13th Annual

International Rainy-Lake of the Woods Watershed Forum

March 9 - 10, 2016

Rainy River Community College

International Falls, Minnesota, USA

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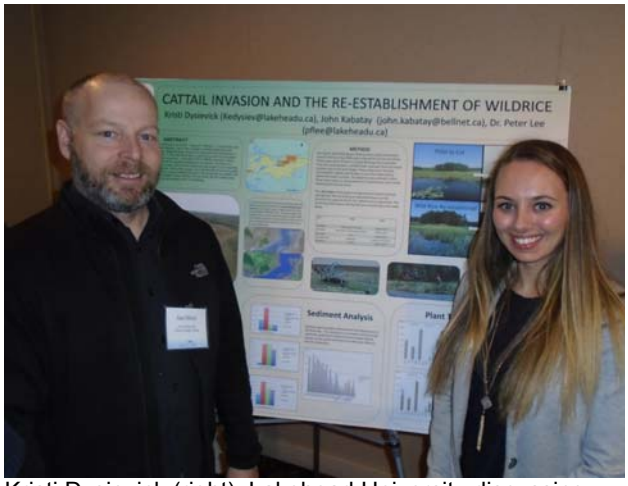
Executive Summary

The 13th annual International Rainy-Lake of the Woods Watershed Forum (the Forum) was held on March 9-10th at the Rainy River Community College in International Falls, Minnesota. This year, a record 160 researchers, resource managers, and policy makers attended the Forum. Participants reflect a broad range of interests and involvement in the watershed, including representation from agencies of local governments, soil and water conservation districts, provincial and state governments, federal governments, US Tribes, Canadian First Nations, industry and non-governmental organizations – all with the common connection of working on water or water-related issues in this binational watershed.

A record 160 attended the 2016 International Rainy-Lake of the Woods Watershed Forum

The Forum is the only professional symposium for scientists and resource managers working on research and management activities related to the Rainy-Lake of the Woods watershed. The Forum's ecosystem focus welcomes presentations from all disciplines relevant to water quality and aquatic ecology in the watershed and, this year, in particular, played host to a number of ancillary meetings and workshops that both broadened the audience and broadened the scope of topics. The Forum is organized and hosted by a partnership of agencies led by the Lake of the Woods Water Sustainability Foundation.

This year's Forum featured a one and a half day symposium and an evening poster session, together totalling 34 presentations. Research topics covered a wide range of disciplines including studies on cyanobacteria and algal toxins, flora and fauna, climate change, remote sensing, monitoring and modelling. One session was dedicated to an introduction of the new Rainy-Namakan Lakes Rule Curves Study initiated in August of 2015 and some initial, preliminary modelling results. The 2016 Forum also featured a special issues session entitled "Climate 2050" with keynote speakers Dr. Brian Cumming discussing recent and long-term climate change in Northwestern Ontario and Drs. Richard Kiesling and Erick Smith on the use of predictive modelling to assess lake ecosystem responses to stressor gradients. The International Joint Commission (IJC) provided an update on contributions being made by its Board, committees and the local stakeholders to binational water management and applauded the partnerships that have developed across the border. The International Multi-Agency Arrangement (IMA) presented an update on its activities during 2015 and indicated the importance of the Lake of the Woods Water Quality Plan of Study approval to ongoing work of the IMA.



Kristi Dysievick (right), Lakehead University discussing her research on cattail invasion and re-establishment of wild rice at poster session, with Jean Morin, Environment Canada (left).

Over the years, the Forum has become well known as the venue to hold meetings when many of the key players in the basin are already gathering. This year, several ancillary meetings were held just before and just following the forum, including:

- Meetings of the International Multi-Agency Arrangement Working Group and its Technical Advisory Committee;
- IJC Rainy-Namakan Lakes Rule Curves Study Board meeting with its Public Advisory Committee and first Practice Decision Workshop;
- IJC International Rainy-Lake of the Woods Watershed Board Water Levels Committee and Rainy-Namakan Lakes Rule Curve Review Public Meeting;

- Minnesota's Lake of the Woods Total Maximum Daily Load Technical Advisory Committee;
- IJC's Rainy Lake of the Woods Watershed Board Community Advisory Group
- IJC's Rainy-Lake of the Woods Watershed Board Industry Advisory Group
- IJC's International Watersheds Initiative Stressor Index Project
- Heart of the Continent Science Symposium and Poster Session

Leveraging the Forum as an opportunity for face-to-face meetings is extremely important, given the vast size of the watershed, the number of researchers collaborating "at distance", and the limited funds available in many agencies for travel.

The Foundation reception and poster session on the evening of March 9th once again provided a collegial atmosphere to review the day's work, discuss the research poster presentations and develop professional networks. The reception was opened with welcoming comments from Commissioner Richard Morgan, IJC – Canadian Section. Commissioner Morgan recognized the synergies, engagement, enthusiasm, and the incredible degree of public involvement that, in many ways, make the Rainy-Lake of the Woods "the model" for jointly managing our shared transboundary waters. Commissioner Morgan paid tribute to the Forum, its organizing committee and the Foundation for creating a tremendously successful event that has become the single "must attend" forum for everyone working in the basin – including the IJC that "tags" on many of its meetings to the Forum. He also noted key milestone achievements in the basin, in part the result of the synergies and collaborations incubated by the Forum, including the establishment of the International Multi-Agency Working Arrangement, the Canada-USA reference to the IJC on governance, the establishment of the Rainy-Lake of the Woods Watershed Board and now the development of the Lake of the Woods Water Quality Plan of Study. In concluding his remarks, Commissioner Morgan expressed special thanks on behalf of the IJC, to the officials of American and Canadian federal, provincial, state, and local agencies that provide guidance and support to the IJC.

Commissioner Richard Morgan, IJC Canada-Section addresses audience at the Foundation reception and poster session.

The audience then had the pleasure of hearing from Brian Shipley, Consul and Head, Foreign Policy and Diplomacy, Consulate General of Canada, Global Affairs Canada out of Minneapolis, MN. Mr. Shipley expressed the importance of the binational work occurring in this basin and he emphasized the need to continue to build and maintain strong partnerships to move this important work forward.

The Forum Committee recognized the great breadth of work done by Mr. Steve Heiskary of the Minnesota Pollution Control Agency over the past 30+ years. With his upcoming retirement, it was good timing to recognize his contributions to the advancement of nutrient science and policy in the basin. Mr. Heiskary reflected on the advancements he has seen in science and policy but also the changes he has also monitored on lakes in the region, especially with regard to toxic algae.

This year's Kallemeyn Award was presented to Ryan Maki, Aquatic Ecologist of Voyageurs National Park in recognition of his outstanding professional achievements and contributions to research and resource management in the Rainy-Lake of the Woods Watershed.

2016 Kallemeyn Award recipient Ryan Maki (centre) with previous award recipients Darryl McLeod (OMNRF), Andrew Paterson (OMOECC), Ken Beaty (DFO-ELA retired), Larry Kallemeyn (Voyageurs National Park-USGS retired), Nolan Baratono (MPCA retired), Lee Grim (Voyageurs National Park retired). Missing from picture: Tom Mosindy OMNRF retired, Bev Clark OMOECC-

The Wilson Stewardship Award was presented to Todd Sellers, Executive Director of the Lake of the Woods Water Sustainability Foundation. This award recognizes the outstanding achievements of individuals, groups, or projects that have made a significant contribution to environmental stewardship in the Rainy-Lake of the Woods watershed. All agreed both were very deserving recipients. Special thanks to Bev Clark (retired scientist from the Ontario Ministry of Environment and Climate Change) for the paintings and carving that served as congratulatory gifts for Mr. Heiskary, Mr. Maki and Mr. Sellers.

The 13th annual Rainy-Lake of the Woods Watershed Forum was a tremendous success and many thanks go out to the strong collective of sponsors that make this Forum happen each year – it could not happen without their support. This event saw record attendance – 160 participants – more than double the participation historically. Sustaining, and growing, this event for over a decade and relying on the volunteer researchers and resource managers who help to organize it speaks volumes to the passion and commitment of the professionals working in the Rainy-Lake of the Woods watershed. It also is indicative of the value that is consistently placed on the Forum itself as a meeting place and venue for incubating research and international collaboration in our watershed. As with every year, special thanks are due to all who have helped organize and run the Forum over the years and to making this one the largest yet.

Program At A Glance

MARCH 9 – 12:00 PM

12:00 Kick off Lunch

13:00 Session 1: Bi-National Updates – Moderator Todd Sellers

1. **Welcome & Introductions**
2. **International Joint Commission update.**
   IJC. International Joint Commission, Canada-Section
3. **International Rainy-Lake of the Woods Watershed Board update.**
   Gail Faveri. International Rainy-Lake of the Woods Watershed Board
4. **International Multi-Agency Working Agreement (IMA) update.**
   TBD. IMA Working Group member

13:40 Session 2: Cyanobacteria & Algal Toxins – Moderator Andrew Paterson

5. **Harmful algal blooms in Minnesota: A review of recent incidents, research findings, and questions that need to be answered.**
   Steve Heiskary[1] and Jesse Anderson[2]. Minnesota Pollution Control Agency ([1]St. Paul; [2]Duluth)
6. **Understanding cyanobacterial toxins…we've come a long way.**
   Brian Kotak[1], Susan Watson[2] and Hedy Kling[3]. [1]Miette Environmental Consulting Inc.; [2]Environment and Climate Change Canada; [3]Algal Taxonomy and Ecology Inc.
7. **Using molecular tools to understand and predict cyanobacterial harmful algal bloom toxicity in Kabetogama Lake, Voyageurs National Park, Minnesota.**
   Erin A. Stelzer[1], Victoria G. Christensen[2], Donna S. Francy[3], and Ryan P. Maki[4]. [1]USGS Ohio Microbiology Laboratory, [2]USGS Minnesota Water Science Center, [3]USGS Ohio Microbiology Laboratory, [4]Voyageurs National Park
8. **Developing a spectral inference model to measure trends in cyanobacterial pigments in lake sediments.**
   Hadley, K.R.[1, 2], Paterson, A.M.[3], Michelutti, N.[2], Karst-Riddoch, T.[1], Watson, S.B.[4], Gregory-Eaves, I.[5], Zastepa, A.[4], Smol, J.P.[2], and Hutchinson, N.[1]. [1] Hutchinson Environmental Sciences Ltd., Kitchener, ON; [2] Paleoecological Environmental Assessment and Research Laboratory, Queen's University, Kingston, ON; [3] Ontario Ministry of the Environment and Climate Change, Dorset Environmental Science Centre, Dorset, ON; [4] Watershed Hydrology and Ecology Research Division, Environment Canada, Burlington, ON, Canada; [5] Department of Biology, McGill University, Montreal, QC, Canada, H3A 1B1.

