinator, Division of Ecological and Water Resources, Two Harbors, MN

Abstract: Hydrologist with the US Forest Service have demonstrated the cumulative impacts of land use change, particularly additional open lands and young forest (< 15 yrs.) on bank full flows and in-channel erosion. Mapping these impacts has been difficult due to challenges associated with mapping forest age and the lack of detailed terrain data. Fortunately with available LIDAR data we now have the tools to map forest stand height as a proxy for age, proportion of mature canopy cover and high resolution terrain data to explicitly map these impacts. We used LIDAR return data, classed into low, medium and high forest canopy, to asses the percent canopy cover or mature forest, and inversely open lands (including developed lands and agricultural lands) and young forest lands effects on MN streams flowing to the north shore of Lake Superior. We used a LIDAR derived DEM to populate an ESRI ArcHydro data model. This was then used to create continuous accumulation grids of percent open lands, contributing area and slope. With simple rule sets, these grids were then used to identify stream locations likely to have increased peak flows that might then increase the likely hood of prolonged in-channel stream erosion and sedimentation.

Presentation Highlights: LIDAR provides a tool to assess the hydrologic impact of the area of open lands and young forest upon stream flow and resultant channel stability of North Shore tributaries. The ability to conduct a continuous cumulative assessment along a channel allows for an instantaneous open area watershed analysis at any point along the flow line. This technology can provide land managers a tool to assess, predict and prevent impacts to stream flow and channel stability resulting from land management decisions.

GIS Landscape and Watershed Stressors

George Host*, NRRI

Abstract: Lake Superior, headwaters to the largest freshwater system in the world, faces increasing risk from human activities along the coastline and from contributing watersheds. Human-induced stressors affecting Lake Superior are many, including impacts to water quality from point and non-point sources, changes in hydrologic and thermal regimes, and shifts in patterns of land use. Geospatial analysis can be used to quantify the spatial distribution of human stressors within watersheds at multiple spatial scales. When coupled with field assessments, this provides a means to identify relationships between watershed-scale factors and in-stream habitat and water quality variables. The resulting models can be used to identify 'hot spots' of environmental risk, as well as reference conditions to identify restoration endpoints. Results from studies of the Lake Superior's North Shore, the St. Louis River watershed, and the local watersheds feeding into the St. Louis River Estuary show predictable relationships with key water quality variables, including sediments, nitrogen, and chloride. However, the spatial scale of these relationships varies with flow regime, which alters the relative importance of local vs. whole-watershed characterizations.

Presentation Highlights: The Great Lakes are large in area, making it important to identify appropriate areas where biological sampling to identify and evaluate stressors should take place. The stressors help to identify hot spots and where remediation dollars should be focused. Identifying stressors also helps to reveal what are the reference conditions and least stressed watersheds. Combining GIS data sets that capture environmental stressors and accumulate impacts through stream system flow ranges has been done. Impacts to stream health vary according to soils, antecedent moisture condition and flow characteristics. Selecting appropriate data layers will help address management questions linking stressors to watershed conditions.

Reducing Sediment Loads and Restoring Streams When Nature Controls (Most) of the Cards

Travis A. Dahl*, USACE, Matthew A. McClerren, Calvin T. Creech, & James P. Selegean

Abstract: Most of us have an idea in our mind of what a healthy stream looks like. Sometimes, though, this is not the same as the way the stream looked before significant landscape impacts by humans or the way it will look hundreds of years from now if it is left alone. Many of the watersheds around the western end of Lake Superior, in particular, are still evolving at a geologically rapid pace. In this talk, I will discuss the implications of this evolution and other processes that we can't control for the restoration of streams and watersheds, with an emphasis on sediment. Examples will be taken from four watersheds: the Ontonagon River (MI), the Nemadji River (MN/WI), the Knife River (MN), and Knowlton Creek (MN).

Presentation Highlights: A historical review of stream bank stability in the Western Lake Superior red clay belt indicate unstable slumping banks were the norm and may have been much more active during the post glacial, pre-settlement (logging) period. Realistic achievable common goals are necessary. Traditional bank stabilization/restoration may not be feasible, cost effective, and reasonable for this large of an area. Critical questions are:

- Can we reduce peak flows by other means in the watershed to reduce bank failure?
- How significant was bank failure before historical logging?
- Do we need to improve conditions better than pre logging?

Stream restoration work must be built for resiliency.

Prioritizing Lake Superior Watersheds Using Forest Disturbance and Landscape Metrics

Titus S. Seilheimer*, Wisconsin Sea Grant
Patrick L. Zimmerman, University of Minnesota
Kirk M. Stueve, Natural Resources Research Institute
Charles H. Perry, USDA Forest Service

Abstract: The watershed of Lake Superior is a major source of phosphorus and sediment entering the nearshore environment, therefore, watershed characteristics can be used to prioritize watersheds for the protection of nearshore water quality. We used novel landscape information describing the forest cover change, along with forest census data and land cover data (e.g. agriculture and urban) to predict springtime total phosphorus and turbidity in Lake Superior streams. Models were developed to rank watersheds based on landscape conditions relative to the amount of phosphorus or turbidity produced. Phosphorus was modeled as a function of proportions of persisting forest, forest disturbed during 2000-2009, and agricultural land, and turbidity was modeled as a function of proportions of persisting forest, forest disturbed during 2000-2009, agricultural land, and urban land. We used the models to estimate water quality in watersheds without observed instream data and prioritized those areas for management. These relationships were used to identify areas for restoration in watersheds and catchments of Minnesota's Lake Superior basin. Prioritizing watersheds will aid effective management of the Great Lakes watershed and result in efficient use of restoration funds, which will lead to improved nearshore water quality.
Research funded by the Great Lakes Restoration Initiative.

Presentation Highlights: Models predicting impaired watersheds are useful for prioritizing areas for further evaluation. Turbidity and phosphorus modeling of the MN North Shore streams showed low risk.

A Review of Landscape and Riparian Disturbances to Stream Ecosystems

Gerald J. Niemi*, Department of Biology and Natural Resources Research Institute, University of Minnesota

Abstract: Flowing water ecosystems in forested regions are greatly affected by their associated watersheds and riparian zones and these effects are cumulative as the water flows across the landscape. Riparian zones are important to stream water quality and quantity by reductions in erosion of stream banks, by restricting the flow of water across the land surface, serve as habitat for wildlife, plants, and other biota, and provide recreational opportunities for society. Forested riparian areas are affected by many disturbances from both natural (forest fire, wind, insects, and natural flooding) and human-induced sources (logging, residential or industrial development, and human-induced flooding). In the mid-1990's Minnesota developed voluntary guidelines for logging in riparian areas as a result of the Minnesota Forest Resources Act. These guidelines, recent research, and the continued development of best management practices in landscapes and riparian zones will be reviewed.

Presentation Highlights: The benefits of a healthy riparian forest include:

- The retention of nutrients and sediments to maintain water quality.
- They retain and slow water movement across the landscape.
- They provide woody habitat and moderate temperature by shading.
- They also provide habitat and reduce alien plant invasions in riparian zones.

Existing riparian management guidelines are improvements to protection however using the floodplain may be a better way of determining valuable width to protect aquatic resources.

Hidden Watersheds: Understanding Seasonal Pools in a Landscape Context

Brian Palik*, Research Ecologist, USDA Forest Service, Grand Rapids MN

Abstract: Small seasonal pools and ponds are abundant in many forest landscapes of the Great Lakes region, yet they remain poorly understood in terms of physical and biotic variation, the contributions they make to biodiversity and hydrologic function of watersheds, and their response to disturbance of the surrounding upland forest. The potential for interaction of ponds with the upland is large because of their small size, which increase the importance of functional connections with the surrounding forest, and their often seasonal hydroperiod, which renders them particularly susceptible to degradation during dry phases. My colleagues and I have studied seasonal ponds and pools in northern Minnesota for many years within the context of several interrelated descriptive and experimental studies. Our objectives have been to describe the hydrologic and biotic characteristics of seasonal ponds in a landscape context, to relate variation in these characteristics to multi-scale factors, and to examine the impact of forest disturbance within pond watersheds on hydrology and related biotic communities. Our applied goal of this work is to foster better conservation and sustainable management of these important wetland ecosystems.

Presentation Highlights: Seasonal pools are abundant and have a high landscape importance. They are not inventoried and are not highly protected. They are unique ecosystems, with valuable biological and hydrologic (groundwater recharge) function. Forest harvesting around seasonal ponds results in longer hydroperiods that may lead to increased bioaccumulation of mercury in the pond. Management needs to protect integrity of seasonal pools at the landscape level for the suite of ponds, especially those in a young forested landscape.

Using Zonation, A Value-Based Model, To Prioritize Areas For Watershed Management

Kristen Calrson*, Minnesota Department of Natural Resources
Paul J. Radomski , Minnesota Department of Natural Resources

Abstract: As threats to Minnesota's watersheds continue to mount, it is becoming increasingly important to identify and conserve high-priority areas to produce multiple benefits. Two of the most common approaches for conservation prioritization are system-based models and value-based models. Unfortunately, we often do not have system models that can accurately identify where in the watershed specific good management practices should be applied or that have the ability to simulate alternative land management actions and predict consequences at specific locations in the watershed for multiple benefits. Value-based models use a compilation of individual criteria of valuable landscape features (heterogeneous content) and aggregated criteria (context and connections) with an objective function to prioritize places within the landscape for conservation. Feature-specific weights used in these models should reflect social valuation. Collaborations with multiple watershed groups throughout the state have yielded watershed-wide land prioritizations that can guide local resource protection efforts. We present example values-based model prioritizations with feature-specific weights set using an analytic hierarchy process.

Presentation Highlights: Values-based model prioritizations with feature-specific weights set using an analytic hierarchy process for conservation planning work for watershed management. Public input makes for public acceptance.

Climate Change Vulnerability of Forest Ecosystems in Northern Minnesota

Stephen Handler*, Forest Service Northern Research Station and Northern Institute of Applied Climate Science.

Abstract: Forests in northern Minnesota will be impacted directly and indirectly by a changing climate over the next 100 years. NIACS has recently coordinated a climate change vulnerability assessment for forest ecosystems in northern Minnesota in order to describe these potential changes for forest managers and planners. Information on current forest conditions, observed climate trends, projected climate changes, and impacts to forest ecosystems was considered in combination with manager expertise in order to draw conclusions on climate change vulnerability. Wet forests, Forested Rich Peatlands, and Acid Peatlands were determined to be the most vulnerable Native Plant Communities, whereas Floodplain Forests, Fire-Dependent Forests, and Mesic Hardwood Forests were determined to be less vulnerable to projected changes in climate. Many partners assisted with this report, including federal, state, private, and tribal land managers; conservation organizations; and academic institutions. Stephen will share the results of this assessment on behalf of the author team, focusing in particular on possible implications for the Lake Superior watershed.

Presentation Highlights: The Northern Institute of Applied Climate Science (NIASC) helps forest managers to consider climate change as part of the regular core of forestry management. NIASC has developed "Climate Change Vulnerability Assessments for Forest Ecosystems"[1]. North Shore stream riparian zones are dominated by the "Wet Forests" Native Plant Community category. The wet forest assessment has a "High Vulnerability to stressors:

- Ash decline- current phenomena has caused widespread crown decline and reduced growth
- Insect Pests- current example spruce budworm, future potential for Emerald Ash Borer
- Altered hydrologic regime- excessive water logging or excessive drought resulting in reduced growth and susceptibility to dieback and decline
- Invasive Plants- such as reed canary grass and Pennsylvania sedge will reduce conditions for natural regeneration and facilitate establishment of other invasive species.

Key questions have yet to be answered:

- How can these vulnerability assessments look at riparian systems?
- What will this mean for streams – temp, biota, etc.?

We need to carry this assessment one step further to understand impacts to aquatic systems.

Forest Restoration and Management in Changing Climate: Implications for Lake Superior Watersheds

Mark A. White* and Meredith Cornett, The Nature Conservancy in Minnesota, and North and South Dakota
Matthew Duveneck and Robert Scheller, Portland State University, Portland OR.

Abstract: European settlement led to a more homogeneous forest across northern Minnesota where dominance shifted from long-lived conifers to early successional hardwood species. The range of natural variation (RNV) based on pre-settlement forest condition is commonly used as the basis for restoration objectives. Restoring species and structural diversity can maintain biodiversity and key forest functions including water quality and quantity. Objectives based on past climates and disturbance regimes may not be viable in a rapidly changing climate. We examined the interaction of climate change and forest management using a spatially dynamic forest model, LANDIS II. RNV based restoration may be effective under low greenhouse gas emission scenarios. High emissions scenarios indicated increased forest homogenization, a steep decrease in boreal species biomass, and significant loss of forest cover. We examined climate adaptive management including: adaptive silviculture, planting climate tolerant tree species, and expanded forest reserves. Adaptive silviculture and climate tolerant planting may help maintain diversity and biomass under low and high emissions. Expanded forest reserves could maintain

current composition under low emissions. Climate induced forest change will have significant impacts on North shore watersheds. A long term monitoring program to detect changes and inform adaptive management will be needed.

Presentation Highlights: TNC has developed strategies using LANDIS II model to incorporate climate change into forest management plans. Under a low emission scenario resistance and resilience strategies can help maintain watershed functions-flow regimes, sediments, and LWD inputs. Over the longer-term high uncertainty, high emissions, an increased risk-forest change/loss-degraded watershed-riparian zone functions is projected. Adaptive management incorporating resistance plus resilience is recommended. Adaptive silvculture prescriptions favoring climate tolerant species and assisted species migration will be needed under worst-case scenarios.
Climate induced forest change will have significant impacts on North shore watersheds. A long term monitoring program to detect changes and inform adaptive management will be needed.

Climate Trends and Climate Change in Our Own Backyard: A Review

Mark Seeley*, Professor of Meteorology and Climatology
University of Minnesota, Dept. of Soil, Water, and Climate

Abstract: In recent decades there has been increasing recognition by scientists that the climate is showing several distinct trends or changes quantity and in character. In our own Great Lakes Region there are measurable changes going on. Among these are: (1) warmer temperatures (with seasonal and diurnal disparity); (2) higher frequency of tropical-like dew points, especially in the summer months; (3) and an overall increase in variability of precipitation and other hydrologic features, as well as a change in the character of extremes. These climate trends are clearly linked to visible consequences in the landscape. In addition climate models, validated against three independent sets of climate measurements, suggest our climate will continue to change in the directions shown by these recent trends. There are both quantity and character changes in climate that are important for us to understand if we are to adapt effectively.

Presentation Highlights: Mark Seeley: The three most significant recent climate trends in the western Great Lakes are:

- Temperature: warm winters and higher minimum temperatures
- Dewpoints: greater frequency of tropical-like atmospheric water vapor
- Moisture: amplified precipitation signal, thunderstorm contribution

Consequences of Climate extremes in this area are:

- Amplified variability of surface water flow volume, both low flows and high flows (flash floods, spring snowmelt floods)
- Increased frequency of drought affecting the state landscape- agricultural (forest), fire weather, and hydrologic impacts.
- Impacts of increased frequency and magnitude of insured losses and Infrastructure damages
- Increased frequency of heat advisories and excessive heat warnings
- Need to explore adaptation and mitigation strategies that make us more resilient and incentivize citizens to do so.

Possible Implications of Changes in Precipitation Quantity and Character:

- Altered irrigation, drainage, runoff, sediment, and shoreline management
- Change in storm sewer (culvert) runoff design
- Modified fisheries management
- Mitigation of soil erosion
- Mitigation of flooding potential
- Better management of blowing snow and spring snowmelt runoff

Data indicates a disconcerting northward migration of days with severe parameters in North America to higher latitudes resulting in Minnesota's inclusion into one of the greatest areas of change in climate on the planet.

Effects of Climate Change on Distribution of Cold Water Fish in North Shore Streams

Lucinda Johnson1*, William Herb2, Meijun Cai1
1 University of Minnesota Duluth, Natural Resources Research Institute
2 University of Minnesota, St Anthony Falls Laboratory

Abstract: Water temperature is generally considered one of the primary physical habitat parameter determining the suitability of stream habitat for fish species, with effects on the mortality, metabolism, growth, behavior, and reproduction of individuals. In this study we assessed the potential threats of climate change on stream temperatures and flow regimes in Lake Superior tributary streams in Minnesota. The study included deterministic models for stream flow and temperature of three study streams (Amity Creek, Baptism River, Knife River), and regional (empirical) models for specific flow and temperature parameters to give better spatial coverage of the region. Information on stream flow, stream temperature, and land cover was used to develop a brook trout presence/absence model to understand the current pattern of distribution of brook trout and predict future distributions under future climate.

Presentation Highlights: A NRRI led study to predict the effects of climate and land use/cover change on cold-water fish habitat (brook trout). Conclusions indicate that by 2080 trout will largely disappear from the southern portions of Minnesota's North Shore, streams in the North Shore's middle section will be at increase risk by 2080s. Streams in the Northern area will be least impacted by higher air temperatures and lower flows.