15:00 Break

15:30 Session 3: Flora and Fauna – Moderator Nolan Baratono

9. **Cattails effect on nutrients within the sediment.**
   Kristi Dysievick[1], Peter Ferguson Lee[1] and John Kabatay[2]. [1]Department of Biology, Lakehead University; [2]Seine River First Nation
10. **Solving rice's future now!.**
    Peter Ferguson Lee[1] and John Kabatay[2]. [1]Department of Biology, Lakehead University; [2]Seine River First Nation
11. **Influences of water depth on wild rice (*Zizania* sp.) growth, development, and density.**
    O'Niell Tedrow[1], Peter Ferguson Lee[1], Kristi Dysievick[1], and John Kabatay[2]. [1]Department of Biology, Lakehead University; [2]Seine River First Nation
12. **Rainy River-headwaters monitoring and assessment.**
    Nathan Mielke. Minnesota Pollution Control Agency, Baxter, MN
13. **The influence of the pelagic prey community on the life history variation of northern pike (*Esox lucius*) in the Canadian boreal shield.**
    P.J. Kennedy[1] and Michael D. Rennie[1,2,3]. [1]University of Manitoba, Winnipeg; [2], Lakehead University, Thunder Bay, ON; [3]IISD-Experimental Lakes Area, Suite 325, 111 Lombard Avenue, Winnipeg Manitoba, Canada R3B 0T4

17:10 Break (poster display set up and migration to AmericInn)

18:00 – 21:00 Foundation Reception & Poster Session (AmericInn) – See Over

MARCH 9 – EVENING

18:00 – 21:00 FOUNDATION RECEPTION & POSTER SESSION (AMERICINN)

Guest Speaker – TBA

- **Kallemeyn Award Presentation**
- **Wilson Award Presentation**

Posters

a. Cattail invasion and the re-establishment of wild rice.
John Kabatay[1], Kristi Dysievick[2], Dr. Peter Lee[2].
[1]Seine River First Nation; [2]Department of Biology, Lakehead University.

b. A multi-disciplinary examination of the effects of climate change in the d*eciduous-boreal forest* ecotone of northern Minnesota and northwestern Ontario.
N. Baratono[1], A. Paterson[2], K. Rühland[3], M. Edlund, L. Frelich, W. Herb, P. Jacobson, T. McDaniel, S. Malick, T. Pascoe, E. Reavie, M. Seeley and S. Windels.
[1] Minnesota Pollution Control Agency (retired), International Falls, MN, USA; [2] Ontario Ministry of the Environment and Climate Change, Dorset Environmental Science Centre, Dorset, ON, Canada; [3] Paleoecological Environmental Assessment and Research Laboratory, Department of Biology, Queen's University, Kingston, ON, Canada.

c. Results of the Seine River Temperature Project
Ryan Haines.
Seine River First Nation

d. Multivariable Control of Lake Levels and Stream Flows in the Namakan Reservoir/Rainy Lake Watershed
Jeffrey C. Kantor.
Department of Chemical and Biomolecular Engineering, University of Notre Dame

e. Restoration of Hybrid Cattail Dominated Wetlands in Voyageurs National Park
Bryce T. Olson & Steve K. Windels.
National Park Service Voyageurs National Park, International Falls, MN

f. Developing a stressor-response model for Red River of the north
Tony Miller[1] and Julie Blackburn[2].
[1]RESPEC, Lexington, KY; [2]RESPEC, Roseville, MN

g. Mine-Impacted-Water Threats from the St Louis River Watershed to the Lake of the Woods
Tom Myers.
Hydrologic Consultant, Reno NV

MARCH 10

08:00 Welcome & Introductions

08:10 Session 4: Climate 2050 – Moderator Brian Kotak

14. **Keynote - Recent and long-term climate change in northwest Ontario: assessment of past changes from lake sediments.**
Brian Cumming. Paleoecological Environmental Assessment & Research Lab Queens' University, Kingston ON

15. **Keynote – Using predictive modeling to assess lake ecosystem responses to stressor gradients**
Richard Kiesling and Erik Smith. Minnesota Water Science Center, U.S. Geological Survey

09:30 – 10:00 Break

16. **The effects of climate change on small boreal lakes of the Canadian Shield**.
Scott N. Higgins, P. Blanchfield, C. Emmerton, M. Guzzo, M. Paterson, M. Rennie, and Ken Sandilands. IISD Experimental Lakes Area, Winnipeg MB

17. **High-frequency monitoring of stratification and sediment re-suspension in Lake of the Woods**.
Heathcote, A.J.[1], Edlund, M.B.[1], Engstrom, D.R.[1], Hernandez, C.[2]. [1]St. Croix Watershed Research Station, Science Museum of Minnesota; [2]Minnesota Pollution Control Agency Detroit Lakes, MN

18. **Diffusive Phosphorus Flux in Big Traverse, Lake of the Woods**.
William F. James. University of Wisconsin – Stout, Sustainable Sciences Institute – Discovery Center, Menomonie, WI

19. **Assessing long-term nutrient and primary production trends in embayments containing Lake Trout in Lake of the Woods, Ontario**.
Clare Nelligan[1], Adam Jeziorski[1], Kathleen M. Rühland[1], Andrew M. Paterson[2], and John P. Smol[1].
[1]Paleoecological Environmental Assessment and Research Lab (PEARL), Queen's University, Kingston ON; [2]Ontario Ministry of the Environment and Climate Change, Dorset Environmental Science Centre, Dorset, ON

20. **Tracking the environmental and developmental history of Lake of the Woods over the Holocene using diatoms and sedimentary chlorophyll *a***.
Kathleen M. Rühland[1], Andrew M. Paterson*[2], K. Rentz[1], James T. Teller[3], and John P. Smol[1].
[1]Paleoecological Environmental Assessment and Research Laboratory (PEARL), Queen's University, Kingston, ON;
[2] Ontario Ministry of the Environment and Climate Change, Dorset Environmental Science Centre, Dorset, ON;
[3] Department of Geological Sciences, University of Manitoba, Winnipeg, MB

11:40 – 13:00 Lunch

13:00 Session 5: Rainy-Namakan Rule Curve Review – Moderator Ryan Maki

21. **The Study of the International Rainy and Namakan Lakes Rule Curves Begins**.
Matt DeWolfe[1]; Col. Daniel Koprowski[2], Syed Moin[3]; Larry Kallemeyn[4]; Erika Klyszejko[1]; Pam Tomevi[5]; Scott Jutila[2]; Jean Morin[1]; Bill Werick*[6]. [1]Environment Canada; [2]U.S. Army Corps of Engineers; [3]Independent Consultant; [4]Independent Consultant; [5]Koochiching Soil and Water Conservation District; [6]Independent Consultant

22. **Defining the Best Rule Curve for the Environment**.
Jean Morin Marianne Bachand & Sylvain Martin. Meteorological Service of Canada, Environment Canada, Québec City, QC

23. **Modeling the impact of water level regulation on spawning habitat of lake sturgeon in the Rainy River**.
Marianne Bachand, Sylvain Martin, Olivier Champoux, Jean Morin. Hydrology and Ecohydraulic Section, Meteorological Service of Canada, Environment Canada

24. **Multivariable Control of Lake Levels and Stream Flows in the Namakan Reservoir/Rainy Lake Watershed**.
Jeffrey C. Kantor. Department of Chemical and Biomolecular Engineering, University of Notre Dame, South Bend, IN

14:20 – 14:50 Break

14:50 Session 6: Remote Sensing, Monitoring & Modeling – Moderator Jesse Anderson

25. **Improved land cover classification of the Lake of the Woods/Rainy River Basin for 1990 and 2010: by integrating Landsat imagery with LiDAR and object-based image analysis**.
Leif G. Olmanson and Marvin E. Bauer. Department of Forest Resources and Remote Sensing and Geospatial Analysis Laboratory, University of Minnesota, St. Paul, MN

26. **Lake Of The Woods Total Maximum Daily Load Study: A progress report**
Hernandez C.[1], Hirst M.[2], Kramer, G.[3]. [1]Minnesota Pollution Control Agency, Detroit Lakes, MN; [2]Lake of the Woods Soil and Water Conservation District; [3]RESPEC Water & Natural Resources, Roseville, MN

27. **Implementing the Scenario Application Manager (SAM) in the Big Fork Watershed**
Christopher D. Lupo. RESPEC Water & Natural Resources, Rapid City, SD