Additional information and research is needed on:

- Future forest cover projections at a fine scale
- The locations (impact) of impoundments (beaver)
- Co-location of fish population surveys and stream temperature recording
- Long term monitoring data collected consistently and made available to academics, agencies, nonprofits, and industry.
- Wetland updates
- Riparian vegetation

Stream Restoration: An Evolving Practice

Karen Gran*, Associate Professor of Geological Sciences, University of Minnesota Duluth

Abstract: Stream restoration is a booming industry in the United States, as movement shifts from engineering-focused management of streams to rehabilitation and restoration of impaired waterways. Much of the stream restoration movement follows the concept of Natural Channel Design, which is becoming standard practice in many states. The development and spread of the Rosgen-based NCD practice has inverted the traditional science-to-practice pathway and been opposed by many stream experts in academia, leading to a conflict in the stream restoration community dubbed the "Rosgen Wars". This talk will discuss the conflict and its development through time as well as the role of science in stream restoration. Woven throughout will be issues of predictability and uncertainty in fluvial systems, and the role of sediment transport and complex channel change in restoration practice.

Presentation Highlights: Stream Restoration work has in recent times become dominated by the Natural Channel Design (NCD) concept. NCD is an improvement over pre 1980 restoration efforts but new understanding of rivers and streams could further improve stream restoration techniques beyond NCD.

The gist of the arguments against exclusive use of NCD is that dissemination of information in NCD is from course publications rather than peer reviewed journals, and that some states require exclusive use of NCD. Proponents of NCD counter that non-practitioners do not understand NCD. The bottom line is there is a lack of NCD monitoring and better metrics are needed for success assessment, however there isn't a widespread easily transferable alternative.

There are many alternatives to NCD.

- Watershed assessments and plans
- Watershed Modeling
- Diagnostic geomorphology
- Connectivity
- Peak-flow reduction
- Focus on climate change adaptation
- Resiliency

Stream restoration to date has been driven more by societal demand than by science. Is it right to spend Billions of dollars on restoration projects without a better understanding of their effectiveness?

Economic Aspects of Stream Restoration

Henry Eichman*, USDA Forest Service, TEAMS Enterprise Unit

Abstract: Overview of Forest Service (FS) approach to economic analysis of stream restoration. Includes economic impact analysis (projection of employment and income using Input- Output modeling), economic efficiency analysis and other considerations, such as public perceptions of restoration value. Economic Impact analysis, performed by the forest service, employs expenditure profiles specific to restoration activities across the nation. Economic efficiency analysis explores financial efficiency and consideration of non-market values. Public perception of stream restoration and potentially affected values are prescient. While assessing the efficacy of stream restoration activity is important, the FS explores impacts and efficiency associated with forest/riparian uses affected by stream restoration activities (recreation, grazing, ecosystem services, etc.).

Presentation Highlights: Measures of value can be useful to help justify the cost of stream restoration. Non-market values are often criticized because of their hypothetical nature, but they are grounded in hard science and can be used to justify the cost spent on stream restoration.

John Linc Stine, MPCA Commissioner

Research Identified Stressors and Threats

Stream functions occur in a general order and parameters can be used to assess stressors and threats to those functions. Strategies in response to stressors and treats should be addressed in the order shown to have an overall effective and efficient management strategy. It is important to place reach scale projects into a watershed context and recognize the causes of watershed impairments.

Hydrology:

Landscape Hydrology-Hydrologic processes (precipitation, infiltration, runoff, evaporation) occur at the watershed level and influence the character and functions of streams. The potential to exacerbate peak flow events through the loss of mature forest percentage within subwatersheds is a threat. [2]

Stream Flow- Unstable stream flow regimes were identified by USGS[3], DNR[4], USFS[5], and UMN[6]. Lack of baseflow, extreme low flow, and elevated peak flow events are problematic and negatively impact aquatic organisms[4]. The "amplified variability of surface water flow volume, both low flows and high flows (flash floods, spring snowmelt floods)"[6] can destabilize stream channels and road crossing infrastructure.

Data collected from tributaries discharging to Lake Superior suggest a general south to north pattern of isotopic signatures that are dynamic and change with season. Headwater lakes provide the most important storage of precipitation and sustain baseflow in most tributaries. Subsurface storage is relatively small due to limited aquifer extent. Lake hydraulic residence time is directly influenced by location in the watershed, contributing drainage area and lake volume [7]. Storm flows dominate the hydrologic systems of all Minnesota North shore streams[7].

Connectivity:

Dams- Both, man-made and beaver dams are stressors forming barriers that block organism passage and warm stream temperatures[8,9].

Transportation Infrastructure- Conventional culverts designed only to pass water, potentially destabilize natural stream channels interrupting the movement of wood and sediment through stream systems. Improperly designed culverts concentrate stream power causing unstable channels downstream resulting in perched outlets that block organism passage. Stream culverts that do not pass aquatic organisms fragment longitudinal connectivity. [10]

Barriers reduce organism access to key habitats- spawning, foraging, nursery, and thermal refuge. Barriers increase fragmentation resulting in smaller more isolated populations that are more vulnerable to catastrophic events by restricting organism gene flow and recolonization. [10]

Geomorphology:

Stream Channel Destabilization- The increased frequency of extreme storm events poses a serious threat to stream channel stability. The "amplified variability of surface water flow volume, both low flows and high flows (flash floods, spring snowmelt floods)" [6] will destabilize stream channels and road crossing infrastructure.

The topography of the Lake Superior clay plain is geologically young and is undergoing a high rate of natural erosion as a geologic equilibrium evolves. The heterogeneous mixture of clay and sand produces soils with very little stability which, when exposed to varying moisture conditions on steep slopes, often erodes severely[11]. Managing the landscape for natural runoff is critical in maintaining natural dynamic stability[3], [12], [13].

Water Quality:

Temperature- Increasing stream temperatures were identified and discussed by DNR[8], USFS[5], and NRRI[14]. The loss of cold water stream habitat due to increased summer stream water temperature is a primary threat[14]. The loss of riparian shade trees is a major stressor[8]. Climate change, with the increasing frequency of summer tropical dewpoints and a rise in the mean July air temperature will continue to warm cold water streams and increase in magnitude as a primary stressor[8],[14],[6].

Turbidity-Several Lake Superior tributaries have TMDL status for impairment due to turbidity. Research on suspended sediment as a water quality issue has been investigated by UMD[11], USGS[3], and USACE[12]. Research indicates this may be naturally occurring phenomena for streams flowing through the red clay belt of Lake Superior[15]. Past and current research[16] [17], indicates suspended sediment and resultant high turbidity levels in Western Lake Superior tributaries have little negative effect upon aquatic organisms.

Sedimentation- Streambank and bluff erosion in the exposed till and lacustrine sediments in the high-energy lower reaches of north shore streams are a primary source of sediment loading[11],[18]If the stream runs through an area where there is fine-grained till, then slumping along a stream can be expected.[11]

Current research indicates stream macroinvertebrates show negligible impacts on assemblage diversity as long as fine sediments are continually washed out of rocky substrates, and the substrates do not remain buried.[16]

Mercury-The greatest identified single water quality parameter threat for Lake Superior tributaries is Mercury. Mercury impairments in fish tissue and in the water column account for 1/3 of all current impairments listed in the basin. Many factors affect Mercury availability including transport, industrial generation, biological activity, land use conversion and natural geology. Efforts are needed to establish a baseline for total Hg and MeHg concentrations in sediment, water, fish tissue, and benthic invertebrate tissue. [19] Management efforts are needed to address anthropogenic mercury pollution.

Biology:

Interspecies Competition- Beaver activity is a stressor to cold-water habitat by removing riparian shade trees through grazing and flooding. Beaver dams block connectivity, forming barriers to aquatic organism migration and their ponds can facilitate warming water temperatures.[8],[5],[9]

There have been opinions expressed that beaver colonization benefits cold water stream systems in Minnesota's Lake Superior Watershed. There is however, a lack of scientific research and data specific to this landscape that provides any positive benefit to beaver colonization of cold-water streams. Conversely, there are many studies and supporting data (Avery) specific to Minnesota's Lake Superior watershed showing negative impacts to cold water systems from beaver colonization.[9] It is important to note that research compiled by Avery in 1983 (pre climate change awareness) identified the warming of cold water as a primary threat.

Riparian Habitat- Loss of stream shade provided by riparian forest cover and increased stream water temperature is a threat[8],[5]. The impact of climate change to the composition of the riparian forest is a primary threat.[20],[21] The loss of shade producing canopy over the short term through; drought, floods, blow down, disease, insect pests, fire, deer herbivore, interspecies competition, and invasive species competition will have immediate impacts.

Long term annual temperature increases will result in the gradual loss of the boreal forest through the change in growing conditions favoring temperate forest communities. Vegetation impact models have been based upon variable greenhouse gas emission scenarios. The likelihood of the high emission scenario impacts is probable gauging actual measured rates of greenhouse gas increase.[1]

Summary:

Climate Change is the primary force driving multi faceted interrelated stressors and threats impacting Minnesota's Lake Superior tributaries. Water temperature extremes, flow regime extremes, channel instability, loss of connectivity, and biological stressors all work in combination to degrade cold-water quality and habitat. Stream temperature protection, maintaining connectivity and landscape level flow stabilization should be the central core of management strategy and effort.

Julie Westerlund, DNR Clean Water Coordinator

Broad Scale Management Strategies

The federal Clean Water Act tenants when applied to Minnesota's North Shore Streams should drive goal setting and management strategies to protect and where needed restore cold-water streams as high quality waters supporting appropriate representative biological assemblages.

Minnesota's Clean Water Land and Legacy Amendment and Environment and Natural Resources Trust Fund provides the policy framework and funding ability to address needed monitoring and assessment, along with restoration and protection. The watershed approach paring systematic monitoring, Watershed Restoration and Protection Strategies (WRAPS) with implementation activities delivered through a local implementation framework is the process developed to achieve water quality goals.

The challenge will be to implement and maintain management measures in light of climate change impacts. Accepting this challenge, the following Broad Scale Management Strategies are recommended:

Water Quality-Mercury

Mercury impairments in fish tissue and in the water column are significant issues that should be addressed as part of the WRAPS process.

Stream Temperature and Connectivity

A primary adaptation strategy to climate change is protecting and maintaining cold stream temperatures where possible and resilient connectivity to thermal refuges where feasible. This strategy needs to be the primary water quality and habitat goal for Minnesota's Lake Superior tributaries.

On streams where research determines that maintaining cold water is not possible due to intense development and/or a lack of cold-water flow contribution, alternative goals and adaptation strategies need to be developed.

Inventory cold-water flow contribution to stream system base flow- The location and extent of cold-water contributions to base flow must be identified. This critical component supports the aquatic biota. Isotopic analysis, temperature data, and biological assessment studies must be coordinated to capture this critical information. Much of the temperature and biological data have been collected. A central clearinghouse is needed for data storage retrieval such as LakeSuperiorStreams.org.

Identify and protect cold-water recharge areas- The wetlands, vernal pools, floodplain soils, and other hydro-geologic features that store and transport subsurface flow contributions to base flow must be identified and protected.

Construct and maintain resilient transportation crossing infrastructure- Resilient stream crossings capable of passing organism and fluvial geomorphic processes must be constructed and maintained in areas where connectivity is needed to ensure organism access to key habitats; spawning, foraging, nursery, and thermal refuge.

Design methods that mimic the slope, structure, and dimensions of a natural stream channel, such as the USFS Stream Simulation approach[22] should be the standard used to guide road and infrastructure stream crossings.

Development of a manual offering guidelines for natural stream crossing designs on streams in Minnesota's Lake Superior Watershed, similar to the Minnesota Forest Resources Council's Voluntary Site-Level Forest Management Guidelines, has been identified as a desirable product.

An inventory of stream crossings that inhibit organism access to cold water refuge zones, spawning areas, and nursery zones needs to be developed and used as a guide for prioritizing and funding crossing upgrades. Thermal refuge, and spawning access should be the highest priority.

Build and Maintain Riparian Resiliency- Retain a mix of tree species in both uneven/even age classes in a 1500-meter buffer zone[20]. Within this zone manage for species tolerant of future climate change. Develop silvicultural prescriptions that favor climate adapted trees. Increase rotation periods, and decrease patch size[20].

Riparian Shade- Manage for maximum shade. Do not remove shade-producing trees. Implement assisted migration of future climate tolerant species to overcome spatial and temporal limitations of natural migration. Utilize LIDAR information to assess where riparian reforestation efforts are needed to establish future shade producing trees on high priority streams (see cold water inventory).

A **Riparian Best Management Practice (BMP)** specific to the Minnesota's North Shore streams and all of their tributaries needs to be established. This BMP should emphasize shade tree protection and retention and be of variable width based upon; bank full flow width, floodplain width, valley side slope percentage and width, and mature tree height.

Interspecies Competition-A comprehensive study of the impacts/benefits of beaver colonization to cold-water stream systems in Minnesota's Lake Superior watershed needs to be completed. The context of this study should be based upon thermal impacts and connectivity. Active and inactive sites of colonization should be included

<u>Stream Flow Stabilization</u>

Landscape Hydrology- Stable isotope analysis confirms the surface water driven nature of Minnesota's Lake Superior tributaries. The retention of precipitation upon the landscape should be an overall management goal. Forest management, and infrastructure development should have maintaining sustainable hydrology as primary objectives[7].

Peak Flow Reduction -The development and implementation of landscape level analytical tools to maintain and reduce peak flow events need to be established and incorporated into the land management decision making process. The LIDAR based open area analysis utilizing continuous accumulation grids shows promise as a tool for this purpose.[2] In sub-watershed areas where analysis predicts increased peak flow rates, coordinated forest harvesting by watershed area across land ownership is recommended. Increase adaptive capacity where reforestation efforts are needed favoring tree species tolerant of future climate change.

Sustainable Hydrology- Maintain stable stream bankfull flow rates for 1.5 year average return interval runoff events [23]. Land use changes from mature forest to open land or young (< 15year old) forest can have significant impacts upon runoff events, stream flow volume, and stream channel stability. Coordinated land management is needed to retain at least 40% mature forest by watershed, across ownerships.

Forest Management:

- Manage overall forest composition for future health and resiliency to avoid large-scale catastrophic events.
- Manage for a high retention mix of both even and uneven age stands favoring species tolerant of future climate change.

Base Flow Stabilization- Identify and protect cold water recharge areas. Restore large woody habitat. Maintain critical landscape elements, including headwater lakes and wetlands that provide the most important storage of precipitation and sustain baseflow to tributaries.

Bibliography

1. Handler, Stephen; Duveneck, Matthew J.; Iverson, Louis; Peters, Emily; Scheller, Robert M.; Wythers, Kirk R.; Brandt, Leslie; Butler, Patricia; Janowiak, Maria; Swanston, Chris; Barrett, Kelly; Kolka, Randy; McQuiston, Casey; Palik, Brian; Reich, Peter B., R. *Forest Ecosystem Vulnerability Assessment And Synthesis (DRAFT)*. (2014). at <http://www.nrs.fs.fed.us/niacs/climate/draft_docs/docs/Minnesota_FEVAS_compressed.pdf>
2. Hollenhorst, T. & Jereczek, J. Assessing Cumulative Watershed Stessors: Using LIDAR to Assess the Amount of Open Lands and Young Forest Associated with In Channel Erosion for North Shore Tributaries. (2014).
3. Fitzpatrick, F. A. Diagnostic Geomorphic Methods for Understanding Future Stream Behavior of Lake Superior Streams – What Have We Learned in Two Decades? Faith. (2014).
4. Blankenheim, J. The Status of Migratory Fish Populations in North Shore Streams. (2014).
5. Rye, M. Role of Beaver in Riverine Management. (2014).
6. Seeley, M. Climate Trends and Climate Change in Our Own Backyard: A Review. (2014).
7. Magner, J., Zhang, L. & Engel, L. An Isotopic Approach to North Shore Lake Superior Watershed Management. (2014).
8. Hendrickson, D. Stream Temperatures: Are Our Trout Comfortably Cold? (2014).
9. Avery, E. *A Bibliography of Beaver, Trout, Wildlife, and Forest Relationships*. 23 (1983).
10. Butcher, J. T. Managing Stream Connectivity on the Superior National Forest. (2014).
11. Gran, K. Geologic History of Western Lake Superior Streams. (2014).
12. Dahl, T. A., Mcclerren, M. A., Creech, C. T. & Selegean, J. P. Reducing Sediment Loads and Restoring Streams When Nature Controls (Most) of the Cards. (2014).
13. Andrews, S., Christensen, R. & Wilson, C. *EPA Red Clay Project Final Part II Impact of Nonpoint Pollution Control on Western Lake Superior*. (1980).
14. Johnson, L., Herb, W. & Cai, M. Effects of Climate Change on Distribution of Cold Water Fish in North Shore Streams. (2014).
15. Andrews, S. & Danald Houtman, W. L. *Final Report on the Red Clay Project*. (1980).
16. Brady, V. & Herrera, L. Effects of In-stream Fine Sediments on Stream Macroinvertebrates **. (2014).
17. Hanson, B., Lahti, L., Nieber, J., Evens, K. & Johnson, G. Lake Superior Sediment Assessment; Phase I Poster. (2014).
18. Neitzel, G. D. & Gran, K. B. Monitoring Event-?-Scale Stream Bluff Erosion with Repeat Terrestrial Laser Scanning: Amity Creek. (2014).

19. George, T., Salmon, R. & Kondrat, T. Lake Nipigon Baseline Study for Waterpower Developments Tara. 80 (2014).
20. White, M., Cornett, M., Duveneck, M. & Scheller, R. Forest Restoration and Management in Changing Climate: Implications for Lake Superior Watersheds. (2014).
21. Handler, S. Climate Change Vulnerability of Forest Ecosystems in Northern Minnesota. (2014).
22. Gubernick, R., Cenderelli, D., Bates, K., Johanson, D. & Jackson, S. *Stream Simulation : An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings*. 646 (2008).
23. Verry, E. S. *Land Use and Stream Condition*. *For. Sci.* (2001).

Appendix
MN Lake Superior Watershed Stream Science Symposium

Symposium Agenda

MN Lake Superior Watershed Stream Science Symposium

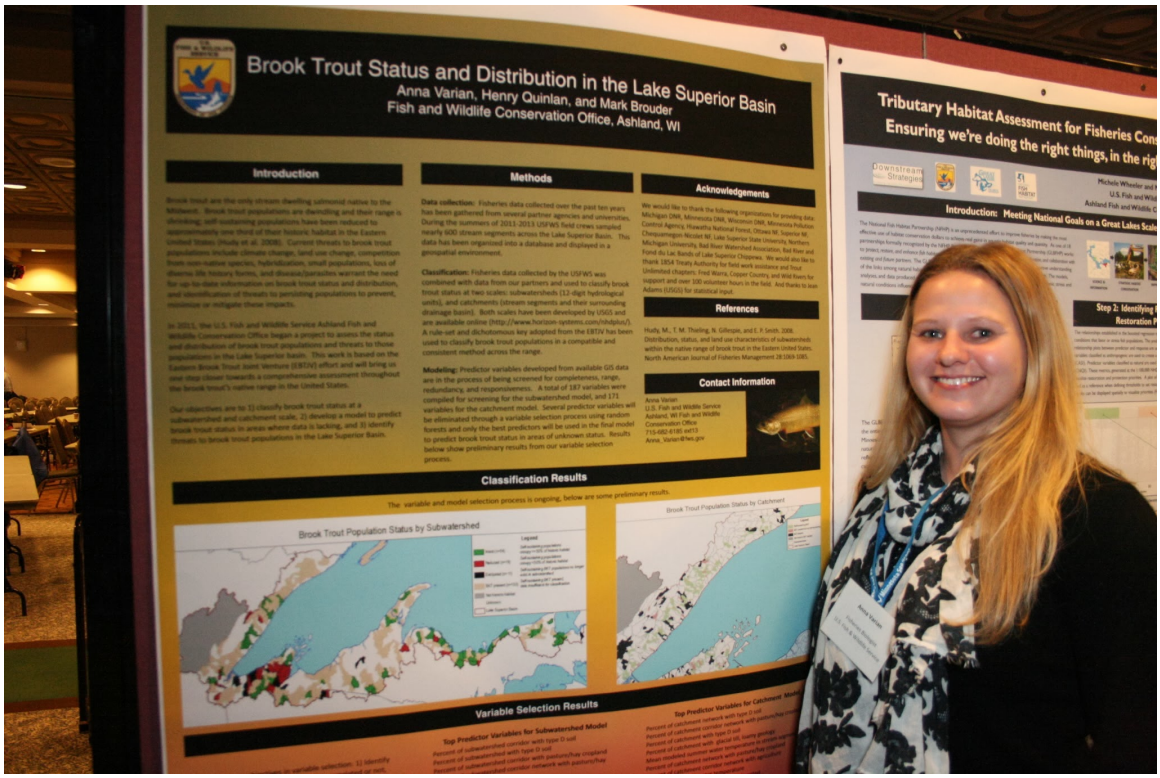
Day One- Tuesday Janurary 7, 2014			
Time	Session	Presenter	Title
8:30	Registration opens		
9:00	Welcome	John Jereczek, DNR	Opening Remarks
9:10	Keynotes	Tom Landwehr, DNR Commissioner John Stine, MPCA Commissioner	The Significance of this Symposium: A Shared Strategic Vision for Future Watershed Health and Management of Minnesota's Lake Superior Tributaries- Research, Management, and Planning
10:00	Intro.	Julie Westerlund, DNR	Minnesota Water Management Framework
10:30	Break		
10:45	Intro.	John Lenczewski, MN Trout Unlimited, Kris Larson, MN Land Trust	The Role of Non-Profits
11:00	Primary	Lee Johnson, USFS	Historic Overview of Logging in the Cross River Watershed: 1895-1925
11:20	Primary	Karen Gran, UMD	Geologic History of Western Lake Superior Streams
11:40	Primary	Faith Fitzpatrick, USGS	Diagnostic Geomorphic Methods for Understanding Future Stream Behavior of Lake Superior Streams – What Have We Learned in Two Decades?
12:00	Lunch		
12:45	Keynote	John Jaschke, BWSR Executive Director	A Shared Strategic Vision for Future Watershed Health and Management of Minnesota's Lake Superior Tributaries- Implementation
1:10	Keynote	Brenda Halter, Superior National Forest Supervisor	Role of the Superior National Forest in Lake Superior Watershed Management
1:35	Primary	Joe Magner, UMN	An Isotopic Approach to North Shore Lake Superior Watershed Management
1:55	Primary	Seth Moore, Grand Portage Department of Biology and Env.	Effects of Climate Change on Watersheds of Grand Portage Indian Reservation; a Case Study in Climate Change Adaptation Planning.
2:15	Primary	Eric Merten, Wartburg College	Large Woody Habitat
2:35	Primary	Josh Blankenheim, DNR	The Status of Migratory Fish Populations in North Shore Streams
2:55	Primary	Marty Rye, USFS	Role of Beaver in Riverine Management
3:15	Break		
3:35	Primary	Deserae Hendrickson, DNR	Are Our Trout Comfortably Cold?
3:55	Primary	Jason Butcher, USFS	Managing Stream Connectivity on the Superior National Forest
4:15	Primary	Brad Hansen, UMN	Cross River Channel Survey: Present Day Effects of Historical Logging Structures
4:35	Wrap-up	Tom Landwehr, DNR	Wrap Up Day One
4:45- 6:00 Poster Social			

This Symposium is funded in part by the Coastal Zone Management Act of 1972, as amended by the NOAA's Office of Ocean and Coastal Resources Manangement, in conjunction with Minnesota's Lake Syperior Coastal Program

MN Lake Superior Watershed Stream Science Symposium

Day Two- Wednesday Janurary 8, 2014			
Time	Session	Presenter	Title
8:25	Welcome	Paul Sandstrom, LRCD	
8:30	Primary	John Nieber, UMN	Effects of Forest Harvesting on Flows in the Cross River; a look with the HMS model
8:50	Primary	Tom Hollenhorst, EPA	Assessing Cumulative Watershed Stessors: Using LIDAR to Assess the Amount of Open Lands and Young Forest Associated with In-Channel Erosion for North Shore Tributaries
9:10	Primary	George Host, NRRI	GIS Landscape and Watershed Stressors
9:30	Primary	Travis Dahl, USACE	Reducing Sediment Loads and Restoring Streams When Nature Controls (Most) of the Cards
9:50	Primary	Titus Seilheimer, WISG	Prioritizing Lake Superior Watersheds Using Forest Disturbance and Landscape Metrics
10:10	Break		
10:30	Primary	Gerald Niemi, NRRI	A Review of Forest Landscape and Riparian Disturbances to Stream Ecosystems
10:50	Primary	Brian Palik, USFS	Hidden Watersheds: Understanding Seasonal Pools in a Landscape Context
11:10	Primary	Kristin Carlson, DNR	Using Zonation, a Value-Based Model, to Prioritize Areas For Watershed Management
11:30	Primary	Stephen Handler, USFS	Climate Change Vulnerability of Forest Ecosystems in Northern Minnesota
11:50	Primary	Mark White, TNC	Forest Restoration and Management in Changing Climate:Implications for Lake Superior Watersheds
12:10	Lunch		
1:00	Keynote	Mark Seeley, UMN	Climate Trends and Climate Change in Our Own Backyard: A Review
1:45	Primary	Lucinda Johnson, NRRI	Effects of Climate Change on Distribution of Cold Water Fish in North Shore Streams.
2:15	Primary	Karen Gran, UMD	Stream restoration: An evolving practice
2:35	Primary	Henry Eichman, USFS	Economic Aspects of Stream Restoration
2:55	Break		
3:15	Breakout Sessions		Identification and Prioritization of Stressors Impacting Streams
4:15	Panel	Keith Hanson- Clean Water Fund, Norm Moody- LCCMR, Jeff Gunderson- Sea Grant, Amber Westerbur- Coastal Program	Research and Implementation Funding Strategies
4:50	Wrap-up	Julie Westerlund, DNR	
5:00	Adjourn		

This Symposium is funded in part by the Coastal Zone Management Act of 1972, as amended by the NOAA's Office of Ocean and Coastal Resources Manangement, in conjunction with Minnesota's Lake Syperior Coastal Program



Poster Abstracts

(Alphabetically by Primary Author*)

Knife River Watershed Habitat Rehabilitation

Sam Alvar*, Seaquest Productions

The Lake Superior Steelhead Association (LSSA) received a grant from the Lessard/Sams Outdoor Heritage Fund to rehabilitate trout habitat in the West Branch of the Knife River. This grant consisted of three phases. Phase I: assessing, designing and rehabilitating trout habitat; Phase II: locating black ash stands; Phase III: improving steelhead passage.

Phase I included conducting an aerial survey, stream walk-through, water temperature monitoring, aquatic invertebrate collection and electro-fish sampling to obtain baseline stream data. This assessment identified impaired stream sections, spring water seepages and stream rehabilitation sites.

Phase II examined color infrared photography to identify black ash tree stands. Color infrared photography differentiated black ash from other tree stands due to

their lack of autumn foliage. Field confirmation was conducted in the spring for quality control.

Phase III consisted of restoring the second falls. The DNR altered the second falls by installing a weir in the 1970s to facilitate fish passage. In ~2003 the weir was lost during a weather event. This project restored the fish passageway by placing large boulders in the proximity of the former weir to create an improved jumping pool. These boulders mimicked the look of the original falls.

Amity Creek Restoration Initiative, Minnesota USA: Demonstration project to help restore and protect north shore Lake Superior Basin trout streams

R. Axler[1*], V.Brady[1,3], G.Host[1], K.Gran[2] , J.Schomberg[3] , G.Neitzel[2], M.Wick[2], J.Jasperson[2,6], J.Henneck[1], E.Ruzycki[1], N.Will[1], J.Geissler[4], C.Kleist[5], T.Carlson[5], K.Anderson[6], K. Kubiak[6], R.C.Boheim[6], J. Magner[7,8], D.Breneman[1,7] , L.Johnson[1], and B.Story[7]. U. of Minnesota-Duluth ([1]NRRI, [2]Dept. of Geology, [3] MN Sea Grant, Boulder Lake Environmental Center [4]), [5]City of Duluth Stormwater Utility, [6]South St. Louis SWCD, and [7]MN Pollution Control Agency, [8]University of Minnesota-Twin Cities

Amity Creek is one of ~720 perennial trout streams flowing into Lake Superior. Bedrock escarpments create steep, forested corridors with thin, erodible soils, low productivity, and "flashy" hydrology. Amity's watershed is mostly undeveloped (~4% rural/urban), but faces increasing development and climate change related impacts from increased temperature, stormwater runoff, erosion, riparian canopy opening, impervious surface, road crossings and reduced base flow. The stream was listed as *Impaired* in 2004 from excess turbidity from suspended sediment. A private gift spawned the *Weber Stream Restoration Initiative* (www.lakesuperiorstreams.org/weber) to help restore and protect Northshore streams using Amity as a demonstration project for restoration, assessment, and outreach activities. Partnership projects since 2005 include: two stream bank/channel stabilizations; a neighborhood stormwater reduction experiment; water, habitat, and biological monitoring; outreach activities, and developing GIS landscape stressor maps highlighting areas of higher environmental risk. GLRI funded efforts since 2011 include: (1) installing BMPs in critical areas; (2) development of on-line mapping tools for rural landowners to reduce erosion and stormwater runoff ; (3) a regional ditch design/maintenance manual; (4) geomorphic assessment of banks/bluffs using aerial and ground-based Lidar scanning; (5) assessing potential for increased groundwater storage; (6) WQ, habitat, and biological assessment; and (7) web-based outreach/education.

Monitoring the effectiveness of large wood at maintaining deep pool habitat… through a 500-year flood event

Ryan Birkemeier*, Water Resources Science Graduate Program, Department of Bioproducts and Biosystems Engineering, University of Minnesota Twin Cities
Karen B. Gran, Department of Geological Sciences, University of Minnesota Duluth
Carl Haensel, Minnesota Trout Unlimited

Habitat improvement projects employ various techniques to corral flow, create hydrologic complexity, or improve specific types of stream habitat. We are monitoring the effectiveness of a habitat improvement project on the Sucker River in NE Minnesota with the goal of improving deep pool habitat through a combination of installed large woody debris (LWD) jams and cross-vanes. We established a monitoring framework being implemented by University of Minnesota Duluth students through class laboratory assignments. To date, we have conducted pre- and post-installation surveys on 16 transects, plus LWD and pool surveys throughout the entire reach. Initial results indicated that pool habitat (areas > 60 cm deep) in the 400 meter reach increased from 53 m2 pre-installation, with 40% of that area in the largest pool, to 123 m2 immediately post-installation, with 18% in the largest pool. Additional surveys in July and October 2011 indicated a continued increase in deep pool area, from 208 m2 to 347 m2; and wood quantities increased with additional installed and captured debris. During a 500-year flood event in June 2012, many pools were filled in, leading to only 94 m2 of remaining deep pool area. While LWD quantity stayed the same, many installed structures were destroyed.

Developing Ecological Criteria for Sustainable Water Management in Minnesota: the Ecological Limits of Hydrologic Alteration (ELOHA)

Kristen Blann,* PhD
The Nature Conservancy in MN, ND, SD

Abstract. Hydrology is increasingly recognized as a primary determinant of aquatic, riparian and shoreland ecological structure and function. Surface and groundwater use, landscape modification, and climate change can all modify basin hydrology and streamflow regimes, but the quantitative connections between these changes and ecological conditions are often poorly understood. This poster will summarize a 2010-2011 initiative led by The Nature Conservancy to advance understanding of ecological flow needs in Minnesota and establish ecological criteria for assessing and preventing flow alteration in aquatic systems based on the Ecological Limits of Hydrologic Alteration (ELOHA) framework (Poff et al, 2009). ELOHA is a rapid, flexible, framework for determining water requirements for healthy, sustainable rivers and integrating those requirements into regional water management. The Conservancy's effort in Minnesota focused on a) assessing available data, criteria, tools and approaches to development of ecological flow criteria (both science and policy), b) developing consensus on technical approaches to characterizing flow metrics and ecological response, c) and assessing ecological flow response relationships for Minnesota's Great Lakes Basin streams as a pilot to identify and develop flow metrics and criteria needed to protect aquatic systems statewide. Currently, a number of state, regional and university research initiatives are continuing to address gaps in the scientific foundation, policy applications, and/or

implementation that were identified in this process. These efforts hold promise for progress on ecological flow protection and sustainable water management in Minnesota.