28. **Assessing the influence of copper-nickel-bearing bedrock on baseline water quality in three northeastern Minnesota watersheds**
Jones P.M.[1], Elliott S.M.[1], Woodruff L.G.[1], Seal, R.R. II[2], Piatak N.[2], Runkel R.L.[3], Hauck S.[4], Monson Geerts S.[4], Jennings C.[5]. [1]U.S. Geological Survey, Mounds View, MN; [2]U.S. Geological Survey, Reston, VA; [3]U.S. Geological Survey, Boulder, CO; [4]Natural Resources Research Institute, University of Minnesota Duluth; [5]Minnesota Department of Natural Resources

16:10 Closing Remarks

16:30 Forum Ends

Forum Sponsors – 2016

The organizing committee would like to thank our 2016 sponsor's for assisting with the 13th annual International Rainy-Lake of the Woods Watershed Forum. This event would not be possible without the assistance of the following groups:

- Lake of the Woods Water Sustainability Foundation
- International Joint Commission
- Consulate General of Canada – Minneapolis
- Minnesota Pollution Control Agency
- Voyageurs National Park
- Dorset Environmental Science Centre (OMOECC)
- Province of Manitoba
- Lake of the Woods District Property Owners Association
- Rainy River Community College
- North American Lake Management Society
- St. Cloud State University
- Rainy Lake Conservancy
- Rainy Lake Property Owners Association

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Presentation Abstracts

SESSION 1 – BINATIONAL UPDATES

IJC Update

Wayne Jenkinson
IJC Canada-Section

Abstract

Wayne Jenkinson, Senior Engineering Advisor, IJC Canadian Section delivered an update on activities of the IJC, progress under its International Watershed's initiative, the Rainy-Namakan Rule Curve Study, and a brief status update on the Lake of the Woods Basin Water Quality Plan of Study. Wayne reported on the IWI workshop held at the October Semi-Annual meeting in Ottawa. Reporting on projects funded by the IWI program, Wayne noted that approximately one third of the research to be presented at the Rainy-Lake of the Woods Watershed Forum this year were funded in part or in whole by the IJC or by its IWI program.

IJC Rainy-Lake of the Woods Watershed Board Update

Gail Faveri

Environment and Climate Change Canada & Water Levels Committee Chair, International Rainy-Lake of the Woods Watershed Board

Abstract

An update is presented on the background, status and activities of the International Rainy-Lake of the Woods Watershed Board during 2015 and the first part of 2016. Presented are a summary of board operations and standing committees, and activities including: water quality reporting, water levels, and public engagement. Major activities include the development of the board's first annual water quality conditions report; ongoing IWI projects, public engagement activities and significant work of the Water Levels Committee with the development of the 2014 High Water Levels Report and Recommendations, engagement with H2O Power Gate Refurbishment Project and the Rainy-Namakan Rule Curve Studies.

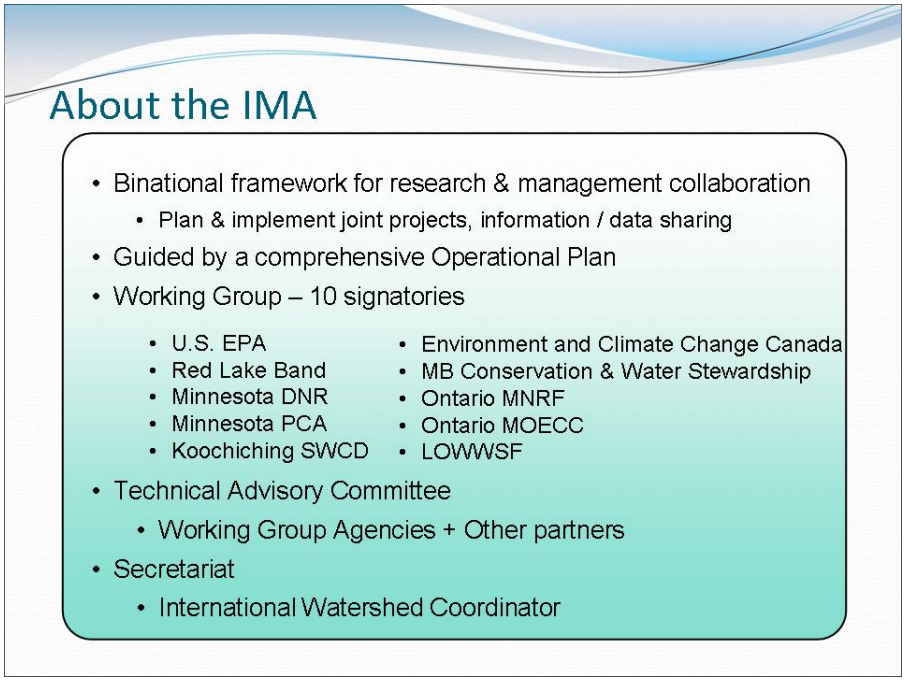
Brief Bio

Gail Faveri is Co-Chair of the Water Levels Committee of the IJC International Rainy-Lake of the Woods Watershed Board, Canadian Secretary to the IJC International St. Lawrence Board of Control and Canadian Co-Chari of the International Lake of the Woods Control Board. In her "day job" Gail is a Manager at the Boundary Waters Issues Unit of Environment and Climate Change Canada.

International Multi-Agency Working Arrangement Update

Shane Bowe

IMA Workgroup Member



Abstract

An update on the activities and progress of the International Multi-Agency Working Arrangement is presented, covering background, purpose and focus, including expanded geographic watershed focus and new consideration of aquatic invasive species. The IMA operation plan guides its activities needed for: core monitoring in the basin, for informing the Minnesota Lake of the Woods TMDL studies for objectives and targets to address nutrients and algae. The IMA had extensive input into the development of the IJC Lake of the Woods Basin Water Quality Plan of Study. The IMA operational plan formed the basin of many recommended projects in the Plan of Study. Many IMA projects, currently funded, are nearing completion and the IMA's proposed "wish list" projects are now intimately tied to the PoS and depended on it being approved. Several IMA member agency projects were highlighted including:

- MPCA Total Maximum Daily Load Study/Lake Modelling for Lake of the Woods
- MPCA Watershed Restoration and Protection Strategy (Big Fork; Little Fork)
- Historical nutrient loading research group (Phase 1: paleo estimates for LOW; Phase 2: Lake thermal modeling)
- Land use mapping – LOW watershed
- Tributary monitoring and in-lake monitoring
- Binational GIS Project Workplan

Brief Bio

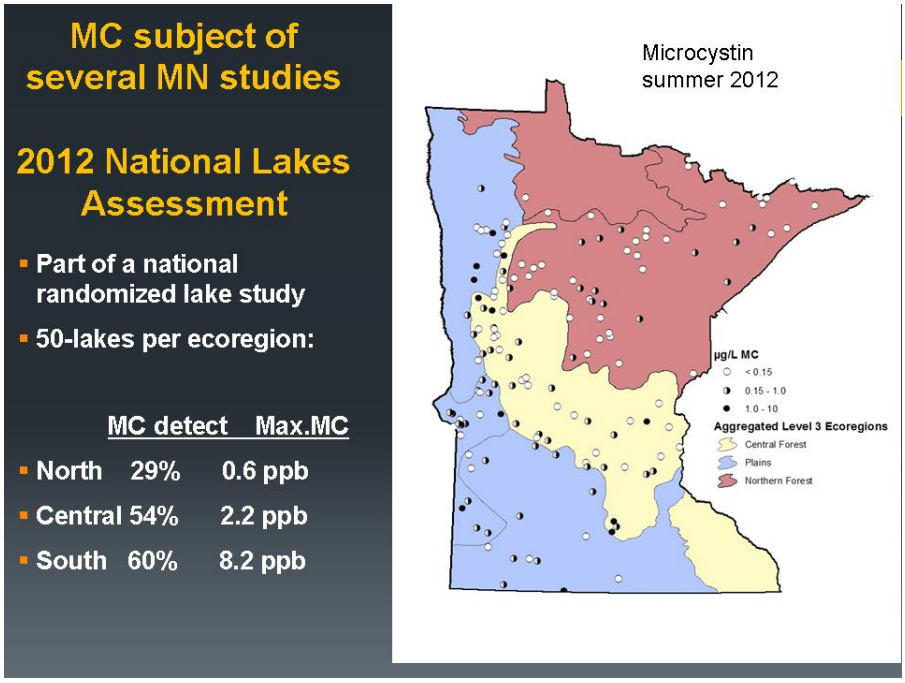
Shane Bowe is an aquatic biologist for the Department of Natural Resources of the Red Lake Band of Chippewa Indians, signatories to the International Multi-Agency Working Arrangement.

SESSION 2 – CYANOBACTERIA

Harmful algal blooms in Minnesota: A review of recent incidents, research findings, and questions that need to be answered

Steve Heiskary*[1] and Jesse Anderson[2]

[1]Environmental Analysis & Outcomes Division, Minnesota Pollution Control Agency, 520 Lafayette Road, St. Paul, MN 55155
[2]Environmental Analysis & Outcomes Division, Minnesota Pollution Control Agency, 525 Lake Avenue South, Suite 400 Duluth, MN 55802



Abstract

Harmful algal blooms (HAB) are a prominent environmental issue worldwide and are a major concern for Minnesota and Lake of the Woods. Over the past ten years, the MPCA, in collaboration with the Minnesota Department of Health and other partners, has invested substantial effort in responding to HAB-related concerns (including dog death and human health incidents) through direct responses, as well as public information campaigns. In addition, the MPCA has undertaken monitoring and research to improve the State's understanding of the extent of HAB and algal toxins (microcystin specifically) across the State and the factors that contribute to excessive blue-green algal growth and directly (or indirectly to toxin production). Even with this effort, many questions go unanswered.