FishVis Mapper Beta Version

Kristen Blann,* The Nature Conservancy

Fish Vis Mapper presents possible changes in fish species occurrence in response to global climate change. Global climate change effects on fish species occurrence in streams were evaluated by means of a number of linked general circulation, groundwater recharge, stream temperature, and streamflow exceedance models.
http://imds.greenlitestaging.com/dynamic-maps/661
General circulation models (GCMs): Fish Vis Mapper results are based on a emissions scenario known as "A1B", developed by the Intergovernmental Panel on Climate Change (for more details see: http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/343.htm#box91). The A1B emissions scenario assumes a balanced approach to energy production is followed (fossil versus non-fossil) for the remainder of this century. The A1B emissions scenario was used as input to 13 general circulation models that provide potential air temperature and precipitation patterns to the remaining models. **Groundwater recharge model:** The USGS Soil-Water-Balance (SWB) model was used to estimate changes in potential groundwater recharge in response to projected air temperature and precipitation patterns for Wisconsin. **Stream temperature model:** An artificial neural network model incorporating landscape factors, air temperatures, and potential groundwater recharge was calibrated to observed stream temperatures. The model was used to estimate potential for changes in stream temperature for individual stream segments. **Streamflow model:** Multiple linear regression models were created to relate landscape and stream network characteristics with precipitation amounts in order to provide estimates of streamflow exceedance for specific parts of the year: annual median, 90% exceedence flow for the month of August, and 10% exceedence flow for the month of April. **Fish habitat model:** Individual fish presence/absence models for 14 species of interest were calibrated to existing fish sample collection data. Fourteen species were selected that occur across the region and represent three thermal classes (cold, cool, and warm water streams). The fish habitat models generally include landscape, streamflow, stream temperature, and climate variables as drivers.
Vulnerability of fish species to climate change was evaluated by comparing predicted species occurrence under current conditions to predicted fish species occurrence under future climate conditions for 13 climate models and 14 fish species using two measures: 1) vulnerability, opportunity, and sensitivity, and 2) probability of occurrence and change in probability of occurrence.
Contact Info
Jana Stewart jsstewar@usgs.gov 608-821-3855

External Links
FishVis Mapper (development site)
Poster submitted: kblann@tnc.org

Effects of In-stream Fine Sediments on Stream Macroinvertebrates **

Valerie Brady* and Larissa Herrera, Natural Resources Research Institute, University of Minnesota Duluth, 5013 Miller Trunk Hwy, Duluth, MN 55811. vbrady@d.umn.edu; risahary@gmail.com

Excess fine sediments are a problem for stream macroinvertebrates when they embed rocky substrates. Previous studies correlated macroinvertebrate traits such as burrowing vs. clinging behavior, case building, and fragile gills with fine sediments. These traits may make macroinvertebrates vulnerable to high sediment loads and would inhibit them from being dominant community members. North and south shore western Lake Superior streams have a wide range of fine sediment amounts due to clay and sand soils, but low amounts of other stressors, and thus are a good region to investigate relationships between macroinvertebrate traits and fine sediments. We created a combined sediment variable comprised of embeddedness, depth of fine sediments, and total proportion fine sediments. Macroinvertebrate traits significantly correlated with the sediment stress axis included mayfly, stonefly, and caddisfly (EPT) richness; fragile gill taxa richness; and proportion taxa with hard exoskeletons. Together, the traits create an indicator that helps determine whether or not macroinvertebrate impairment is due to excessive sediments. Interestingly, stream macroinvertebrates seem to sustain few effects on assemblage diversity as long as fine sediments are continually washed out of rocky substrates, and the substrates do not remain buried.

Twenty-five years of North Shore Stream Macroinvertebrate Sampling

Valerie Brady*, Lucinda Johnson, Dan Breneman*, Josh Dumke, and Robert Hell, Natural Resources Research Institute, University of Minnesota Duluth, 5013 Miller Trunk Hwy, Duluth, MN 55811. vbrady@d.umn.edu.
*Present affiliation: Minnesota Pollution Control Agency

NRRI aquatic ecologists have been sampling Duluth and North Shore stream macroinvertebrates since the late 1980's. Although the studies, goals, and methods varied, these data provide the ability to compare present-day stream invertebrate assemblages with those of up to 25 yrs. ago, investigate yearly variability, compare wet and dry years, put small studies into a larger context, and other analyses. In some cases, basic water quality and habitat data were collected in addition to the invertebrate samples. A couple of studies also took Chironomidae to genus for added taxonomic resolution. Two studies included south shore western arm streams for even more comparative capability and a greater range of stream and

substrate types. PIs included Anne Hershey, Carl Richards, Lucinda Johnson, and Valerie Brady; all were ably assisted by a number of graduate students, technicians, and taxonomists.

PREDICTED RISK OF BROOK TROUT TO CLIMATE CHANGE IN LAKE SUPERIOR'S NORTH SHORE STREAMS

MEIJUN CAI* - *UNIVERSITY OF MINNESOTA*
NATURAL RESOURCES RESEARCH INSTITUTE
5013 MILLER TRUNK HIGHWAY, DULUTH, MN 55811
(218) 720-4286
LUCINDA JOHNSON - *UNIVERSITY OF MINNESOTA*
NATURAL RESOURCES RESEARCH INSTITUTE
5013 MILLER TRUNK HIGHWAY, DULUTH, MN 55811
(218) 720-4251
WILLIAM HERB - *UNIVERSITY OF MINNESOTA*
ST. ANTHONY FALLS LABORATORY
2 THIRD AVENUE SE, MINNEAPOLIS, MN 55414
(612) 624-5147

Brook trout in the North Shore region of Lake Superior are very sensitive to temperature and hydrology changes. Climate change is expected to cause increases in water temperature and possible decline of summer low flow. To estimate the effects of climate change to brook trout in this region, we developed several empirical models to predict stream temperature, and brook trout presence/absence using current (1996-2009) hydrology, air temperature and land cover. Together with projected air temperature and stream flow, these models forecasted the future (2020-2089) stream temperature and the risk of brook trout in more than 400 survey sites located in 329 streams in this region. Results indicated that averagely summer stream temperature in this region will increase by 1.2^{o}C in 50 years. Consequently, 20% of current trout streams may lose trout, particularly in the lower shore area, where trout were predicted to disappear from almost all streams. In middle shore area, brook trout may be extirpated from half of current trout presence streams. Streams in the upper shore were less affected by climate change. Overall, suitable brook trout habitat in North Shore streams was predicted to shift northward in response to climate change.

The Watershed Health Assessment Framework

Ian Chisholm*, Stream Habitat Program Supervisor
MN DNR, Division of Ecological and Water Resources

The Watershed Health Assessment Framework (WHAF) provides a consistent approach for assessing watershed health at a variety of spatial scales. Statewide GIS

datasets from multiple sources are summarized into a suite of health index scores. An interactive map delivers the health index scores, facilitating information access, enhancing communication and fostering a common understanding of the context for natural resource work. A demonstration of the WHAF mapping application will highlight new functionality that allows users to view health scores at multiple scales, and navigation tools that explore complex relationships. The new WHAF application is available here: http://www.dnr.state.mn.us/whaf/index.html

Effects of riparian timber harvesting on detrital resources in northern Minnesota stream food webs **

Sue Eggert,* Brian Palik, Doug Kastendick, Josh Kragthorpe, and Randy Kolka
Northern Research Station, USDA Forest Service, Grand Rapids, MN 55744

Guideline development for timber management within riparian management zones (RMZs) requires consideration of economic benefits and potential effects on water quality and riparian/stream ecosystem function. The quantity and quality of organic matter (OM) inputs and standing crops of OM within streams can affect aquatic food webs. We measured organic matter inputs and in-stream OM standing crops in eight Minnesota streams in an experimental manipulation of varied levels of riparian harvesting. RMZs were either unharvested (controls), or harvested within 45 m of the streams to low (5.7 m2/ha) or medium (11.5 m2/ha) residual basal area (RBA). Total overhead organic matter inputs to streams were lower immediately after riparian harvesting in low and medium RBA treatments. Five years post-harvest, low RBA treatments had higher overhead wood inputs to streams. In-stream standing crops of leaves, wood, and fine organic matter 5 years post-harvest were greater and more variable at medium RBA sites than low RBA sites, but no significant differences between harvested and control reaches at either harvesting level were found. Our results show riparian harvesting treatments of similar magnitude would have minimal long-term impact on OM inputs and standing crops in streams of similar geomorphic settings of the riparian areas we examined.

Improved Stream Food Web Function Associated with Stream Simulation Design Culverts in Northern Great Lakes Streams **

Sue Eggert[1*], Anne Timm[1], Nicole King[2], James Olson[2], Amy M. Marcarelli[2], Randy Kolka[1], Dale Higgins[3], and Sue Reinecke[3]

[1]USDA Forest Service Northern Research Station, Grand Rapids, MN
[2] Department of Biological Sciences, Michigan Technological University, Houghton, MI
[3]Chequamegon-Nicolet National Forest, US Forest Service, Park Falls, WI

Typical goals of aquatic organism passage projects include providing adequate passage of aquatic organisms and rarely consider whether stream food web function is improved. We examined differences in habitat and food web responses (periphyton, organic matter, and invertebrates) in upstream, downstream, and culvert reaches at paired road-stream crossings in northern Wisconsin streams located within the Chequamegon-Nicolet National Forest. One culvert of each pair was constructed using the Stream Simulation Design (SSD) which mimics natural channel structure, while the other was left to fill on its own (non-SSD). Habitat characteristics within SSD crossings included shallower depths, faster velocities, and substrate dominated by cobble, pebble, and gravel, while silt dominated non-SSD crossings. Periphyton standing crop was greater in SSD crossings than non-SSD crossings. Fine benthic organic matter was significantly greater at non-SSD crossings than at all other reaches. Standing crops of coarse organic matter food resources (leaves/wood) and invertebrate abundances were significantly lower at non-SSD crossings compared to upstream and downstream reaches. Collector-gatherer chironomids dominated invertebrate communities at non-SSD crossings, while mayflies, stoneflies, and caddisflies dominated reaches at SSD sites. Food webs at SSD road-stream crossings more closely reflected reference reaches demonstrating that SSD can provide ecological functions beyond aquatic organism passage.

Monitoring and Assessment Results, Lake Superior South Watershed

Tom Estabrooks*, MPCA Project Manager; Nathan Mielke, Ben Lundeen, and John Sandberg, MPCA North Biological Monitoring Unit; Jesse Anderson and Stacia Grayson, MPCA Environmental Analysis & Outcomes.

Abstract: MPCA's Watershed Approach to condition monitoring and assessment is conducted on a major watershed scale with the goal of assessing all of Minnesota's surface waters over a ten year period. Through the Watershed Approach, lakes and streams are intensively monitored to determine the overall health of the water resources, identify impaired waters, and identify those waters in need of additional protection efforts to prevent impairments. Collection of data on water quality conditions includes: biological and physical monitoring, flow and load monitoring, and chemical monitoring. Intensive watershed monitoring began in the Lake Superior South watershed in 2011. The data collected, along with other credible data is used to assess Minnesota's surface waters to determine if they are meeting the appropriate designated uses for Aquatic Life, Aquatic Recreation, Aquatic Consumption, and Drinking Water. Results of the assessment process for Lake Superior South watershed identified nine stream segments and five beaches as not meeting the designated uses and were added to Minnesota's Draft 2014 Impaired Waters List. Current activities within the watershed include ongoing civic engagement and a stressor identification process for biological impairments. Future activities will include watershed modeling, TMDL completion and a Watershed Protection and Restoration Strategies (WRAPS) development.

Lake Nipigon Baseline Study for Waterpower Developments

Tara George[1*], Rick Salmon[2], and Todd Kondrat[1]
[1]Ontario Ministry of the Environment
[2]Ontario Ministry of Natural Resources
Keywords: Lake Nipigon, waterpower, mercury, methyl-mercury

Lake Nipigon is the largest inland lake in Ontario and is an important fisheries and recreational resource. Currently, two large systems that discharge into the Lake have proposed hydroelectric developments. It is well documented that increases in mercury (Hg) and methyl-mercury (MeHg) can result from the establishment of waterpower developments. The purpose of this study was to establish a baseline for total Hg and MeHg in sediment, water, fish tissue, and benthic invertebrate tissue at the mouths of tributaries and open water sites. Samples were analysed for low-level total Hg and MeHg, general chemistry, and metals. Total Hg and MeHg concentrations in water ranged from 0.33 to 2.13 ng/L and 0.01 to 0.1 ng/L, respectively. Total Hg concentrations in sediment ranged from 3 to 58 ng/g dry weight, with MeHg accounting for an average of 0.4% of the total Hg concentration. MeHg did not correlate well to total Hg or total organic carbon content in the sediment. In the young-of-year Spottail Shiners, MeHg accounted for an average of 80% of the total Hg concentrations measured in the whole fish, and exceeded the Canadian tissue residue guideline for the protection of wildlife consumers of aquatic biota. Oligochaetes were collected for tissue analysis, and contrary to the fish tissue, only 5% of the total Hg concentration was comprised of MeHg. A food web assessment will be conducted to establish a baseline that can be used for comparison purposes in post-development monitoring.

Lake Superior Sediment Assessment; Phase I Poster

Bradley Hansen*, Senior Scientist
Linse Lahti, MNDNR
John L. Nieber, Professor
Department of Bioproducts and Biosystems Engineering
University of Minnesota

Karen Evens and Greg Johnson, Minnesota Pollution Control Agency

This report details the first of a two part effort to begin developing an ecological systems understanding of sediment loading and its impacts on stream health along Lake Superior's North Shore. This initial assessment focused on characterizing the landscape of the North Shore as well as collecting and organizing available water quality data and data on aquatic organism health. This assessment also used GIS-based tools to identify reference and degraded areas along the North Shore. Aerial flyovers and field studies were also used to expand upon GIS findings and to further

characterize stability and erosion hazard along North Shore streams. Initial findings show wide variability in stream turbidity levels with some of the greatest suspended sediment loads occurring in the spring of the year. IBI scores were found to have "Good", if not "Fair", overall health and diversity. Anthropogenic stressor results showed that potential impacts from these variables were most highly concentrated around the more urbanized areas of Duluth and Two Harbors near the Lake Superior Shore. A group of 33 sites was also field assessed for channel stability using Rosgen's modified Pfankuch assessment; approximately ~42% of those sites were considered to have "Good" stability, ~27% "Fair"stability and ~31% "Poor" stability.

STREAM TEMPERATURE MODELING FOR NORTH SHORE TROUT STREAMS

WILLIAM HERB *- *UNIVERSITY OF MINNESOTA*
ST. ANTHONY FALLS LABORATORY
2 THIRD AVENUE SE, MINNEAPOLIS, MN 55414
(612) 624-5147
herb0003@umn.edu

LUCINDA JOHNSON - *UNIVERSITY OF MINNESOTA*
NATURAL RESOURCES RESEARCH INSTITUTE
5013 MILLER TRUNK HIGHWAY, DULUTH, MN 55811
ljohnson@umn.edu

MEIJUN CAI - *UNIVERSITY OF MINNESOTA*
NATURAL RESOURCES RESEARCH INSTITUTE
5013 MILLER TRUNK HIGHWAY, DULUTH, MN 55811
mcai@umn.edu

Compared to trout streams in central and southern Minnesota, the trout streams along Lake Superior's North Shore lack substantial groundwater aquifers, and are therefore particularly susceptible to both land use change and climate change. To help develop management strategies to address urbanization and climate change impacts on these streams, stream temperature models have been developed specifically for North Shore streams. As part of a temperature TMDL, a relatively detailed, network stream temperature model was developed for a highly urbanized trout stream (Miller Creek). Urban development was found to impact the temperature of Miller Creek via both stormwater inputs and reduced riparian shading. In a subsequent project focused on climate change, catchment-level deterministic and empirical models were developed to project the impacts of climate change on stream temperature in less developed North Shore trout streams. These models were calibrated based on historical climate and stream data, and then used to project future (2020-2089) stream temperature conditions based on climate data from several global climate models. Overall, stream temperatures were

projected to increase 1.3 to 3.5 °C, depending on the month and climate model data used. The projected stream temperatures were used to project the future extent of brook trout habitat in the North Shore region.

Invasive earthworms and their potential influence on runoff related to vernal pools

Authors: Ryan Hueffmeier1*, Jennifer Olker1, Dr. Lucinda Johnson1
1The Natural Resources Research Institute, Duluth MN,

Since European settlement, invasive earthworms have transformed the structure, composition and function of cold-temperate hardwood forests of North America. Earthworm-invaded areas are characterized by reduced forest floor thickness, altered biogeochemical processes, increased soil compaction and leaching, and reduced soil moisture and nutrient availability. These ecosystem level changes are correlated with a cascade of changes in forest communities, however, little is known about the impacts on associated aquatic ecosystems. Hydroregime in vernal pools is expected to change as a result of earthworm invasion. Heavily earthworm-invaded areas that contain multiple species in different ecological groups are expected to experience increased inflow of water and volume following spring run-off and precipitation events resulting from increased compaction and the loss of the forest floor. However, the burrowing behavior of earthworms should result in shorter hydroperiods due to more rapid draining from increased and deeper water infiltration. Nutrient inputs into vernal pools should increase with earthworm invasion. Persistently wet riparian zones of vernal pools can support highly active earthworms which incorporate the previously thick floor into the upper mineral soil horizon. These heavily impacted soils will be associated with substantially increased transport of mineralized or highly labile forms of N, P and C.

A Review of the Western Lake Superior Basin Erosion-Sediment Control Project; the Red Clay Research and Demonstration Project

John Jereczek*, DNR, Paul Sandstrom, LRCD, Valerie Brady, MN Sea Grant Brian Fredrickson, MPCA, Cliff Bentley, DNR, Jesse Schomberg, MN Sea Grant, Brian Hill, EPA, Marty Rye, USFS, Carl Haensel, TU

The Red Clay Project was a research and demonstration project completed in 1980 and sponsored by five soil and water conservation districts from two states. The local district supervisors were committed to the task of seeking practical solutions to the many forms of red clay erosion and the resulting water quality problems. The overall objectives of this project were to demonstrate economically feasible methods of improving water quality, to assess the capabilities of existing institutions to cooperatively implement a pollution control program and to provide data and recommendations that could be used in future programs. This poster is a

review of the recommendations that came out as a result of this extensive research and management project.