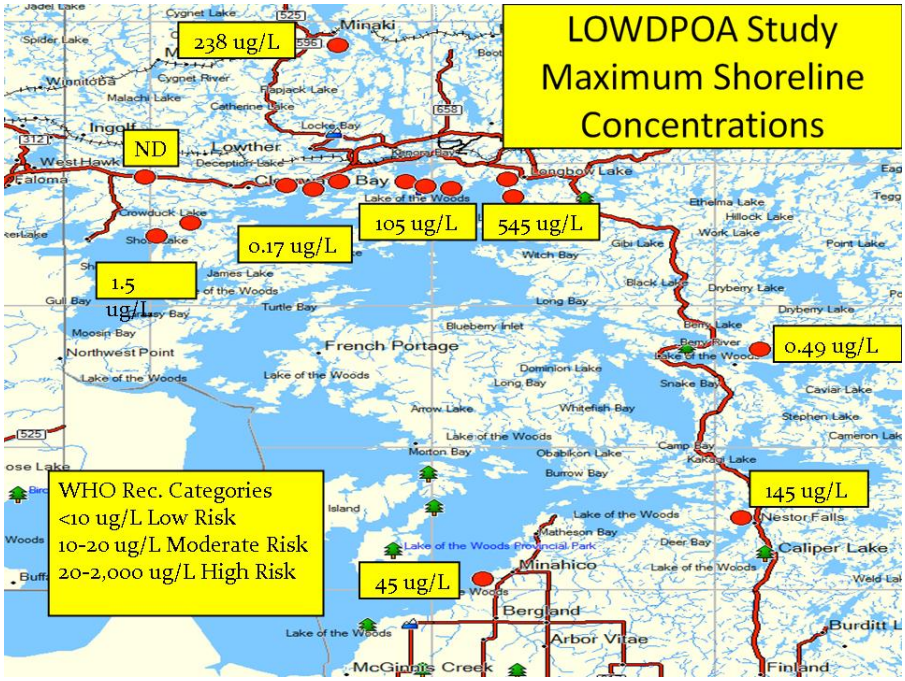
This presentation will provide:

1) An overview of recent HAB-related dog death (one of which was on Lake of the Woods in 2015) and human illness incident investigations;
2) Description of Minnesota's collaborative approach to public outreach on this topic;
3) Review of some MPCA research findings on this topic to-date; and
4) Summary of questions yet to be answered and
5) Overview of proposed research to address these questions.

Understanding cyanobacterial toxins…we've come a long way

Brian Kotak*[1], Susan Watson[2] and Hedy Kling[3],

[1]Miette Environmental Consulting Inc.; [2]Environment and Climate Change Canada; [3]Algal Taxonomy and Ecology Inc.



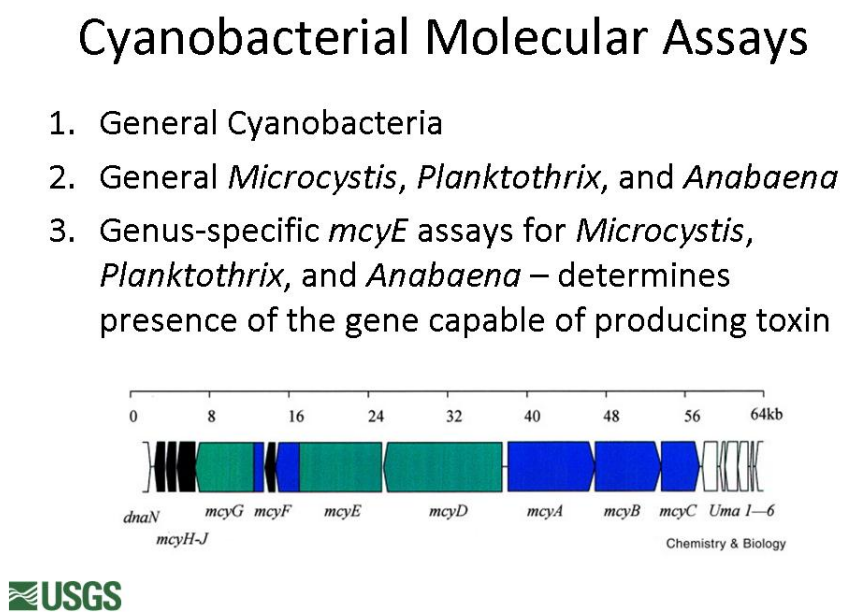
Abstract

Cyanobacteria are the most ancient form of life on earth, having originated more than 2 billion years ago. It is likely that the toxins they produce also have an ancient history. Despite this, our understanding of cyanobacterial toxins only began to take shape since the late 1950s. Since that time, advances in science has allowed us to determine the chemical structure of the toxins, their properties and the acute and sublethal toxicity to aquatic and terrestrial animals (including humans). More recently, we have gained a better understanding of their occurrence in aquatic environments and the factors influencing the occurrence of toxin-producing species and of the production of the toxins themselves. This presentation will review these topics, along with the scientific data collected on cyanobacterial toxins in Lake of the Woods to date. Our scientific understanding of cyanobacterial toxins is still incomplete, however, and thus the need to support the work proposed in the International Lake of the Woods Basin Water Quality Plan of Study.

Using molecular tools to understand and predict cyanobacterial harmful algal bloom toxicity in Kabetogama Lake, Voyageurs National Park, Minnesota

Erin A. Stelzer*[1], Victoria G. Christensen*[2], Donna S. Francy[3], and Ryan P. Maki[4].

[1]USGS Ohio Microbiology Laboratory, [2]USGS Minnesota Water Science Center, [3]USGS Ohio Microbiology Laboratory, [4]Voyageurs National Park



Abstract

Cyanobacterial harmful algal blooms (HABs) in Kabetogama Lake of Voyageurs National Park (VOYA) frequently produce the toxin microcystin and HABs also affect other large lakes in VOYA. Microcystin was detected in 78% (11 of 14) of bloom samples collected during a recent VOYA study, with 50% (7 of 14 samples) exceeding the 1 microgram per liter (ug/L) drinking water guideline of the World Health Organization (WHO). Two samples were in the WHO high-risk category for recreational exposure (concentrations >20 micrograms per liter). The WHO guidelines recommend the additional surveillance due to the high microcystin concentrations in Kabetogama Lake. An additional concern is the lack of data for other cyanobacterial toxins, such as saxitoxin and cylindrospermopsin, which could be present in these lakes.

The U.S. Geological Survey and the National Park Service are cooperating in a new study to better understand the drivers of algal bloom toxicity in VOYA lakes. A total of 126 environmental samples will be collected at three recreational areas where blooms frequently occur. Those samples will be analyzed for field parameters, nutrients, cyanotoxins (including saxitoxin and cylindrospermopsin), phytoplankton abundance and community structure, and cyanobacteria by molecular methods. The phytoplankton community in the cyanobacterial blooms of Kabetogama Lake has included significant biovolumes of *Microcystis* and *Anabaena*, known toxin producing genera. Microcystins are commonly produced by cyanobacteria of the genera *Microcystis*, *Planktothrix*, and *Anabaena*. Toxin production occurs when the microcystin synthetase (mcy) genes are present in the genome of toxic strains. Known microcystin-producing genera include both toxic strains (with the mcy genes) and nontoxic strains (without the mcy genes), which can be differentiated by molecular detection methods, such as quantitative polymerase chain reaction (qPCR).

This study will use optical sensors in the field to measure algal pigments such as chlorophyll and phycocyanin, a pigment found in cyanobacteria. The early-warning indicators and the procedures

and data collected from optical sensors and qPCR assays (which can be completed in three hours) have widespread applications. For example, early warning of potential cyanobacterial HABs will give resource managers the ability to inform the public of the threat before visitors engage in water-based activities. In addition, this study will collect data at algal bloom sites before blooms occur, which will allow researchers to determine whether toxins are present when HABs are not visible. This study also will document how simple chemical parameters that are routinely measured may be used as a screening tool for prediction of cyanotoxin presence and indication of the need for further testing. Harmful algal blooms are a problem across the region, having been identified as a major concern in the Lake of the Woods Water Quality Plan of Study (2015). Application of the methods presented here may be relevant to water resource managers across the region.

Brief Bio

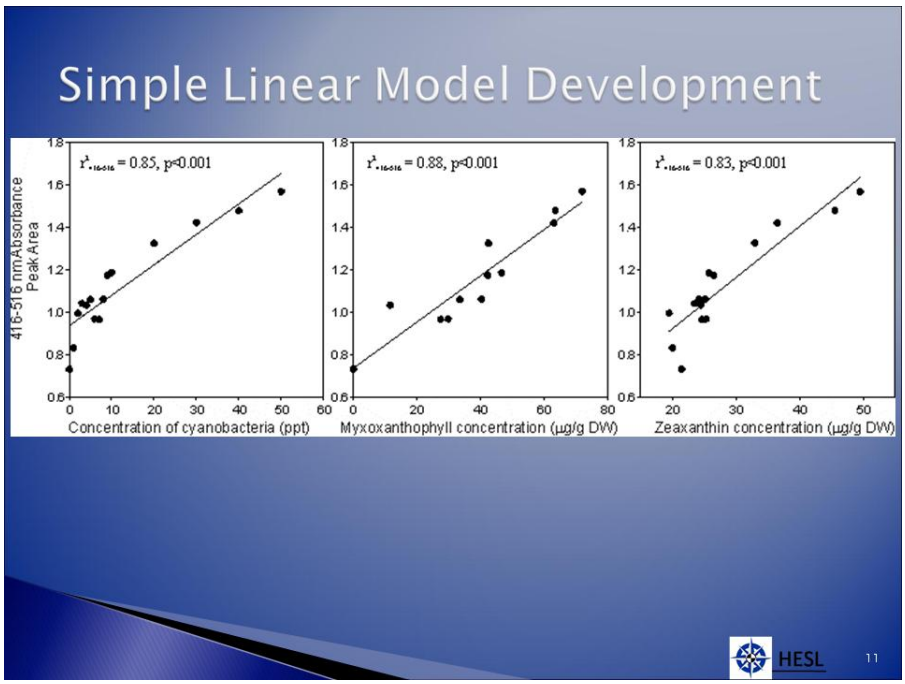
Victoria Christensen is a hydrologist with the USGS Minnesota Water Science Center. Her interests and project work include real-time water-quality sensors, nutrient cycling in agriculture and reservoir systems, and reservoir sediment studies.

Erin Stelzer is a microbiologist with the USGS Ohio Water Science Center. She has been applying PCR/qPCR techniques to projects that involve microbial source tracking, cyanobacteria, rapid viability, and direct detection of pathogens in environmental waters. Recently, she has focused research efforts on understanding what triggers both cyanotoxin and/or taste and odor compound production in recreational and source waters and determining what factors and tools can be used to help support predictive capabilities.

Developing a spectral inference model to measure trends in cyanobacterial pigments in lake sediments

Hadley, K.R.*[1, 2], Paterson, A.M.[3], Michelutti, N.[2], Karst-Riddoch, T.[1], Watson, S.B.[4], Gregory-Eaves, I.[5], Zastepa, A.[4], Smol, J.P.[2], and Hutchinson, N.[1]

[1] Hutchinson Environmental Sciences Ltd., Kitchener, ON;
[2] Paleoecological Environmental Assessment and Research Laboratory, Queen's University, Kingston, ON;
[3] Ontario Ministry of the Environment and Climate Change, Dorset Environmental Science Centre, Dorset, ON;
[4] Watershed Hydrology and Ecology Research Division, Environment Canada, Burlington, ON, Canada
[5] Department of Biology, McGill University, Montreal, QC, Canada, H3A 1B1.



Abstract

Cyanobacteria blooms pose a serious threat to lake ecosystems, and are a significant management concern in Canada and across North America. The ability to collect a long-term historical record of cyanobacteria blooms from lake sediments will provide information about the ecosystem state prior to disturbance (i.e., the ecological baseline condition), and the timing of the historical disturbance. High-performance liquid chromatography (HPLC) measurement of cyanobacterial pigment concentrations in lake sediments involves chemical extraction of pigments from the sediments, and thus renders the sediment useless for future analysis. Past research has focused on the development and application of visible near-infrared spectral techniques (VNIR) as a cost-effective, rapid and non-destructive alternative to HPLC, specifically, assessing changes in chlorophyll *a* concentrations as a method to reconstruct primary production in lakes over time. Here, we have expanded on the chlorophyll *a* VNIR technique and developed a Partial Least Squares (PLS) regression model by combining cultures of three cyanobacteria taxa common in Canada (i.e., *Anabaena*, *Microcystis*, and *Aphanizomenon*) with a matrix of lake sediments to construct a calibration series. Spectral profiles from the calibration series were compared against HPLC-measured pigment concentration, thereby creating a tool to estimate the frequency and magnitude of cyanobacteria blooms in lakes across North America.

Brief Bio

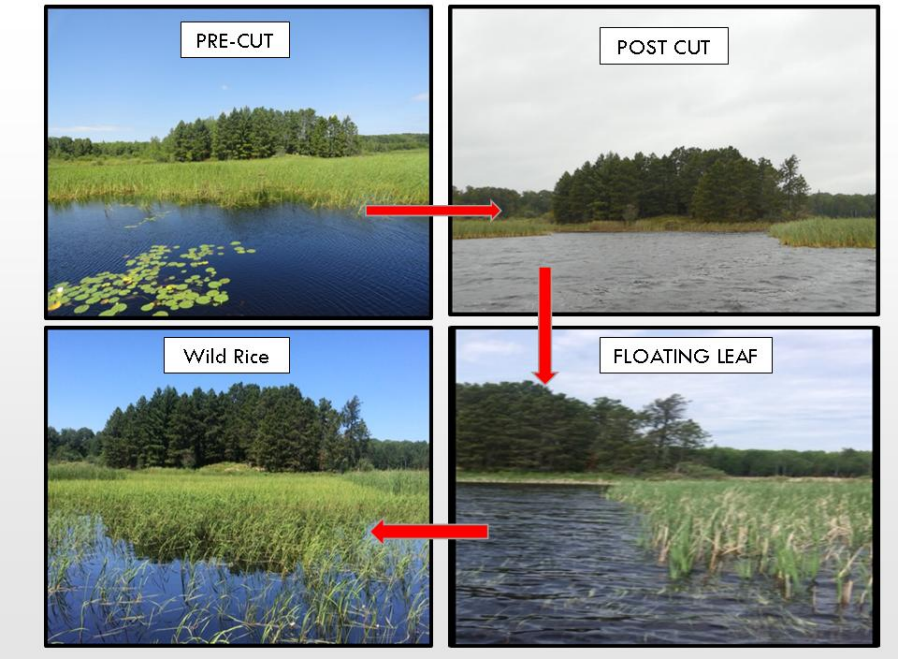
Dr. Kristopher Hadley joined HESL in late-October 2013 after completing his Ph.D. at Queen's University, and a post-doctoral fellowship with the Ontario Ministry of the Environment's Dorset Environmental Science Centre. Kris has 10 years of experience in aquatic science with a focus on using paleolimnological techniques to assess the ecological conditions and water quality of lakes in temperate and Arctic regions. He has experience using multiple paleolimnological proxies including diatom and scaled chrysophyte microfossils, as well as cladoceran zooplankton remains.

SESSION 3 – FLORA AND FAUNA

Cattails effect on nutrients within the sediment

Kristi Dysievick*[1], Peter Ferguson Lee[1] and John Kabatay[2]

[1]Department of Biology, Lakehead University; [2]Seine River First Nation



Abstract

A major issue with the traditional wild rice stands of SRFN has been the devastating invasion of the extoic narrowleaf cattail, *Typha angustifolia* or the hybrid, *T. glauca* (*T. latifolia x T. angustifolia*). Rat River Bay, historically a very productive bay for wild rice within the Rainy Lake Watershed has been invaded by cattails. It was used as a study area to quantify effects of cattail invasion on sediment nutrient levels. Comparison of invaded and uninvaded zones was achieved by core sampling and sediment grab samples along a transect. Additionally, Dialysis porewater samplers, commonly known as peepers, were deployed to collect pore water along a depth gradient within the sediment. Acrylonitrile butadiene styrene (ABS) pipes and fittings were used to construct the structure, which held the sample tubes. Holes were drilled to allow three sample tubes every 10 cm along the ABS pipe when deployed into the sediment. Fisherbrand® 50 mL sample tubes were modified by drilling a 19 mm diameter hole in the cap and replaced with a 0.45 µm pore size Millipore Durapore® membrane filter. At deployment sample tubes were filled with degassed distilled deionized water (DDW), capped with zero head space, and placed within the ABS pipe structure. In total 6 peepers were deployed within the study area, with the goal of comparing invaded and uninvaded stands. Both sediment and porewater were returned to the university and analyzed for nutrients and metal content. Comparison of sediment and porewater of invaded and uninvaded zones indicated significant differences in nutrients and metals.In particular, there was a noticeable depletion of nitrogen levels in cattail invaded sites.

Brief Bio

Kristi Dysievick is a Master student in the department of Biology at Lakehead University. Miss. Dysievick completed her honours bachelors of water resource at Lakehead University in 2013. Kristi has experience working in Lakehead University Environmental Laboratory, which is an ISO 170025 accredited Laboratory. Her thesis is focusing on the re-establishment of Wild Rice and the potential influence of cattails on sediment characteristics which may be detrimental for Wild Rice development, growth and productivity.

Solving rice's future now!

Peter Ferguson Lee*[1] and John Kabatay[2]

[1]Department of Biology, Lakehead University; [2]Seine River First Nation

Abstract

Wild rice production in Rainy Lake and Lake of the Woods has declined from over 680,000 kg per year (1.5 million pounds) in the 1970's to negligible amounts today. The last wild rice processing plant in Ontario closed in 2014 due to shortage of product and this company relocated to Manitoba. Elsewhere in Canada, wild rice production has increased to up to 2.3 million kg per year (5,000,000 pounds). With the introduction of paddy wild rice culture into Minnesota and California, production in those states now reaches 27 million kg per year (60,000,000 pounds). The main problems for wild rice production in Ontario have been the loss of crops due to high water levels on Rainy Lake, Lake of the Woods and the Winnipeg River where the major wild rice stands are located and the associated invasion of exotics into these stands, notably narrowleaf cattails. Seine River First Nation (SRFN) is taking proactive steps to reverse this trend. In partnership with Lakehead University, water level and cattail control research projects are currently in place to develop recommendations and management practices to reduce losses in their traditional wild rice areas. Other strategies include the seeding of smaller lakes that can be controlled for water level fluctuations, and experimental seeding of paddies which can be drained or permanently flooded. Progress and problems associated with these developments are detailed in the presentation.

Brief Bio

Dr. Peter Lee is a Professor of Biology at Lakehead University in Thunder Bay, Ontario. He has worked on wild rice for over 40 years in the public, private and academic sectors, notably as the Director of the Centre for Lake Wild Rice at Lakehead University from 1981-1985. He is currently he Director of the Lakehead University Environmental Laboratory and the Lakehead University Aquatic Toxicity Research Centre. He continues to actively research wild rice on a number of topics ranging from genetics to nutrient relationships and plant competition.