The Lake Superior Biodiversity Conservation Strategy

John Jereczek*, DNR and Rob Hyde, Environment Canada

Lake Superior is a lake of extraordinary biodiversity. It contains endemic fishes, a unique deepwater form of Lake Trout, and the cool coastlines and islands harbor arctic-alpine plants and Woodland Caribou. It is also a region of growing threats. In the fall of 2012, the Superior Work Group of the Lake Superior Lakewide Action and Management Plan (LAMP) initiated a biodiversity conservation assessment for Lake Superior. This project supports implementation of the Great Lakes Water Quality Agreement (GLWQA), and contributes to the GLWQA Annex 7 commitment to "complete the development and begin implementation of lakewide habitat and species protection and restoration conservation strategies…" This Biodiversity Conservation Assessment will provide the scientific basis for a biodiversity conservation strategy that will be initiated later this year. The final Lake Superior Biodiversity Conservation Strategy will be similar to projects that have been completed for the other four Great Lakes.

Lake Superior Climate Change Impacts and Adaptation Report

John Jereczek*, DNR and Julie McDonnell, DNR

Changing climate conditions will impact efforts to protect and restore Lake Superior. Current observations in the Lake Superior basin demonstrate that some changes in climate are already occurring, including increases in surface water and air temperatures and a decrease in the extent and duration of ice cover. Projected climate changes could have a range of future potential effects on Lake Superior ecosystems, including a decrease in the abundance of cold-water fish and changes to coastal wetlands. In this report on Lake Superior Climate Change Impacts and Adaptation (referred to as the Report), the available science and identified adaptation opportunities for Lake Superior ecosystems has been synthesized.

Stewart River Watershed Project

Forrest Johnson, Stewart River Watershed Coordinator, Trout Unlimited

The Stewart River Watershed is a small but important slice of the Lake Superior basin. The drainage is a combination of landscapes and ownerships, from maple highlands and aspen forests and openings to spruce muskegs and a mix of conifer cover in both public and private management. Swaths of public county tax-forfeit

forestry lands cover the northern half of the drainage while parcels of private lands primarily dot the downstream landscape.
The watershed has been reshaped numerous times since the heyday of white pine logging, a century of settlement and the more recent removal of large areas of forest cover. Since 1900 the forest type has shifted from primarily conifer species to deciduous species with the overall age of the forest growing much younger and able to provide less cover and vegetative matter for the stream. The result is that stream flows fluctuate wildly and the entire hydrologic holding capacity of the watershed has been reduced. Water simply runs off the landscape faster today than ever before.
The Stewart River Enhancement and Watershed Improvement Project of Trout Unlimited aims to focus on several in-stream restoration projects that can directly enhance fish habitat as well as involve private landowners and their property in conservation practices across the landscape.
Grants made possible through the Legislative Commission on Minnesota Resources (LCMR) have allowed Trout Unlimited to focus on improving the overall health of the Stewart River watershed.

Nemadji River Watershed Stressor Identification Project

Greg Johnson*, Jeff Jasperson, Karen Evens, MN Pollution Control Agency
Jason Naber, Emmons & Olivier Resources, Inc.
Carlton County Soil & Water Conservation District
Nemadji Stewardship Committee

The Stressor Identification process is part of the larger Watershed Restoration and Protection Strategies for the Nemadji River watershed. The process identifies potential biotic stressors and develops the preliminary information necessary to complete TMDL reports for water bodies listed as “Impaired” or not meeting designated water quality standards. Each potential stressor is evaluated thoroughly. Although a significant volume of research and monitoring data are available for this watershed, and likely stressors are known by professionals familiar with the watershed, a robust Stressor ID process is being initiated with the broadest range of candidate stressors developed from similar aquatic systems with aquatic life impairments.

Targeted Sediment Management Practices in the Lower Poplar River

Greg Johnson*, Pat Carey, Karen Evens, MN Pollution Control Agency
Tom Rider, Poplar River Management Board
Kerrie Berg, Cindy Gentz, Cook County Soil & Water Conservation District

John Nieber, Brad Hansen, University of Minnesota

Abstract: The lower reach of the Poplar River is impaired due to excess sediment entering the stream. A TMDL report has been completed, along with extensive field reviews of watershed land use and water erosion prediction modeling to understand and quantify the sources of sediment to the river. Concurrent with the TMDL investigative work, local landowners have made a consistent effort to select and construct the most effective BMPs to manage sediment in the watershed. A recent review of water quality data shows sediment declining by 35% from the earlier annual average loads prior to BMP work. Additional projects to further reduce run-off and erosion are under development.

Assessing the Influence of Natural Copper-Nickel Bedrocks On Water Quality

Perry M. Jones* and Laurel Woodruff, U.S. Geological Survey, 2280 Woodale Drive, Mounds View, MN; Steve Hauck, Natural Resources Research Institute, 5013 Miller Truck Highway, Duluth, MN 55811;Carrie E. Jennings, Minnesota Department of Natural Resources, 500 Lafayette Road, St. Paul, MN 55155

The U. S. Geological Survey, Natural Resources Research Institute, and Minnesota Department of Natural Resources are conducting a three-year study to: 1) assess copper, nickel, and other metal concentrations in surface water, rocks, streambed-sediments, and soils (including parent material) in watersheds that cross the mineralized basal contact of the Duluth Complex; and 2) determine if these natural concentrations are currently influencing regional water quality in areas of potential base-metal mining. Water-quality, streambed-sediment, soil, and bedrock samples will be collected and analyzed in three unmined watersheds with the following different mineral-deposit settings: (1) copper-nickel-cobalt-platinum group metal mineralization (Filson Creek watershed), (2) titanium-oxide mineralization (headwaters of the St. Louis River watershed), and (3) no identified mineralized deposits (Keeley Creek watershed). Water samples will be analyzed for 12 trace metals (total and dissolved concentrations), 14 inorganic constituents (dissolved concentrations), alkalinity, and total and dissolved organic carbon. Soil, streambed-sediment, and bedrock samples will be analyzed for 44 major and trace elements, total and inorganic carbon, and 10 loosely bound metals. Continuous streamflow and water-quality data will be applied to new hydrologic models and existing biotic ligand models to assess the influence of existing geochemistry and possible mining activities on regional water quality.

Historical Geomorphic Assessment of the Grand Portage Creek Watershed, Grand Portage, Minnesota

Susan Kilgore[1*], Faith Fitzpatrick[2], Brandon Seitz[3], Sadie Libal[1]

[1] Grand Portage Reservation Tribal Council, Grand Portage, MN
[2] U.S. Geological Survey Wisconsin Water Science Center, Madison, WI
[3] National Park Service, Grand Portage National Monument, Grand Portage, MN

Over the last decade, bank erosion and lateral migration along Grand Portage Creek have threatened important cultural resources and historical landmarks, especially near its mouth at Lake Superior. The purpose of this study is to identify stream reaches throughout the watershed that are migrating, eroding, or depositing sediment at rates above pre-EuroAmerican settlement or prior to the 1700s. The study is being conducted by a partnership of the National Park Service, U.S. Geological Survey, Grand Portage Band and Geological Society of America. The watershed-based study uses a combination of field-based channel and floodplain geomorphic assessments, historical records, Geographic Information System analyses, and alluvial stratigraphy. A rapid geomorphic assessment of the creek from its mouth to headwaters was completed in 2012-13 along 67 reaches and includes measurements of channel morphology, streambed sediment, bank erosion, valley type, and geologic setting. Permanent channel cross sections, longitudinal profiles, and floodplain soil cores were established at a subset of 15 reaches and measurements will continue into 2014. Data analyses has just began, but preliminary results show the importance of glacial geomorphic setting and bedrock structure in regulating the Creek's responses to land cover and climate change.

REDUCTION OF SEDIMENT LOAD THROUGH IMPLEMENTATION OF STREAMBANK STABILIZATION PROJECTS ON THE KNIFE RIVER

Lake County Soil and Water Conservation District*

The Knife River was listed as impaired with a total maximum daily load (TMDL) for turbidity in 2010. Much of the sediment leading to this impairment enters the river from unstable streambanks. The Lake County Soil and Water Conservation District (SWCD) is working to reduce the sediment load by designing and implementing streambank stabilization projects. Streambank stabilization projects use natural design methods established by hydrologist Dave Rosgen. This method, known as toe-wood, uses tree trunks, root wads, and brush to create a stable streambank. A stable streambank is more able to withstand erosion, resulting in less sediment entering the Knife River. A toe-wood project constructed in 2011 by the SWCD withstood the June 2012 flood. More projects of this type are in design to be constructed on the Knife River.

Lake Superior South Watershed Monitoring and Assessment

Authors: Nathan Mielke*(MPCA), Tom Estabrooks (MPCA), Ben Lundeen (MPCA), Jesse Anderson (MPCA)

In 2011, the Minnesota Pollution Control Agency (MPCA) undertook the intensive watershed monitoring effort of both the Lake Superior South and the Nemadji River Watersheds. A total of 77 biological monitoring stations were established at the outlets of varying sized sub-watersheds. As part of this effort, MPCA staff joined with local government units and organizations to complete stream water chemistry sampling at the outlets of eight subwatersheds. In 2013, a holistic approach was taken to assess all of the watershed's surface waterbodies for support of aquatic life, recreation, and consumption. Seventy-one stream segments and 14 lakes were assessed in this effort. Not all lake and stream segments were assessed due to insufficient data, modified channel condition and/or their status as "limited resources waters". Data collected between 2001 and 2011 suggest aquatic life impairments on 20 stream segments, aquatic recreation impairments on five streams segments and two lakes, and aquatic consumption impairments on two stream segments. Impairments found in both watersheds include biological (fish & macroinvertebrate), turbidity, dissolved oxygen, pH, bacteria, and mercury in fish.

Nemadji River Watershed Monitoring and Assessment

Nathan Mielke* (MPCA), Karen Evans (MPCA), Ben Lundeen (MPCA), Jesse Anderson (MPCA)

In 2011, the Minnesota Pollution Control Agency (MPCA) undertook the intensive watershed monitoring effort of both the Lake Superior South and the Nemadji River Watersheds. A total of 77 biological monitoring stations were established at the outlets of varying sized sub-watersheds. As part of this effort, MPCA staff joined with local government units and organizations to complete stream water chemistry sampling at the outlets of eight subwatersheds. In 2013, a holistic approach was taken to assess all of the watershed's surface waterbodies for support of aquatic life, recreation, and consumption. Seventy-one stream segments and 14 lakes were assessed in this effort. Not all lake and stream segments were assessed due to insufficient data, modified channel condition and/or their status as "limited resources waters". Data collected between 2001 and 2011 suggest aquatic life impairments on 20 stream segments, aquatic recreation impairments on five streams segments and two lakes, and aquatic consumption impairments on two stream segments. Impairments found in both watersheds include biological (fish & macroinvertebrate), turbidity, dissolved oxygen, pH, bacteria, and mercury in fish

Monitoring Event-Scale Stream Bluff Erosion with Repeat Terrestrial Laser Scanning: Amity Creek

Grant D. Neitzel*; Karen B. Gran

UMD Geological Sciences Department; NCESD (NSF Science and Technology Center; EAR 0120914); GLRI (funding through MPCA)

Terrestrial laser scanning (TLS) technology provides high-resolution topographic data that can be used to detect geomorphic change in fluvial environments. In this study, we utilize successive terrestrial laser scans to investigate the relationship between peak flow rates and stream bluff erosion in the Amity Creek watershed in Duluth, Minnesota. Eight sites were selected for TLS analysis; scans were conducted following all large rain events, spring melt, and during times of low base flow.

Using our change detection measurements, we calculated an annual average retreat rate of -0.50 m/yr. By applying this rate to a watershed-scale bluff inventory, we estimated the total volume of sediment eroded from unvegetated bluffs in the watershed between November 2011 and November 2012. Results show that bluffs are likely the primary source of fine sediment contributing to the creek's turbidity impairment. Load calculations from our bluff erosion work were compared to MPCA estimates from previous years, and were found to conceivably represent 100% of the total sediment load even with the 500-year event removed. June flood loads were determined to account for approximately 80% of the sediment load from bluff erosion between November 2011 and November 2012.

TLS results from this study prove that major events are responsible for inducing considerable bluff erosion and moving the vast majority of sediment through the system. Additionally, our data demonstrate that management of turbidity-plagued watersheds along the North Shore and other regions of the state must include a focus on bluffs.

Modeling sources of erosion for the Knife River

John L. Nieber*, Professor
Jason Ulrich, Graduate Research Assistant & Hydrologist, EOR Associates
Bradley Hansen, Senior Scientist
Department of Bioproducts and Biosystems Engineering
University of Minnesota

A study was conducted beginning in 2007 to estimate the magnitude of sediment sources along the Knife River, a tributary to Lake Superior. The study involved conducting geomorphic assessments of the main channel of the river, characterization of the bluffs lying adjacent to the river, outlining of tributary watersheds to the river, and modeling of surface runoff, overland flow erosion, channel erosion, and streambank erosion. The modeling involved the use of the SEDIMOT model for tributary hydrology and overland flow erosion, and the CONCEPTS model for simulating the erosion of the channel and streambanks. Cross-section data for about 25 locations along the river were available, and these were augmented with section data generated using a well-tested synthetic method. Precipitation data for three storm events was used with the hydrologic model to simulate surface runoff and overland flow erosion. The sediment generated from the various sources, overland flow in tributary watersheds, overland flow from bluffs,

and streambank erosion was compared to the measured sediment loads at the gaging station at the mouth of the Knife. Comparison between simulated loads and measured loads was considered fairly good. The fraction of sediment generated from the three sources were: 59% from streambanks, 29% from bluffs, and 12% from upland areas.

Geomorphic Effects of the Forbay Levee Breach at Jay Cooke State Park

Kristin Riker-Coleman*, Dept. of Natural Sciences, University of Wisconsin Superior
Karen Gran, Dept. of Geological Sciences, University of Minnesota Duluth
Kris Hiller, Minnesota Department of Natural Resources, Jay Cooke State Park

The Duluth, MN, area experienced massive flash flooding following 8-10 inches of rain in 24 hours in June 2012, causing extensive damage at Jay Cooke State Park. One affected site involved a levee breach on Forbay Lake, releasing a flood wave downslope, carving a deep valley and destroying part of Highway 210. Although devastating for the park, the event provided opportunities for student research and outreach. Students from two classes at the University of Minnesota Duluth (UMD) conducted research in October 2012 to reconstruct magnitude and timing of the flood wave, impoundment behind the road, breaching of the road, and subsequent incision. Student projects focused on delineating the flood wave's lateral extent; determining peak shear stress and its effect on sediment mobility; estimating volumes of material eroded from the levee and deposited in the temporary impoundment; and tracking knickpoint propagation. Graduate students in a fluvial geomorphology course were able to address more complex issues including paleoflood discharge, levee geotechnical stability, and detailed long profile development. Collectively, they were able to extensively document what happened during the flood event at this site. To explain this dramatic event to park visitors, science education students from the University of Wisconsin Superior are taking data collected by UMD students and developing education materials. This collaboration between UMD, UWS, and the Minnesota Department of Natural Resources has provided research and public outreach opportunities for students that will eventually help educate the general public.

MPCA Biomonitoring Projects in the Lake Superior Basin

John Sandberg*, Minnesota Pollution Control Agency

The Minnesota Pollution Control Agency's (MPCA) North Biological Monitoring Unit works actively in the Lake Superior Basin on projects related to the monitoring, assessment, restoration, and protection of rivers and streams. Biomonitoring is an important component of the Intensive Watershed Monitoring (IWM) approach; since 2009, IWM biomonitoring, assessment, and reporting has been completed (or is near completion) in three of Minnesota's five Lake Superior Basin major watersheds. The Lake Superior North watershed will enter its second year of

monitoring in 2014, and work is scheduled to begin in the Cloquet River watershed in 2015. A parallel project was recently initiated to more frequently monitor a network of least-impacted "reference sites" across the state; many of these sites lie within the Lake Superior Basin. These long-term monitoring sites represent a variety of stream types (e.g., headwater streams, large rivers, coldwater streams, low gradient streams) in their most natural condition, and will be monitored on a biennial schedule. This poster may also briefly cover other aspects of MPCA's biomonitoring program in the Lake Superior Basin, including: the development of Tiered Aquatic Life Uses, biota-based diagnostic tools to aid stressor identification, and a database tool for rapidly summarizing temperature logger data in terms of species-specific growth/stress/lethal durations.

The Watershed Game: Engaging local leaders in achieving clean water goals

Jesse Schomberg*, University of Minnesota Sea Grant Program, Duluth, MN
jschombe@umn.edu
Secondary Author(s): John Bilotta, University of Minnesota Extension and Sea Grant Program, St. Paul, MN; Cynthia Hagley, University of Minnesota Sea Grant Program, Duluth, MN

Abstract: The Northland NEMO (Nonpoint Education for Municipal Officials) program's Watershed Game is an interactive tool with a record of success in helping local government officials and others understand the connection between land use and water quality. Participants learn how a variety of land uses impact water and natural resources, increase their knowledge of best management practices (BMPs), and learn how their choices can prevent adverse impacts. Participants apply plans, practices, and policies that help them achieve a water quality goal for a stream, lake, or river. It has been used throughout Minnesota and in other areas of the country to build the knowledge base of local leaders, providing sound science and easier understanding of TMDL's and their role in achieving them. Currently, nearly 100 facilitators in 9 states have been trained to use the activity.