Influences of water depth on wild rice (*Zizania* sp.) growth, development, and density

O'Niell Tedrow*[1], Peter Ferguson Lee[1], Kristi Dysievick[1], and John Kabatay[2]

[1]Department of Biology, Lakehead University; [2]Seine River First Nation

Abstract

Wild rice (WR; *Zizania* sp.) progresses through three primary phenological stages prior to maturation; submerged, floating leaf, and aerial stages. Water depth is likely a critical influence on growth, development, and ultimately productivity of WR. Increased water depth may have differential influences on WR development during various WR phenological stages. During 2013 and 2014, years with extraordinarily high water levels, no field-grown WR was harvestable in the Seine River throughout two study areas; Wild Potato Lake (WPL) and Rat River Bay (RRB). During 2014, multiple 3m x 3m rafts were deployed in a protected area of WPL; each containing 36 tubs planted with WR seedlings, suspended at specific initial water depths; some exposed to periodic increases in water depth at different WR phenological stages. Conclusions from the 2014 raft study supported that the submerged stage was more sensitive to water depth increases than aerial stages. During 2015, exceptional densities of WR were present throughout the WPL and RRB study areas. Therefore, a field study of WR density relative to water depth was completed in RRB. Study areas were subdivided into two specific categories; an area from which cattails had been harvested, and 'natural' WR area. Data from this study indicate that WR density did not decrease with increasing water depth in the area of cattail harvest. However, WR density decreased with increasing water depth in the natural WR area. This could suggest an increased WR seed bank due to a competitive influence from cattails. Data obtained during the raft and field studies critical to supporting WR productivity include decreasing water depths (≤ 40 cm) during the submerged plant phenological stage; removal of cattails as a source of competition for resources; and maintaining water depths (≤ 60 cm) throughout WR maturation.

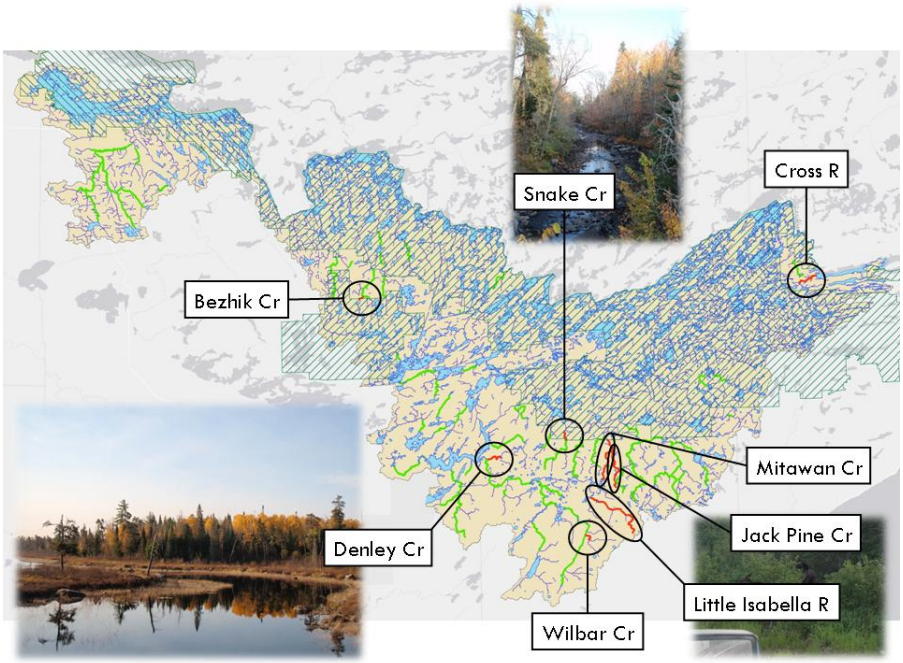
Brief Bio

O'Niell Tedrow is a Ph.D. student in the Department of Biology at Lakehead University. Mr. Tedrow is also a professor at Vermillion Community College in Ely, Minnesota. After completing his undergraduate training in Minnesota, O'Niell completed his M.Sc. degree in aquatic toxicology at Clemson University in South Carolina. He later worked for the US EPA in Athens, Georgia, before moving back to Minnesota, initially working with Northeast Technical Services, Inc., in Virginia, Minnesota. O'Niell's Ph.D. Dissertation is concerned with site specific physical and chemical influences on the survival and growth of wild rice. This includes water depth fluctuations as outlined in this presentation, as well as the chemical characteristics of sediment supporting wild rice. His Ph.D. supervisor is Dr. Peter F. Lee.

Rainy River-headwaters monitoring and assessment

Nathan Mielke*

Minnesota Pollution Control Agency, 7678 College Road, Suite 105, Baxter, MN 56425



Abstract

In 2014, the Minnesota Pollution Control Agency (MPCA) undertook the intensive watershed monitoring effort of the Rainy River-Headwaters Watershed. A total of 74 biological monitoring stations were established in 2014/15 at the outlets of varying sized sub-watersheds. As part of this effort, MPCA staff joined with two soil and water conservation districts (Cook & Lake) and one community college (Vermilion) to complete stream water chemistry sampling at the outlets of 13 sub-watersheds. In 2016, a holistic approach was taken to assess all of the watershed's surface waterbodies for support of aquatic life, recreation, and consumption. Through this process, we have identified waters that were not meeting standards (impaired), as well as waters that were in exceptional condition. A number of streams with exceptional biological, chemical, and physical parameters are worthy of additional protections in order to preserve their valuable aquatic resources. Overall, water quality conditions are good and can be attributed to the forest and wetlands that dominate land cover within the Rainy River-Headwaters Watershed.

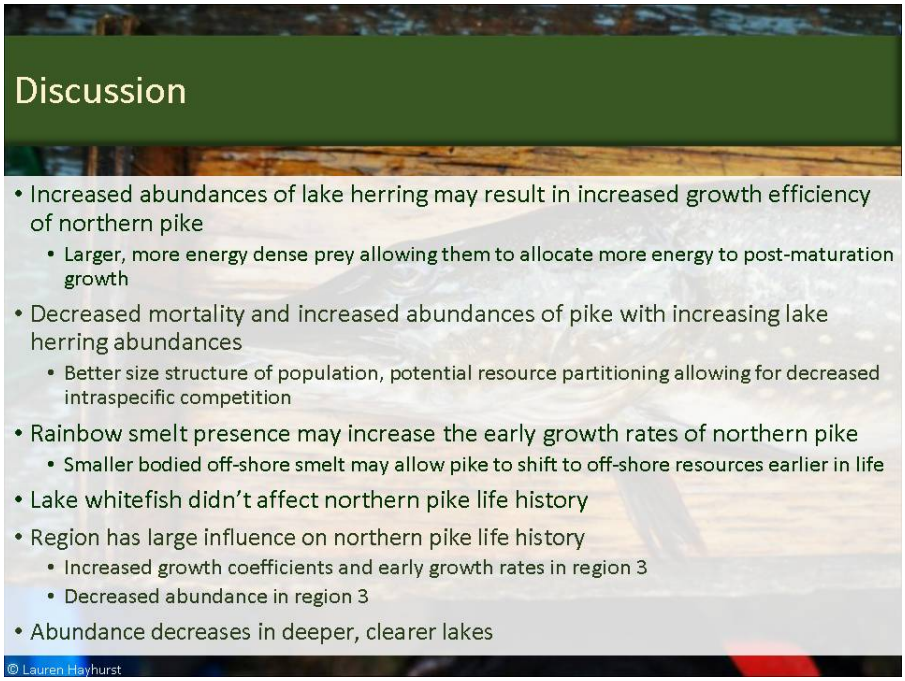
Brief Bio

Nathan Mielke is a Stream Fish Biologist with the North Biological Unit of the Minnesota Pollution Control Agency. He is the lead researcher for the monitoring and assessment of the Rainy River-Headwaters major watershed.

The influence of the pelagic prey community on the life history variation of northern pike (*Esox lucius*) in the Canadian boreal shield

P.J. Kennedy*[1] and Michael D. Rennie[1,2,3]

[1]Department of Biological Sciences, University of Manitoba, Winnipeg, MB R3T 2N2
[2]Department of Biology, Lakehead University, 955 Oliver Road, Thunder Bay, Ontario, Canada P7B 5E1
[3]IISD-Experimental Lakes Area, Suite 325, 111 Lombard Avenue, Winnipeg Manitoba, Canada R3B 0T4



Abstract

Northern pike (*Esox lucius*) are opportunistic apex predators that have a ubiquitous distribution across the Canadian boreal shield. Since northern pike are typically viewed as sit-and-wait ambush predators that use the cover of littoral vegetation, few studies have investigated the use of pelagic habitat by northern pike. Our study used a mixed-effects model approach to investigate the relative influence of the pelagic prey community on northern pike growth and life history variation across a large portion of the Canadian boreal shield (*N*= 478 lakes) using Ontario Fall Walleye Index Netting (FWIN) survey data from 1993 to 2003. The northern pike life history characteristics investigated in this study were asymptotic fork length ($L\infty$), early growth rate, Brody's growth coefficient (*K*), instantaneous total mortality (*Z*), and relative abundance. Our analysis revealed that both male and female northern pike had significantly greater asymptotic fork lengths in lakes with greater relative abundances of lake herring (*Coregonus artedi*). The relative abundance of lake herring also had significant negative effects on the early growth rates and Brody's growth coefficients of male and female northern pike. The presence of rainbow smelt (*Osmerus mordax*) resulted in significant positive increases in the early growth rates and Brody's growth coefficients of female northern pike, though region had the strongest effect on these characteristics. Variation in instantaneous total mortality rates was explained best by lake surface area for males and the relative abundance of lake herring for females. Variation in the relative abundances of both sexes was explained best by lake surface area. Our results indicate that life history characteristics of Ontario northern pike populations are significantly affected by pelagic prey abundance, and as a consequence are likely exhibiting more generalism and habitat-coupling than previously thought.

Brief Bio

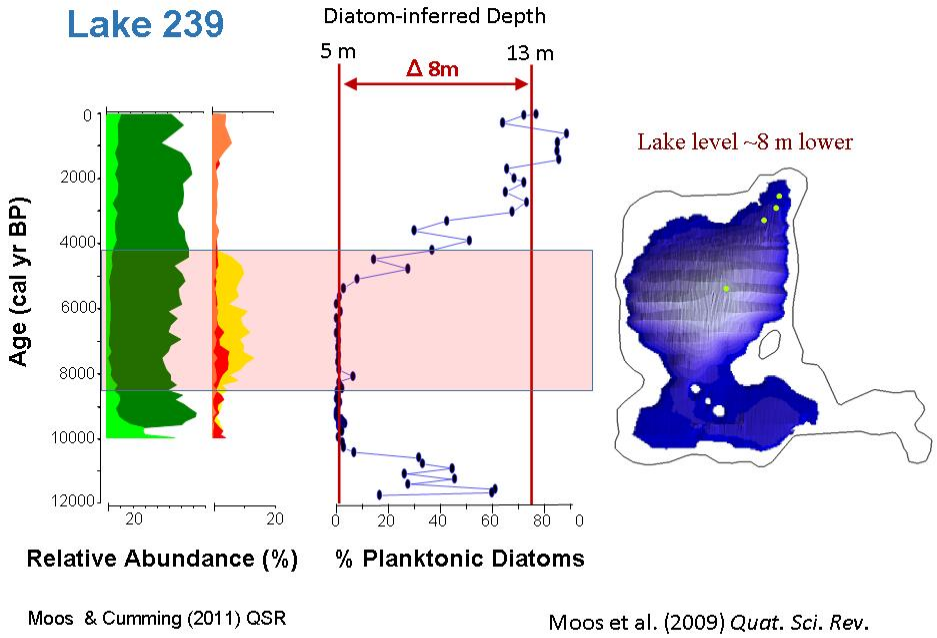
Patrick Kennedy is currently a Master of Science candidate at the University of Manitoba in the department of Biological Sciences under Dr. Michael D. Rennie. Patrick has received a few awards while at the University of Manitoba, including the International Graduate Student Entry Scholarship and the IISD-Experimental Lakes Area Graduate Fellowship. He received a Bachelor of Science degree in Biological Sciences from Illinois State University in 2013. As an undergraduate student, Patrick volunteered in the Environmental Quality Laboratory at the John G. Shedd Aquarium. He also worked as an undergraduate research assistant in Dr. William Perry's laboratory helping with a study on denitrification in constructed wetlands. Patrick then had an internship with the Illinois Environmental Protection Agency where he helped survey streams, rivers, and lakes across northern Illinois. After his internship and before starting his graduate degree, Patrick worked as an aquatic research technician at the Illinois River Biological Station where he assisted with research projects on the Illinois, Mississippi, and Ohio rivers.

SESSION 4 –CLIMATE 2050

Keynote: Recent and long-term climate change in northwest Ontario: assessment of past changes from lake sediments

Brian Cumming*

Paleoecological Environmental Assessment & Research Lab (PEARL), Queens' University, Kingston ON



Abstract

Long-term data on the impact of climate change in many parts of Ontario, including the northwest, is sadly absent. Fortunately sediment cores from many head-water lakes can provide information on past changes vegetation, water levels and lake production. This presentation will summarize our studies from a network of lakes in northwest Ontario on a variety of time scales, from centuries to millennia, with an emphasis on periods of enhanced warmth in the past including the Medieval Climate Anomaly and the Holocene Thermal Maximum. Our results show that the instrumental record is certainly not representative of the changes in climate that have occurred in northwest Ontario. Past changes have included regional droughts, enhanced fire regimes and more productive lakes.

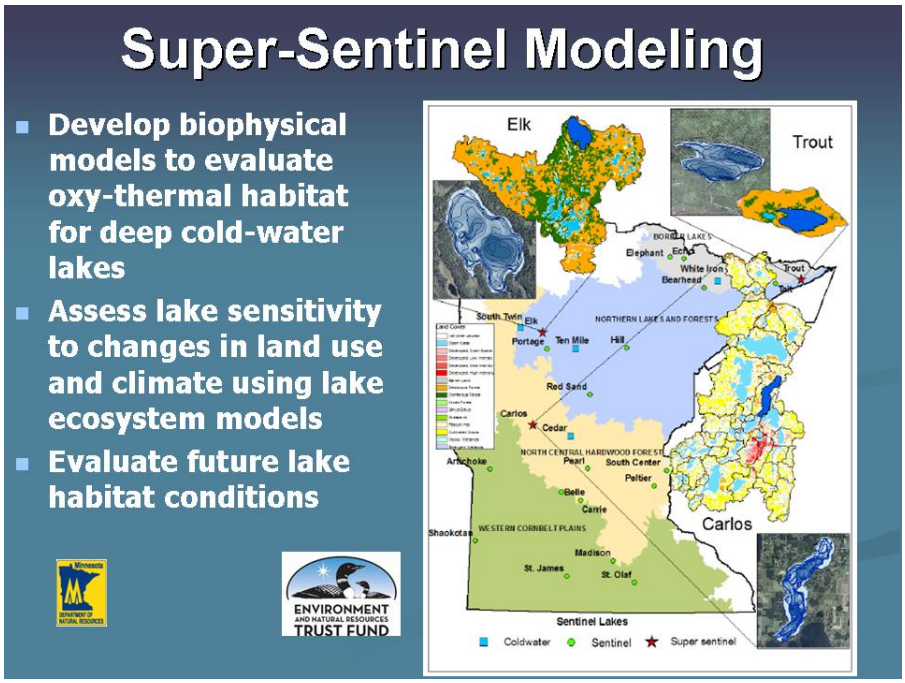
Brief Bio

Brian Cumming is a professor in the Department of Biology at Queen's University (Ontario, Canada) where he is a co-director of the Paleoecological Environmental Assessment and Research Laboratory (PEARL). PEARL is a state-of-the-art research facility that is recognized as one of the leading labs in the world in paleolimnological research. Dr. Cumming received his B.Sc.H. (Biology) and Ph.D. (Biology) from Queen's in 1987 and 1991, respectively. He was a visiting scientist at the University of Bergen (Norway) and an NSERC Post-Doctoral Fellow at the Limnological Research Center (Dept. of Geology) at the University of Minnesota, prior to starting his tenure as a faculty member at Queen's in 1994. He has authored well over 100 peer-reviewed scientific papers, notes and book chapters on a wide variety of topics with a focus on the development and application of limnological and paleoecological approaches to assess environmental change.

Keynote: Using predictive modeling to assess lake ecosystem responses to stressor gradients

Richard Kiesling* and Erik Smith

Minnesota Water Science Center, U.S. Geological Survey, Mounds View, MN 55112



Abstract

The U.S Geological Survey (USGS) Minnesota Water Science Center, in partnership with the Minnesota Department of Natural Resources (MDNR), the St. Croix Watershed Research Station, and the National Park Service, has developed mechanistic, bio-physical lake models that simulate trophic dynamics and track changes in oxy-thermal habitat gradients in three deep, cold-water lakes. In all three lakes, calibrated models captured the trajectories of water temperature and dissolved oxygen concentrations over time at multiple depths. Calibrated models were used to evaluate changes in cold-water fish habitat under changing productivity and meteorological stressor gradients. Model simulations indicate that lethal oxy-thermal habitat develops in these lakes as the result of interactions between lake stratification, primary production in the upper mixed layer of the lake, and water column oxygen demand below the photic zone. In Lake St. Croix, a multi-basin, riverine glacial scour lake that is the subject of a phosphorus TMDL, a calibrated model was able to predict the spatial and temporal development and persistence of a cyanobacterial algal bloom. Sensitivity analysis revealed significant differences in which parameters were driving algal bloom dynamics. Model simulations of different load scenarios indicate that primary production in Lake St. Croix results from complex interactions between hydrology, lake stratification, and hypoxia in the deep pools of the lake. In all of these lakes, dynamic, mechanistic models provide a tool to simultaneously evaluate the influence of multiple factors on whole-lake metabolism.

Brief Bio

Dr. Richard L. Kiesling is an aquatic ecologist and limnologist with USGS. He holds a B.S. in Biology from the University of Minnesota (1980) and a Ph.D. in Biological Sciences from the University of Michigan (1990) with specialization in limnology and community ecology. He is currently a Hydrologist and Water Quality Specialist with the Minnesota Water Science Center. Dr. Kiesling's current research includes studies of the effects of endocrine disruption on lake fish

communities and the effects of land use and hydrologic modifications on nutrient fate and transport in aquatic ecosystems.

Erik Smith has been a hydrogeologist with the U.S. Geological Survey since 2004. Erik started as a student while finishing a MS in Geology from the University of Minnesota. In 2005, Erik transferred to the Iowa Water Science Center to work as a supporting scientist and full-time hydrologic technician on the NAWQA program's Agricultural Chemicals Transport (ACT) team. During the ACT tenure, Erik assisted in all aspects of the South Fork Iowa River's ACT project, including the management of an extensive groundwater monitoring network, groundwater and surface water sampling, and instrumentation of an in-field subsurface drainage monitoring site. In 2008, Erik moved back to Minnesota to complete work on a PhD tied into the Iowa ACT project. Erik's research during this period focused on the spatial and temporal variability of preferential flow in a subsurface-drained landscape. Since graduating from the University of Minnesota in 2011, Erik has been a full-time hydrologist with the Minnesota Water Science Center. His current research focuses on CE-QUAL-W2 modeling of Sentinel Lakes, SWB modeling to estimate recharge across Minnesota, and groundwater sustainability.