A Self-Assessment to Address Climate Change Readiness in Your Community

Hilarie Sorensen*, University of Minnesota Sea Grant Program, Duluth, MN
soren360@d.umn.edu
Jesse Schomberg, University of Minnesota Sea Grant Program, Duluth, MN

Abstract: Through surveys, focus groups, and interviews, Minnesota Sea Grant recognized that communities were interested in adapting to climate change, but didn't know where to start or how to begin thinking about climate adaptation. To address this need, we worked with the Great Lakes Sea Grant Network to develop a checklist designed to start the conversation. Titled "A Self-Assessment to Address Climate Change Readiness in Your Community," it covers a range of categories

including: critical infrastructure and facilities, infrastructure, operations & maintenance, water resources, ecosystems & habitats, tourism & recreation, and community planning. During an initial meeting with community staff and officials, we present introductory information on climate change and adaptation, describe the self-assessment, and come up with a process for participants to return the assessments to us. We then analyze the responses and schedule follow up meetings to discuss the results and help the community determine their next steps.

Moose use of water, wetland cover types, and surrounding areas from GPS collar data

J. Trevor Vannatta1* and Ron A. Moen1

1Natural Resources Research Institute, University of Minnesota Duluth, 5013 Miller Trunk Highway, Duluth, MN 55811-1442, USA

Moose are commonly seen feeding in aquatic environments, but moose spatial and temporal relationships with aquatic environments across longer time periods is difficult to quantify. One reason for this is that moose are easy to observe in the water. We radiocollared moose and collected location data over a three year period and determined time moose spent in or near water over an entire season. Use of aquatic environments by moose occurs from late May through early August. We analyzed locations of moose in water, wetland cover types, and adjacent to water and wetland cover types. For most moose there was an increase in use of wetland cover types in the summer when temperatures were warm. From 30 to 70% of locations were in and near wetland cover types on hot summer days. In some cases moose were still not selecting for wetland cover types at the landscape scale because 40 to 50% of the home range was of the wetland cover types. Moose also consume aquatic macrophytes to supplement sodium in their diets. We are using activity loggers on collars in association with cover type identifications and aerial photographs to identify what proportion of active time moose are feeding on aquatic macrophytes.

Brook Trout Status and Distribution in the Lake Superior Basin

Anna Varian*, Henry Quinlan, and Mark Brouder
U.S. Fish and Wildlife Service, Ashland, WI

Brook trout are the only stream dwelling trout native to the upper Midwest and populations have declined dramatically since early settlement; however, the extent, severity, and in some cases, the specific cause of the decline is unknown. Current fishery data along with landscape scale GIS data is being used to model the status and distribution of brook trout at the catchment and subwatershed scales in an effort to complete a range-wide status and distribution map throughout their native

range in the United States. Partner agencies have provided recent fisheries data collected throughout the U.S. portion of the Lake Superior basin, and additional data has been collected during the 2011-2013 field seasons. Catchments and subwatersheds with sufficient data have been classified according to brook trout population status. Landscape scale metrics are being used to develop a classification tree model to predict brook trout status in areas where fishery data is insufficient. The end product, geo-referenced maps and data will assist biologists, land managers, and other interested parties evaluate and prioritize areas for protection, enhancement, or restoration of brook trout populations and provide a baseline for monitoring climate change effects on cold-water species.

Tributary Habitat Assessment for Fisheries Conservation: Ensuring we're doing the right things, in the right places

Michele Wheeler*, Great Lakes Basin Fish Habitat Partnership Coordinator

The Great Lakes Basin Fish Habitat Partnership is committed to supporting healthy fisheries by funding and coordinating efforts to improve and protect fish habitat. We utilize a strategic, science-based approach to address the root cause of habitat decline on a landscape scale. The proposed poster will describe the Minnesota portion of our habitat assessment modeling that was completed on all US streams that drain to the Great Lakes.

The models, analyses, and data produced in tributary habitat assessments first describe fish distribution as a result of land use and habitat conditions. The statistical modeling that predicts fish distribution is then used to generate indices of anthropogenic stress and natural habitat quality. These indices can be used to set restoration and protection priorities with a broad scale perspective.

These models can help managers, agencies and local groups identify what kinds of restoration projects will improve fish distribution and target where those projects will be most effective in benefiting aquatic species. Model results and associated decision support tools can be used by partners all throughout the region to focus limited resources in areas where restoration will most make a difference.

Identifying Erosional Hotspots in North Shore Streams Using Airborne LiDAR

Molly Wick*, Karen Gran, Dept. of Geological Sciences, University of Minnesota Duluth

Many streams on the North Shore of Lake Superior are impaired for turbidity. High-resolution LiDAR-derived DEMs offer a unique opportunity to develop a GIS model for identifying erosional hotspots in these streams, which can be used to inform

watershed management decisions to reduce sediment loading. We used 3-m LiDAR-derived DEMs to identify several erosion predictors along Amity Creek. Because bedrock exposure significantly limits erodibility, we investigated bedrock exposure using Minnesota Geological Survey bedrock outcrop maps and by mapping bedrock exposure using a feature extraction tool.

Predictions based on remote data were compared with a field dataset that recorded erosion after a 500-year flood event. The most significant variables are bedrock exposure, a stream power-based erosion index, and bluff proximity. A threshold-based conceptual model including the three successful predictors was 70% accurate for predicting erosion hotspots. The limited predictive power of the model stemmed in part from differences in locations of erosion hotspots in a single large-scale flood event vs. long-term erosion hotspots. The inability to predict site-specific characteristics like large woody debris or vegetation patterns makes predicting erosion hotspots in a specific event very difficult. In addition, this model requires high-resolution bedrock exposure data, which may limit widespread application.

Breakout Sessions

Breakout Session Facilitators: Led by NE MN Civic Engagement Cohort on Water Quality

Facilitator and Topic:

1. Derrick Passe — Invasive Species
2. Mike Kennedy — Water Quality and Chemistry
3. Hilarie Sorensen — Suspended Sediment
4. Dan Schutte — Landscape Hydrology
5. Jesse Schomberg — In-Stream Habitat
6. Patty Fowler — Water Temperature
7. Cindy Hagley — Riparian Habitat

Recorders: John Jereczek, Marty Rye, Brian Fredrickson, Val Brady, Carl Haensel, Paul Sandstrom, Cliff Bentley

Stream Science Symposium Notes

1 INVASIVE SPECIES BREAKOUT

1.1 #1 WHAT IS ONE POINT YOU HEARD OR SAW DURING THE CONFERENCE THAT REALLY CAUGHT YOUR ATTENTION OR STOOD OUT FOR YOU THAT RELATES TO OUR BREAKOUT TOPIC?

1.1.1 Responses from Breakout Session:

- Climate change effects on invasives (Survival & Spread)
- Connectivity (Disconnect to prevent spread)
- Some we like introduced species and not others
- Applying biases like this to climate change movements
    - E.g.- striped bass, rusty crayfish vs. Red oak and other species
- USFS can manage for natives and desired non-natives
- Some naturalized fish may be better pre-adjusted to climate triangle
- 989 degrees H2O from our own state is responsibility to protect the water, & we can export our problems

1.1.2 Submitted Comments (from green sheets):

- none

1.1.3 Submitted comments from Evaluation:

- none

1.2 #2 What did you hear that surprised or inspired you? That made you struggle, or concerned you?

1.2.1 Responses from Breakout Session:

- Climate change allow more invasives to survive'
- Manage for new non-natives to respond to climate change-is this ok? Need public conversation & public discussions. Public more ready than agencies, so may not have control. Need to talk to public and guide conversation.
- Planting zones ahead- good or not? How decide what species and when?
- Biocontrol species to control invasives-trust this?
- Lack of empirical data on impacts of invasives
    - Things are looming
- Ontonagon R presentation & red day erosion- mostly natural-same here for nemadji argument brookies not native above barrier falls, so should we abandon trying to save them from the effects of climate change in these areas

1.2.2 Submitted Comments (from green sheets):

- none

1.2.3 Submitted comments from Evaluation:

- none

1.3 #3 What is the significance of this to our work on streams?

1.3.1 Responses from Breakout Session:

- Very careful about not being vector ourselves
- Have to watch for new invasives
- Look for effects and understand bio/spread as we find new species
- Need better rapid response on control
- Ballast water treatments needed
- Pay for invasives monitoring? Who will do it? USFWS
- Adoptive management- may have to give things up such as marginal cold water fisheries. $ is limited, have to triage what spend on what smart about how spend $
- Invasive plants in forest- have a few but not big scale, but worried about losing conifers and this going to brushland and how much spend on this? Should we spend a ton on garlic mustard?
- Also gypsy moths, EAB, Tansy
- Prioritize and educate public

1.3.2 Submitted Comments (from green sheets):

- none

1.3.3 Submitted comments from Evaluation:

- none

1.4 #4 What will change for you because of what you've heard?

1.4.1 Responses from Breakout Session:

- Climate change impacts, stuff already happening, have to adapt, plan, mange, do vulnerability assessment, risk asses change for invasives because of climate change
- What ecosystem functions will we lose due to climate change even just temporarily? Should we introduce something to mitigate it?
- Some (Seth Moore's talk) already doing this
- Adaptive VS. Accidental management- if we move something in instead of let an invasive take over, is this what we should do?
- Will be pressure from the public to introduce species to fill empty niches
- Landowner comments-good luck to next generation to solve this problem
- Need landowners to implement so much of the management, so nee to convince them.
- Need good data but also ned informed public to be able to allowed to do the good management

1.4.2 Submitted Comments (from green sheets):

- none

1.4.3 Submitted comments from Evaluation:

- none

2 Water Quality & Chemistry

2.1 #1 What is one point you heard or saw during the conference that really caught your attention or stood out for you that relates to our breakout topic?

2.1.1 Responses from Breakout Session:

- Watershed influences on Water quality
- Climate change effects- more info needed on impacts
- Drivers a focus as opposed to end point conc./values
- Discussion was lumped/ high level more detail needed to identify specific management step.

- MN has unique AYd setting 98% of water in mn fell in mn- it's a headwater state
- Knowledge of river processes has improved in last 10-20 years-sensitivity
- New tools (isotopes. Etc) that can be useful
- Some old tools may have pointed in wrong direction
- Convert data to management actions/approach
- Careful using mopels
- Connectivity-good to see culvert alternatives
- Buffers-need additional research RE: effectiveness
- Wood is good
- EPA Reference documents
- Valley wall/ bank erosion natural progress- need to understand historical context

2.1.2 Submitted Comments (from green sheets):

- Connectivity in water flow is essential to water quality; fragmentation needs to be addressed
- that the effectiveness of fixed width buffers has not been studied
- models were used a lot
- we know that watersheds affect water quality
- we do not know how climate will affect Water quality because of the impacts (I am surprised there was nothing on mercury-except in passing)
- enjoyed hearing Travis Dahl Discuss eroding day banks as natural process-especially for Lake Superior streams like Ontonagon R, Nemadji R
- Acknowledge that this process not really caused by logging, natural part of ecosystem
- Lots of reference to different reference documents
- We need to go back and revisit these as they can be useful

2.1.3 Submitted comments from Evaluation:

- lack of regional and local monitoring results.

2.2 #2 WHAT DID YOU HEAR THAT SURPRISED OR INSPIRED YOU? THAT MADE YOU STRUGGLE, OR CONCERNED YOU?

2.2.1 Responses from Breakout Session:

- Greater confidence in climate change impacts related to natural variation was surprise
- Erosion a natural process
    - Projects lead to natural US induced
    - Where to focus/how to design
- Surprised not more restoration monitoring
- Finding good sweet spot in science VS implementation is difficult

- Competing priorities- still a political process- often react to recent hot issue
- Why no large study on effectiveness on fixed buffered widths
- Careful using models without knowing assumptions/details
- Careful about group think related to change and watershed planning; need to include diversity of perceptives including industries

2.2.2 Submitted Comments (from green sheets):

- How little remediation occurs amid tons of research and study; how mandates of clean water act have failed to be achieved amid substantial legacy money, "we're only starting a road map"
- Climate change-the extent that this train is moving very swiftly or we don't really know where it is going.
- A lot of assumptions
- How there is still information we don't have that would be needed to help define management
    - Specific local soil data
    - Influence of seasonal ponds & headwater streams
    - Measurements of success of restoration projects & voluntary buffers
- Inspired by box quote "essentially, all models are wrong, but some are useful" applies to work I've done w/ restoration models & plant community classifications. Question is how to evaluate what's useful.
- I'm surprised that much of the info presented on stream hydrology is similar to what I learned 20 years ago in a hydrology workshop, surprised there wasn't more new info.
- That the basin is tilted
- This group seemed to be confident in their approach to climate change- more confident than at other meetings

2.2.3 Submitted comments from Evaluation:

- I enjoyed the generally positive audience responses throughout.

3-discussion

- How do we incorporate public into ideas/process
- How do we boil this information "down" to folks directly impacted
- Good to be patient to allow process to incorporate public input
- Details of processes relating to water quality missing

2.3 #3 WHAT IS THE SIGNIFICANCE OF THIS TO OUR WORK ON STREAMS?

2.3.1 Responses from Breakout Session:

- Very little being done to reverse degradation impaired water list of Minnesota continues to expand this year to my neighborhood streams- chester and tischer
- Complicates the selection of indicators to include in long term monitoring

- Think carefully about what we include or exclude
- Need to be able to convey watershed health importance to local citizens since watershed impacts water quality.
- Need to be able to monitor actions for success
- "so What" Mark Seeley's comment/bullet point that "tropical or high dewpoints affect the efficiency and persistence of herbicides (Volatility)" raises some questions that may be helpful for interpreting pesticide contamination in sediments and water.
- Not a lot of water quality talks so difficult to say the significance of some of the talks to the work I do on water quality

2.3.2 Submitted Comments (from green sheets):

- none

2.3.3 Submitted comments from Evaluation:

- We need a new framework for stratifying Western Lake Superior watersheds as to surficial geology/soils and perhaps vegetation and other factors in order to link WQ and biological data to the Impairmet List.

2.4 #4 WHAT WILL CHANGE FOR YOU BECAUSE OF WHAT YOU'VE HEARD?

2.4.1 Responses from Breakout Session:

- Contact M Sealy RE: changes in air transport of constituents
- Decision- making matrix apply to northern MN setting
- Public input at point of implementation may be reasonable
- Work with industry to develop SOL's
- Understanding human impacts (Development) and relative import to national processes
- Long-term databases important

2.4.2 Submitted Comments (from green sheets):

- I have less faith in government, academia to actually affect change for the better
- I think the scope in which I look at my work has been broadened
- Think about the role of models more
- Pay attention to long-term planning
- Work with natural range of variation concept
- I'll contact Mark Seely to learn more about #3 useful for networking.
- I got more of an understanding of streams and can integrate them into my lake work

2.4.3 Submitted comments from Evaluation:

- none

3 SUSPENDED SEDIMENT BREAKOUT

3.1 #1 WHAT IS ONE POINT YOU HEARD OR SAW DURING THE CONFERENCE THAT REALLY CAUGHT YOUR ATTENTION OR STOOD OUT FOR YOU THAT RELATES TO OUR BREAKOUT TOPIC?

3.1.1 Responses from Breakout Session:

- The USACE (T.Dahl) illustration presented on the pre-settlement appearance of the stream banks (Ontonagon River) and how they appear today in such a similar condition.
- The land cover analysis Tom Hollenhorst presented to aid in forest management planning.
- The new technology developed over the last 5 years i.e. LIDAR and the applications to pull it all together.
- The Cross River Project conclusions that it is OK to leave some things alone (dam remnants).
- Suspended sediment was not directly addressed in the conference, only referred to several times.
- The sediment- hydrology link.
- It felt like sediment was the 800 lb gorilla in the corner. Opportunity to address that next year.

3.1.2 Submitted Comments (from green sheets):

- Cross river study result that suggested no-action was best course
- Success of the legacy at least in terms of interagency collaboration and monitoring

3.1.3 Submitted comments from Evaluation:

- Faith's work showing increased sediment loads due to land practices, while not new, was interesting.

3.2 WHAT DID YOU HEAR THAT SURPRISED OR INSPIRED YOU? THAT MADE YOU STRUGGLE, OR CONCERNED YOU?

3.2.1 Responses from Breakout Session:

- Loved John Neiber's acknowledgement that you can use any number you want to in the formula he presented.
- Practice implementation element of stream science was not presented.
- The huge effort and amount of money spent with out knowing if we are fixing the problems.
- MPCA's ten-year rotation in watershed study work. Producing then reproducing work and not helping each time.

- Hydrology varies from year to year and that was not part of the discussion.
- There is no requirement for monitoring and assessment.
- Data assessment, all the data available with no correlations to say what is meaningful.
- The recognition of the large amount of data available to do mass analysis.
- We should by now know what needs to be monitored.
- The talk of sentinel watersheds, data needs on comparative watershed studies over 20 years. We need a few watersheds intensively monitored instead of the short time studies that run only two years and end. We need a longer time scale and longitudinal studies.
- The polar vortex we are having now compared to the warm winters of prior years and public sentiment on climate change.
- The presentation on Using Zonation by Kristen Carlson was inspiring.
- The social aspects of working with landowners to implement watershed improvements will be a greater factor than science. Outreach and education will be important.

3.2.2 Submitted Comments (from green sheets):

- Lack of discussion regarding how to improve the regulatory framework for identifying sediment and nutrient standards for NS Streams

3.2.3 Submitted comments from Evaluation:

- I was concerned about statements by Dahl about sediment loading on the Nemadji being a normal rate and substantiating it with one old drawing. There have been studies on that watershed that concluded that historic logging caused channel incision which increased the rate of erosion on the channels, and field observations of erosion on straight reaches and presence of what appears to be relatively recent terraces suggest that erosion rates are not at the same rate as pre-settlement rates.

3.3 WHAT IS THE SIGNIFICANCE OF THIS TO OUR WORK ON STREAMS?

3.3.1 Responses from Breakout Session:

- When putting together research proposals it will be important to find out what other people are doing.
- WRAPS and all agencies working together since the legacy amendments.
- The suggestions for increasing collaboration on projects.
- With respect to the Nemadji there is more participation from the forestry community.
- The Knife River watershed work was a good example of collaboration between watershed interests and forestry work

3.3.2 Submitted Comments (from green sheets):

- Lack of funding for long term longitudinal studies
- Lack of funding for meta-analysis of the project outcomes

3.3.3 Submitted comments from Evaluation:

- People need to accept that turbidity and high sediment loads are indications of unstable streams. In many cases, the only approach to address this is through active stream restoration with the goal of creating a stable form.

3.4 WHAT WILL CHANGE FOR YOU BECAUSE OF WHAT YOU'VE HEARD?

3.4.1 Responses from Breakout Session:

- We need the presentations from this symposium to be available for future reference.
- There will be great interest in the vernal pools and buffer strips.
- Our future work on sediment/hydrology indices and their relationship to biological and other indices will be improved.
- We need biological sampling to be completed year after year to assess variability.
- The question to be answered, are biological communities resilient?
- Is the purpose of stream restoration more than working with brook trout?
- Funding sources are pointed towards specific problems.
- This symposium and others help to understand needs when requesting grant funding, use the term assessment rather than monitoring.
- I'm going to discuss this symposium with my supervisors, we need to develop priorities for work and use the information we have on how to expend funds.
- How will the engineers work on suspended sediment, we need a water resources conference on turbidity and need to link the science with engineering.
- We need to follow-up up on things that have been fixed with engineering.
- Federal requirements (NRCS) do not require monitoring. (EDITORS Note, NRCS does require an operation and maintenance plan be developed and implemented with the project owner), EPA, or state does or should.
- The infrastructure for academia is not there to do long term monitoring, agencies do have the infrastructure.
- To complete long term monitoring you need a core of people in place, temporary workers and students do not provide this.
- People need to be on staff for a long enough period to collect information and currently they have full time jobs but not a living wage.
- Hope we do additional (Stream Science) symposiums to offer a platform for people to keep up with what's happening. Regularly scheduled like the Estuary Science for the Saint Louis River.

3.4.2 Submitted Comments (from green sheets):

- none

3.4.3 Submitted comments from Evaluation:

- Nothing in this area.

4 BREAKOUT SESSION – LANDSCAPE HYDROLOGY

Opening question: What does "Landscape Hydrology" mean to you?
(Brief, < 1 minute brainstorming of ideas to frame discussion)

- Forestry practices & BMPs
- Ditching (control runoff)
- Stream crossings
- Levees (flood control projects)
- Hold water on the landscape ("Slow the Flow")

4.1 #1 WHAT IS ONE POINT YOU HEARD OR SAW DURING THE CONFERENCE THAT REALLY CAUGHT YOUR ATTENTION OR STOOD OUT FOR YOU THAT RELATES TO OUR BREAKOUT TOPIC?

4.1.1 Responses from Breakout Session:

- Surprised by the large number of small Ponds on the landscape, and how little groundwater\baseflow exists in the watershed
- # of impaired waters is greater than expected
- Disconcerted by climate change and the predicted increase in severity of storms
- Slope's effect on riparian buffers is interesting
- Forest management planning not incorporating hydrology
- Geologic context provides new perspective on present hydrology of Lake Superior
- Cumulative stressors data
- The importance of intermittently flooded areas during flow peaks (storage provided by seasonal pools)
- What is\should be target when restoring stream channels (pre-logging, for example?)
- Need\desire for more high-res data – it has so many valuable applications
- Lack of consistent setback requirements to mitigate thermal impact of land use changes - definitive buffer width studies needed
- Effects of remnant logging structures on stream channels
- Difference between north shore and south shore streams
- Geologic landscape changes

- LiDAR uses (There are so many!)
- Thermal suffering of north shore streams, temperature impacts on trout

4.1.2 Submitted Comments (from green sheets):

- none

4.1.3 Submitted comments from Evaluation:

- Concern over climate change affecting funding for projects.
- Perception that controlling hydrology will fix degraded streams. It is an effective prevention strategy and one that should be done, but if a channel is unstable, "slowing the flow" doesn't fix it by itself. But the message of some seemed to be that reducing hydrology alterations is the solution to degraded streams.

4.2 #2 What did you hear that surprised or inspired you? That made you struggle, or concerned you?

4.2.1 Responses from Breakout Session:

- Researcher says: "I'm glad I don't have to manage all the diverse factors presented, or have to make decisions on these issues!" Great that all this data is being collected and made available, however
- Overwhelmed by sheer volume of research - slightly dismayed by remaining number of unanswered questions
- How to set goals and measure success of restoration?
- How to understandably deliver all this information to citizens?
- Disappointed that all this hydrologic knowledge is ignored in forest management planning
- Need to market or "sell" conservation
- So much is beyond human control
- No standard, unified method for stream restoration
- Excited by amount of research
- Data\knowledge\insights need to be readily available
- Frustrating that political decisions are so frequently made independently of all this scientific knowledge

4.2.2 Submitted Comments (from green sheets):

- none

4.2.3 Submitted comments from Evaluation:

- The extreme reliance on GIS based evaluation and models with little or no field verification or empirical data collection. Models and GIS is a great first step for evaluating watersheds and prioritizing study sites, but stream

responses vary greatly, many impacts are legacy impacts that might not be revealed using current data, so there is a need to do field evaluations before a LGU can be given information on correct restoration approaches and prioritization.

4.3 #3 WHAT IS THE SIGNIFICANCE OF THIS TO OUR WORK ON STREAMS?

4.3.1 Responses from Breakout Session:

- Now that we're aware of how few and fragile the overall trout stream resources are, it's imperative to effectively manage the relatively limited miles of trout streams on north shore
- Need to differentiate between natural and human-induced variations – focus efforts on the right scale (avoid wasting time on big projects to fix small problems & vice a versa)
- Researchers often lack local knowledge – large studies conducted from remote facilities potentially miss important nuances that local resource managers are aware of
- Need reliable communication mechanisms to connect researchers with local experts & resource managers
- Tribes too often left out of communication networks
- Encourage access to distilled knowledge\research (scientific journals, literature review)
- Interpretation of all this research is difficult – what's useful, what's not?

4.3.2 Submitted Comments (from green sheets):

- none

4.3.3 Submitted comments from Evaluation:

- Forest harvest limits to prevent altering hydrology enough to cause channel instability is one of the best protection strategies available in forested region of state where many of the impacts of ag or high development densities are not a major factor.

4.4 #4 WHAT WILL CHANGE FOR YOU BECAUSE OF WHAT YOU'VE HEARD?

4.4.1 Responses from Breakout Session:

- Valuable personal connections have been made – increased network is great resource
- *Note:* MDA developed GIS tool for making landscape assessments at small scale – define critical source areas
- *Note:* DNR Watershed Health Assessment Framework tool available on DNR website

4.4.2 Submitted Comments (from green sheets):

- none

4.4.3 Submitted comments from Evaluation:

- May seek out incorporating more protection strategies for forest mgmt planning where available.

5 IN-STREAM HABITAT BREAKOUT

5.1 #1 WHAT IS ONE POINT YOU HEARD OR SAW DURING THE CONFERENCE THAT REALLY CAUGHT YOUR ATTENTION OR STOOD OUT FOR YOU THAT RELATES TO OUR BREAKOUT TOPIC?

5.1.1 Responses from Breakout Session:

- Is it right to spend billions of dollars on restoration without evidence of effectiveness?
- Some commonality between old and new restoration structures
- No universally accepted standard for in-stream work
- So many projects underway that communication is critical – could improve project effectiveness
- Safer to study than implement (second comment from the same person)
- The value of large wood to streams (could be used to create step-pool environment)
- How do we build things to last with increased rainfall, increased velocity?
- We need to take a systems approach to stream management. We need to set our goals broadly to recognize components of stream management
- There not a lot of talks on in-stream habitat. As a practicing stream restoration professional, it would be helpful to have some data on effectiveness.
- There is a huge disconnect between the researchers and on the ground work.
- It is hard to think that we are going to make progress given all the stressors, climate change included.
- There was not a lot of discussion on road crossings as it relates to road authorities and the potential to improve connectivity. Roads are discussed as barriers and stressors (follow up comment). We need to do more effectiveness monitoring (another comment).

5.1.2 Submitted Comments (from green sheets):

- none

5.1.3 Submitted comments from Evaluation:

- none

5.2 #2 WHAT DID YOU HEAR THAT SURPRISED OR INSPIRED YOU? THAT MADE YOU STRUGGLE, OR CONCERNED YOU?

5.2.1 Responses from Breakout Session:

- Lake managed for cold water brook trout and converted to warm water fishery – Grant Portage (seconded)
- Climate change and the tough decisions ahead
- Surprised that wetlands were not discussed more, particularly because of their role in watershed storage
- I was surprised that mining never came up (not even obliquely)
- Surprised by the talk of introducing non-native tree species, disconcerting given that it is hard to predict
- Cannot believe that climate change deniers are still out there – hard to argue with the science
- Surprised that there is not more information on stream habitat projects that are effective or not effective
- Stream habitat program at DNR does do effectiveness monitoring
- Some sources of funding are problematic – does not fund effectiveness work or is limited by the term of the grant or funding source (trees were discussed as an example – long term horizon)

5.2.2 Submitted Comments (from green sheets):

- none

5.2.3 Submitted comments from Evaluation:

- none

5.3 #3 WHAT IS THE SIGNIFICANCE OF THIS TO OUR WORK ON STREAMS?

5.3.1 Responses from Breakout Session:

- Need to link up with researchers who can do long term monitoring
- Combine goals (fragmented approaches)
- Disconcerting to see everyone doing their own thing (lack of communication)
- Fish Habitat Partnership – what can we do to improve collaboration for partners?
- Lots of good collaboration resulted from the conference itself (informal and formal). It stimulated ideas for other uses.
- Not familiar with the state watershed framework – subwatersheds were not necessarily connected well (example would be Cloquet). Is there anything goes to targeting actions (e.g., upland, stream restoration?)
- There are some processes that require fieldwork (stream geomorphology) to inform larger decisions about watershed management.
- Landscape vs. temperature impacts will drive adaptation strategies
- GIS has its limitations when it comes to describing historic habitat impacts – need field work

5.3.2 Submitted Comments (from green sheets):

- none

5.3.3 Submitted comments from Evaluation:

- none

5.4 #4 What will change for you because of what you've heard?

5.4.1 Responses from Breakout Session:

- It will help in identifying who to reach out to on particular issues
- Valuable information sources – web sites
- Look at alternatives to natural channel design – if they exist
- Climate change might influence everything we do

5.4.2 Submitted Comments (from green sheets):

- none

5.4.3 Submitted comments from Evaluation:

- none

6 Water Temperature Breakout

6.1 #1 What is one point you heard or saw during the conference that really caught your attention or stood out for you that relates to our breakout topic?

6.1.1 Responses from Breakout Session:

- Northshore streams empty out fast – warm quickly rocks warm water runoff – Interested in what can be done for shade? Use of rocks or CWD?
- Seth Moore's presentation on writing off cold water species in certain lakes
- Sensitivity of fish to different ranges (Deserae)
- Areas we will potentially loose trout – where to prioritize for future 2060's
- Protect woody wetlands for baseflow
- exposure times – how long for lethal range – duration, oxygen availability, threshold temperature
- Isotopic study for temperature impacts related to resident time and rain source
- Temperature flow relationships – cook county more baseflow - due to forest practices
- Fish species transition due to limitations
- Fish tolerance to temps.
- Overall loss of habitat in N shore region- how to prioritize work

- Duration to lethal limits/ do availability
- 75'F seth/ 78'F
- Climate change- increase flows importance

6.1.2 Submitted Comments (from green sheets):

- none

6.1.3 Submitted comments from Evaluation:

- none

6.2 #2 WHAT DID YOU HEAR THAT SURPRISED OR INSPIRED YOU? THAT MADE YOU STRUGGLE, OR CONCERNED YOU?

6.2.1 Responses from Breakout Session:

- How can we improve baseflow situation – adjacent riparian wetlands increase?
- Analysis of relationship of wetlands (riparian) connection to streams – quantity and flow
- NS streams not much baseflow little ability to hold water
- What flow criteria to use time, timing, duration etc
- What % of presettlement wetlands do we have need more info n wetland to guide restoration
- Black Ash are woody wetlands – What about Emerald ash borer
- Surprised by Lucinda's results in orange – large area – where to apply BMPs targets? – what about shading?
- Streams with bedrock mitigation limited vs watershed with woody wetlands more options
- very few fish monitoring sites with temperature monitoring sites – need a lot more thermistor sites – may not have used DNR data – need to confirm
- Collaboration on stream and fish data management and sharing
- Temperature varies with reaches in a single stream watershed
- Baseflow question w/ relation to
- Stream connectivity w/ baseflow contributions

6.2.2 Submitted Comments (from green sheets):

- none

6.2.3 Submitted comments from Evaluation:

- none

6.3 #3 WHAT IS THE SIGNIFICANCE OF THIS TO OUR WORK ON STREAMS?

6.3.1 Responses from Breakout Session:

- Changed "my" idea of what greatest concern is maybe not turbidity but temperature instead
- Impacts of beaver – isotope works to determine if we get baseflow benefit or temperature impairment – need research to determine – very important research need – what about fish migration
- Woody wetlands beneficial – if we remove beaver can we restore to woody wetlands?
- What is the natural succession of abandoned beaver dam meadows?

6.3.2 Submitted Comments (from green sheets):

- none

6.3.3 Submitted comments from Evaluation:

- none

6.4 #4 WHAT WILL CHANGE FOR YOU BECAUSE OF WHAT YOU'VE HEARD?

6.4.1 Responses from Breakout Session:

- Climate modeling will affect where we invest or recommend investing in management practices
- Work on bmp to protect best baseflow and temperature
- Focus, prioritize watersheds to research
- Focus on protection where we have best chance of survival
- Cannot forget impairments
- Focus on forest landscape change
- Hydrologist participate with foresters for future management
- Should we manage forests for different species?
- Manage for resilience
- stormwater management for temperature – BMPs
- Urban forest management

6.4.2 Submitted Comments (from green sheets):

- none

6.4.3 Submitted comments from Evaluation:

- none

7 RIPARIAN HABITAT BREAKOUT

7.1 #1 WHAT IS ONE POINT YOU HEARD OR SAW DURING THE CONFERENCE THAT REALLY CAUGHT YOUR ATTENTION OR STOOD OUT FOR YOU THAT RELATES TO OUR BREAKOUT TOPIC?

7.1.1 Responses from Breakout Session:

- Riparian fixed width buffers and questions about that
- Importance of coarse woody habitat
- Timber cruising potential of missing vernal ponds
- Stream restoration and differences of opinion in the practice of it
- Warmer climate species planting and litter fall
- Coarse woody habitat – stop removing it
- Vernal pool buffers and their importance
- LIDAR usage in young forest and how to plan timber harvest
- Changing stream temperatures and riparian impact
- Better mapping of vegetation by LIDAR
- Allowing forest to mature in the buffer zone
- Lack of wetland integration in talks
- Fixed width buffer doesn't tell the story
- Lack of buffers on intermittent streams – no discussion
- Background on logging
- Lack of wetland integration discussion
- Lack of mining discussion
- Importance of open space in runoff in sub watersheds
- Riparian Habitat
- Sharing info and results
- Case studies were interesting
- Reference "Deposit"
- Efficacy of approaches
- Evaluation of success/res.
- Economic tradeoffs of different management options
- Practical Approaches – CC
- Research
- Headwater catchments are important measuring tools
- The fixed width buffer discussion needs better context
- Perceptions/value of buffers
- Stream crossings create "pinch points" within habitat
- Integration/synthesis, not silos of res. + info.
- (looking back, across disciplines, across media) Res. Vs. manage)
- Parameters of acceptable health

- End goals (more than 1)
- Monitoring to evaluate
- Stream crossings
- Address/integrate data for multiple tools (culverts, LIDAR, etc.)
- $$ vs best design. (good strategy plans help encourage $$$)
- Connectivity – broader view quantify
- Connect climate change to biologic connections
- Need discussion invasive species in the riparian corridor
- Habitat focus rather than individual species approach

7.1.2 Submitted Comments (from green sheets):

- All aquatic and wetland habitats deserve consideration protection
- Are fixed riparian buffers that important quantify quality impacts
- Significance of seasonal ponds and linkages with riparian habitats

7.1.3 Submitted comments from Evaluation:

- None

7.2 #2 What did you hear that surprised or inspired you? That made you struggle, or concerned you?

7.2.1 Responses from Breakout Session:

- Reports on progress
- Case studies
- Want reference list from all the presenters
- Lack of assessment of projects
- How do we determine if there is a good use of funding?
- Good to hear economic analysis
- Surprised to not hear more about social vs. extractive values
- Why no "what to do" to deal with climate change?
- Headwater streams, not well protected, need more info, research
- Feels like criticism for short term impact vs. long term goal when working in the R-Corridor
- Hard to talk about long lived conifer restoration
- Public perception of buffer zones
- Riparian zones are not just a buffer they are an important ecosystem type
- Need discussion on the connectivity of the corridors
- Stream crossings as pinch points for wood transport vs. water vs. fish passage
- We should plan for the "100 year tree" vs. the 100 year flood

7.2.2 Submitted Comments (from green sheets):

- Disagreement and lack of understanding on assessment/techniques/success

- Too much old forest will result in future catastrophic event- blow-down, fire
- Lack of information available for impacts of riparian buffers on headwater/intermittent streams and their functioning
- Inspirational- this entire meeting need to continue holding this meeting if possible

7.2.3 Submitted comments from Evaluation:

- none

7.3 #3 What is the significance of this to our work on streams?

7.3.1 Responses from Breakout Session:

- Excited to deal with connectivity
- Share Data Sets
- Share information
- Integration of disciplines
- Working on informational flow from research to management
- Importance of that communication for riparian specifically
- Establish stream health parameters, then test buffers. What are those? Ecosystem services
- Can alder be used in the corridor as an appropriate species to manage for?
- What about catastrophic wind and fire events
- Digital dams on LIDAR, how to deal with them for watershed modeling
- Budget concerns to do evaluation, implement solutions
- Good strategic plans are needed to prioritize implementations
- Need to work on other connectivity
- Wetland, Biological, Groundwater
- How do we quantify that? Insects, Fish, Biomass Flow
- Migration needs for climate change via riparian corridors
- Lack of invasive discussion overall
- Use more riparian plant discussion, emergent, submerged

7.3.2 Submitted Comments (from green sheets):

- A good step to continued research and discussions

7.3.3 Submitted comments from Evaluation:

- none

7.4 #4 What will change for you because of what you've heard?

7.4.1 Responses from Breakout Session:

- New connections –we will share new knowledge
- Cooperate across entities more (leverage, partnerships)

- Communication fosters results (connect connectivity clubs)
- Full watersheds need to be managed – don't stop at political boundary
- Data event slam would be great for researchers
- Monitoring and evaluation are hard to fund

7.4.2 Submitted Comments (from green sheets):

- Help focus on specific projects and collaboration
- Made many new contacts with collaborators and partners

7.4.3 Submitted comments from Evaluation:

- none

Symposium Attendees

1

Last Name	First Name	Job Title	Company
Widner	Neva	Water Resources Coordinator	Carlton SWCD
Schutte	Dan	District Manager	Lake SWCD
Thompson	Ann	Conservation Specialist	Lake SWCD
Dalen	Karola	Water Planner	Carlton County
Jaschke	John	Executive Director	Board of Water & Soil Resources
Fleming	Jennifer	Environmental Engineer	Barr Engineering Company
Foster	Inga	Environmental Project Manager	St. Louis County Public Works
Koller	Karl	Regional CleanwaterLegacy Specialist	DNR -EWR
Johnson	Lucinda	Interim Director	NRRI, UMD
Hughes	Ryan	Board Conservationist	Board of Water and Soil Resources
Chisholm	Ian	Natural Resources Program Supervisor	Minnesota DNR
Babeu	Lecia	River Ecologist	MN DNR
Axler	Rich	Sr Research Associate	NRRI - UMD
Ruzycki	Elaine	Research Fellow	UN-Duluth/NRRI
Harris	Michael	Clean Water Legacy Watershed Specialist	MN DNR
Eggert	Sue	Aquatic Ecologist	USDA FS - Northern Research Station
Mohar	Dave	Hydraulics Engineer	MN Dept of Transportation
Bergstrand	Jon		MN Dept of Transportation
Micke	Shelly		MN Dept of Transportation
Anderson	Jesse		MPCA
Meier	Gary	Cold Water Coordinator	McCabe Chapter Izaak Walton League
Fitzpatrick	Faith	Research Hydrologist	U.S. Geological Survey
Gran	Karen	Associate Professor	University of Minnesota Duluth
Wick	Molly		University of Minnesota Duluth
Targos	Courtney		University of Minnesota Duluth
Hansen	Brad	Senior Scientist	Bioproducts/ Biosystems Department UM
Henneck	Jerry		NRRI/UMN
Merten	Eric		Wartburg College
Bethke	Bethany	Fisheries Research Biologist	Minnesota DNR
Sandberg	John		Minnesota Pollution Control Agency
Mielke	Nathan		Minnesota Pollution Control Agency
lavigne	clifford	Clean Water Legacy Watershed Specialist	MNDNR
Hanson	Keith	Vice President - NPDES Senior Consultant	Barr Engineering
Jasperson	Jeff		MPCA
Pagel	Craig		Iron Mining Assoc.
Kohlhase	Katy		Iron Mining Assoc.
Handler	Stephen	Climate Change Specialist	US Forest Service
Andrews	Carol	Sr. Environmental Engineer	Barr Engineering
Bomier	Will	Area Resource Conservationist	USDA / NRCS
Collins	Patrick	Regional Manager	Department of Natural Resources
Seilheimer	Titus	Fisheries Specialist	Wisconsin Sea Grant
Johnson	Kaitlin		University of Minnesota Duluth
Westerbur	Amber		Minnesota's Lake Superior Coastal Program
Little	Clint		Minnesota's Lake Superior Coastal Program
McDonnell	Julie		Minnesota's Lake Superior Coastal Program
Fedora	Mark	Hydrologist	USFS - Ottawa NF
Armbruster	Todd	Natural Resources Scientist	SEH
Olson	Jessica	Water Resources Engineer	Barr Engineering
Jones	Perry	Hydrologist	U.S. Geological Survey
Hrubes	Jeff	Clean Water Specialist	MN Board of Water & Soil Resources
Rye	Marty	Forest Hydrologist	Superior National Forest
Shedd	Mary	Natural Resources Team Leader	Superior National Forest
Halter	Brenda	Forest Supervisor	Superior National Forest
Butcher	Jason	Aquatic Ecologist	Supterior National Forest
Creighton	Emily	Hydrologist	Superior National Forest
Wilfahrt	Amy	Biologist - Water Resources	Superior National Forest
Eichman	Henry	Economist	USFS - Teams Enterprise Unit

Attendeellist.xls

Blankenheim	Josh		MN DNR
Radomski	Paul		MN DNR
Hendrickson	Deserae	Duluth Area Fisheries Supervisor	MN DNR
Magner	Joe	Research Professor	University of Minnesota
Varian	Anna	Fisheries Biologist	U.S. Fish & Wildlife Service
Fowler	Patricia	Area Hydrologist	Minnesota DNR - EWR
Peterson	Nick	Fisheries Specialist	Minnesota DNR
Cai	Meijun		NRRI, UMD
Garono	Ralph		UM-D
Hagley	Cindy	Environmental Quality Extension Educator	University of Minnesota Sea Grant
Wheeler	Michele	Fisheries Biologist	U.S. Fish & Wildlife Service
Gunderson	Jeff	Director	University of Minnesota Sea Grant Program
Sorensen	Hilarie	Climate Change Educator	University of Minnesota Sea Grant Program
Brady	Valerie J	Aquatic Ecologist	NRRI UMD
Dumke	Josh	Aquatic Scientist	NRRI UMD
Hell	Bob	Research assistant	NRRI UMD
Erickson	Jeremy	Aquatic Scientist	NRRI UMD
Wellard Kelly	Holly		NRRI UMD
Thompson	Molly	Executive Director	Sugarloaf: The North Shore St. Assoc.
Scomberg	Jesse	Extension Educator	University of MN Sea Grant Program
Nieber	John	Professor	University of Minnesota
Lenczewski	John	Executive Director	Minnesota Trout Unlimited
Lee	Jeffrey	Ecologist	Barr Engineering
Kilgore	Susan	Physical Scientist	Grand Portage Reservation Tribal Council
Erickson	Gary	Region Manager Wood Fiber And Fuel Procure	Sappi Fine Paper NA
Fredrickson	Brian	Water Resources Planner	MPCA
Evens	Karen R	Watershed Project Manager	MN Pollution Control Agency
Stutzman	Kirstin	Hydrologist	Mn DNR
Passe	Derrick	Project Coordinator	Lake County SWCD
Billotta	John	Water Resources Extension Educator	University of Minnesota Sea Grant Program
Jasperson	Jenny	Watershed Unit	MPCA
herr	erika	area hydrologist	MNDNR
Loiselle	Amy	Area Hydrologist	MN / DNR / EWR
Schaub	Tom	Hydrologist	MPCA
Jereczek	John		MN-DNR
Hess	Jonathan	Graduate student	UMD NRRI
ongaro	dave	student	UMD/NRRI - Integrated Biosciences
Host	George	Senior Research Associate	Natural Resources Research Institute,UMD
Carey	Pat	Regional Watershed Supervisor	Mn Pollution Control Agency
Peloquin	Mike	NE Asst. Regional Manager	MNDNR Ecological/Water Resources
Blann	Kristen	Freshwater Ecologist	The Nature Conservancy
Schroeder	Nate	Environmental Engineer	Northshore Mining
Kramka	Larry		Houston Engineering, Inc.
Kleist	Chris	Program Coordinator	City of Duluth
Carlson	Todd	Program Coordinator	City of Duluth
Johnson	Tom	Project Engineer	City of Duluth
Pfeffer	Tom	Project Engineer	City of Duluth
Brown	Terry	Research Associate	UMN/NRRI
Edgerton	Angelique	Invasive Species Coordinator	Cook County Invasives Team
Galdonik	Patrick	Senior Procurement Forester	Sappi Fine Paper
Pessenda	Joseph	Retired	None
Hanson	Suzanne	Watershed Manager	Minnesota Pollution Control Agency
Reeves	Keith	Assistant Area Fisheries Supervisor	MN DNR
Tillma	Jeff	Fisheries specialist	Minnesota DNR
Kubiak	Kate	Conservation Specialist	South St Louis SWCD
O'Hara	Timothy J	Vice President of Forest Policy	Minnesota Forest Industries
Anderson	Robert	Environmental Engineer	Sappi
Melchior	Marty		Inter-Fluve

Attendeellist.xls

Meyer	Jason	Area Land Manager	St. Louis County Land & Minerals Dept
Pannkuk	Mark	Forester III	St. Louis County Land & Minerals Dept
Boheim	R.C.	Manager	South St. Louis SWCD
Olker	Jennifer		Natural Resources Research Institute,UMD
Westerlund	Julie	Clean Water Coordinator	MN DNR
Kaspar	Tyler	Environmental Specialist	1854 Treaty Authority
Niemi	Gerald	Professor	NRRI/U of Minnesota-Duluth
Proulx	Nick	Clean Water Specialist	Minnesota DNR
Bathke	Jill	Natural Resources Scientist	Minnesota Center for Env. Advocacy
Ledder	Tracey	Monitoring Coordinator	Lake Superior NERR
Granley	Mindy	Sustainability Coordinator	UMD Facilities Management
Goettel	Michael		Independent
Bartsch	Will	ORISE Fellow	EPA
Vogt	Darren	environmental director	1854 Treaty Authority
Mitchell	Don		LSSA and TU
Neitzel	Grant		University of Minnesota Duluth
Birkemeier	Ryan		University of Minnesota
Babeu	Leo	Member, Board Chair	Advocates for the Knife River Watershed
Stark	Jim	Center Director	USGS- Minnesota
Streitz	Andrew	Research Scientist	MN Pollution Control Agency
HOLLENHOR	TOM		US EPA
HILL	BRIAN		US EPA
Story	Brittany	Project Manager	Minnesota Pollution Control Agency
Young	Mike	Area Forestry Supervisor	MN DNR Forestry
George	Tara	Environmental Scientist, Great Lakes	Ontario Ministry of the Environment
McChristie	Michelle	Great Lakes Advisor	Ministry of the Environment
Lee	Jeffrey	Plant Ecologist / Botanist	Minnesota Biological Survey / DNR
Kiesling	Richard	Hydrologist	USGS
Dusek	Jim	Area Engineer	USDA / NRCS
Wilson	Greg		Barr Engineering Company
Johnson	Greg	Hydrologist	Minnesota Pollution Control Agency
Kennedy	Michael	project manager	MPCA
Sprague	Tiffany	Graduate Student	Natural Resources Research Institute
Bentley	Cliff	Area Hydrologist	MN DNR
White	Mark	Forest Ecologist	The Nature Conservancy
Bovee	Kevin J.		LSSA
Goutermont	Phil	Supervisor	Lake County SWCD
Thompson	Jo	Planning and Zoning	Duluth Township
Vannatta	Trevor	Teaching Assistant	UMD
Minchak	Martha J	Assistant Area Wildlife Manager	MN DNR - Wildlife
Weaver	Thomas	Supervisory Hydrologist	U.S. Geological Survey
Kuiti	Scott	VP / Grant Manager	Lake Superior Steelhead Association

TAYLOR	DEBRA		US EPA
Bathke	John		Encampment Forest Association
Wilson	Craig	President	Lake Superior Steelhead Association
VanNingen	AmberBeth	Ecologist	MN DNR
alvar	sam		Seaquest Productions
Ziegeweid	Jeffrey	Hydrologist	USGS MN Water Science Center
Herb	William	Research Associate	University of Minnesota
Wherley	Patrick	Forester	Dept. of Natural Resources
Slater	Robert	Asst. Area Forestry Supervisor	Dept. of Natural Resources
Ferrington Jr.	Leonard C.	Professor	University of Minnesota
Kesner	Shannon	Wetland Specialist	Fond du Lac Environmental Program
Johnson	Forrest	Stewart River Watershed Project Coord.	Trout Unlimited
Hueffmeier	Ryan	Jr. Scientist	NRRI
Reschke	Carol		UMD - NRRI
Luedtke	Rebekah		MNDNR Forestry
Dusek	Siri		Student
Haensel	Carl	Northern MN Vice Chair	Minnesota Trout Unlimited
Craig	Neal	Hydrologic Technician	USGS
Anderson	Keith	Engineer	SWCD Northeast Technical Svcs.
Schuldt	Nancy	Water Projects Coordinator	Fond du Lac Reservation
Stroom	Kevin	Aquatic Ecologist	Minnestota Pollution Control Agency
Carlson	Bruce	Regional Plant Ecologist	MN Dept of Natural Resources
Jacobson Hec	Kari	Watershed Specialist	Fond du Lac Reservation
Crotteau	Michael J.	Mining Hydrologist	MDNR
Palik	Brian	Research Ecologist	USDA Forest Service
Hemmila	Matthew	Bridge Superintendent	St. Louis County Public Works
Robertson	Lance	Project Supervisor	St. Louis County Public Works
Johnson	Lee	Archeologist	Superior National Forest
Sellner	Linda	Public Utilities Commission	City of Duluth
Eliot	Amy	Assistant Scientist	UWS Lake Superior Research Institute
Hanson	Adrian	Dept Head/Prof	Civil Eng Univ Minn Duluth

Symposium Planning Committee: Minnesota Department of Natural Resources, University of Minnesota Sea Grant, UMD Natural Resources Research Institute, Minnesota Pollution Control Agency, US Forest Service, US Environmental Protection Agency, Lake Superior Coldwater Coalition, Minnesota Trout Unlimited, and Laurentian Resource Conservation and Development Council

Sponsored in part by: MN Trout Unlimited, Lake Superior Steelhead Association, The Nature Conservancy, and the McCabe Chapter Izaak Walton League of America

This Symposium is funded in part by the Coastal Zone Management Act of 1972, as amended, by the NOAA's Office of Ocean and Coastal Resources Management, in conjunction with Minnesota's Lake Superior Coastal Program.

"The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of NOAA's Office of Ocean and Coastal Resource Management, Minnesota Department of Natural Resources or Minnesota's Lake Superior Coastal Program."