The effects of climate change on small boreal lakes of the Canadian Shield

Scott N. Higgins*, P. Blanchfield, C. Emmerton, M. Guzzo, M. Paterson, M. Rennie, and Ken Sandilands

IISD Experimental Lakes Area 111 Lombard Avenue, Suite 325, Winnipeg MB, R3B 0T5

Abstract

Canada's boreal zone contains more than half of the world's lakes, 25% of its wetlands and represents over 50% of Canada's land surface. Climate change in this region is projected to increase air temperatures by 2.0-3.5 times the global average and the potential impacts to freshwater ecosystems are only beginning to be understood. Over the past 47 years, mean annual air temperatures at the IISD Experimental Lakes Area have increased by 0.5 °C/decade, with largest increases found during January, March, September, November and December. The period of ice-cover was strongly dependent on air temperatures during spring and autumn periods, decreasing by >3 days/decade. Long-term variation in precipitation was correlated with loadings of dissolved organic carbon (DOC) that significantly affected water transparency, heat absorption, lake stratification, and photosynthesis. Changes in thermocline depth and duration of the ice-free season appear to have impacted both warm and cold water fish species; leading to smaller individual body sizes, but reduced potential for winter mortality. Our data suggest biota in boreal lakes are highly sensitive to changes in physical and chemical parameters associated with climate change.

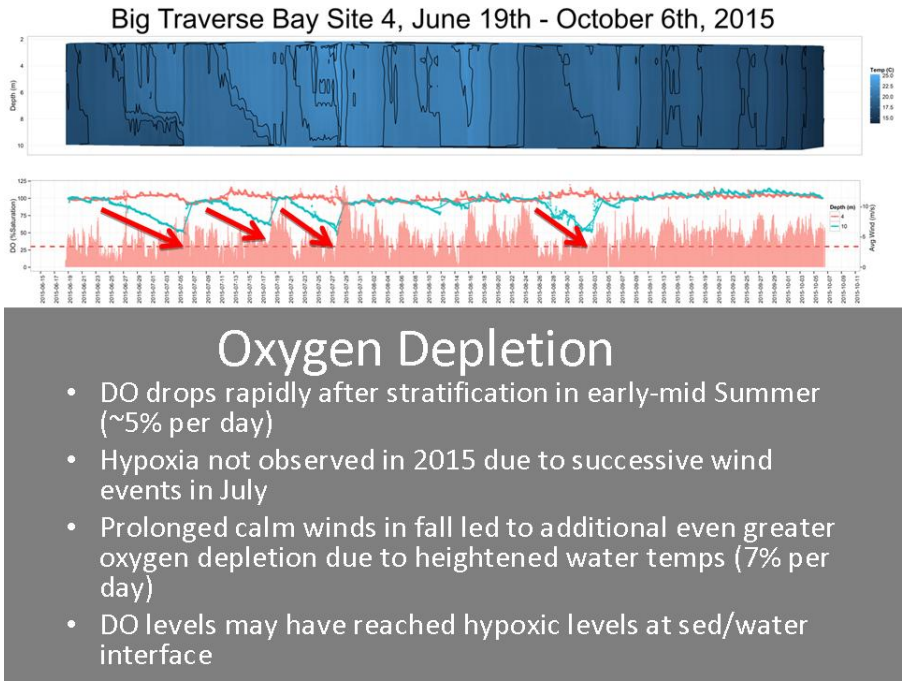
Brief Bio

Dr. Higgins is a Research Scientist at the IISD Experimental Lakes Area, where his research focusses on the impacts of climate change, eutrophication, and other ecosystem disruptions on lake food webs and processes.

High-frequency monitoring of stratification and sediment re-suspension in Lake of the Woods

Heathcote, A.J.*[1], Edlund, M.B.[1], Engstrom, D.R.[1], Hernandez, C.[2]

[1]St. Croix Watershed Research Station, Science Museum of Minnesota, 16910 152nd St North, Marine on St. Croix, MN 55047
[2]Minnesota Pollution Control Agency, 714 Lake Avenue, Suite 220, Detroit Lakes, MN 56501



Abstract

The persistence of algae blooms in the southern basin of Lake of the Woods (LoW), despite drastic reductions in external phosphorus (P) inputs, is thought to be, in large part, a result of internal P recycling from the sediments. Previously buried P (or legacy P) may be liberated from the sediments by two primary pathways: 1) direct flux across the sediment-water interface and 2) de-sorption from particles re-suspended into the water column through physical (wind or wave) mixing. To assess the potential magnitude and seasonality of internal P loading within LoW, we deployed three arrays of moored buoys over the 2015 ice-free season along a latitudinal transect across the southern basin to monitor physical and chemical properties of the lake that control sediment P flux and resuspension. Using thermistor strings and hypo-and epilimnetic dissolved oxygen (DO) sensors we determined that, despite the shallow water depth relative to fetch in LoW's southern basin, stable stratification occurred five times between June and October. This stratification lasted between 4 and 11 days before being broken due to high winds (1-hr average windspeed > 18 mph [~29 km/h]). Concurrent with stratification, oxygen in the bottom waters was depleted at a rate of ~5% per day. Though anoxia was never observed in 2015, conditions approached hypoxia in early July and may have reached anoxic conditions at the sediment-water interface if stratification persisted for an additional week. Suspended sediment was also measured over the same period using sediment traps to measure suspended particulate flux and algal production between each site visit (approx. 30 days). By pairing high-frequency physical data with monthly water chemistry, we are able to begin to construct a picture of the potential and magnitude of internal P recycling in the southern basin of LoW. This project will continue with measurements being taken this winter under the ice and re-deployment of buoys for the 2016 ice-free season.

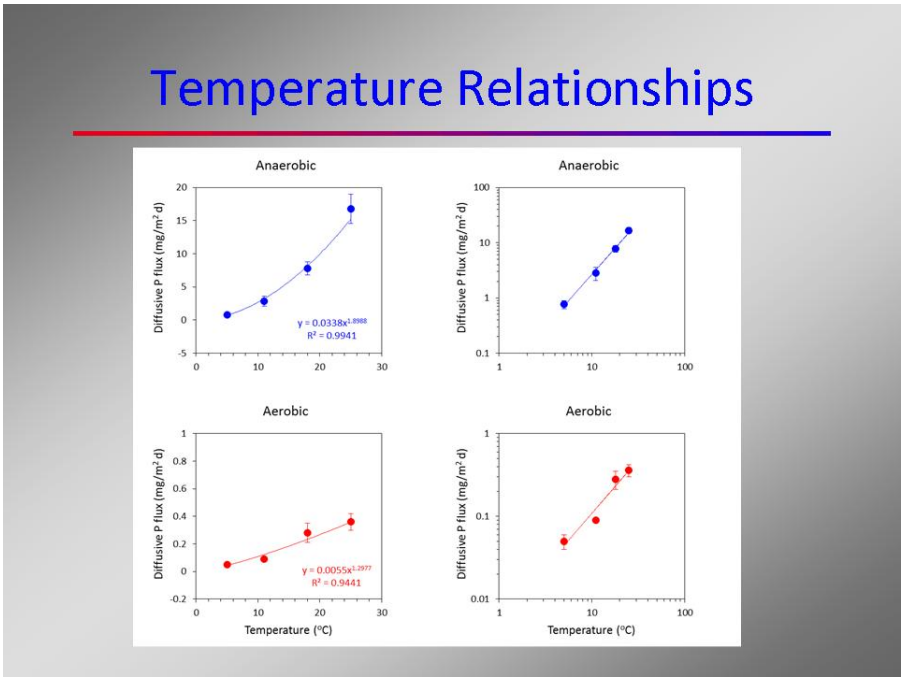
Brief Bio

Adam Heathcote is an assistant scientist at the Science Museum of Minnesota's St. Croix Watershed Research Station. Heathcote has experience using high-frequency monitoring techniques in systems ranging from the shallow prairie potholes of Iowa to deep boreal lakes on the Canadian Shield.

Diffusive Phosphorus Flux in Big Traverse, Lake of the Woods

William F. James*

University of Wisconsin – Stout, Sustainable Sciences Institute – Discovery Center, Menomonie, WI



Abstract

Diffusive sediment phosphorus (P) flux from sediment may contribute to the phosphorus (P) budget of the Lake of the Woods (LOTW) and needs to be considered in Total Maximum Daily Load (TMDL) development. The objectives of this research were to develop regression relationships between temperature and diffusive P flux for more accurately quantifying and predicting internal P loading in Big Traverse Lake and other basins in LOTW. Intact sediment cores (~ 30 cm in length) were collected from a centrally-located station in the eastern basin of Big Traverse Lake in July (18 C) and late August, 2014 (25 C), and February (5 C) and May, 2015 (11 C), to examine temperature-driven and seasonal variations in diffusive P flux and surface sediment characteristics. Under aerobic and anaerobic conditions, mean diffusive P fluxes increased in an exponential pattern as a function of temperature. Fluxes were greatest under anaerobic conditions, ranging between 0.8 mg/m^2 d (± 0.13 standard error, SE) at the lowest temperature (5 ^{o}C) and 16.8 mg/m^2 d (± 2.2 SE) at 25 ^{o}C. Under aerobic conditions, mean diffusive P fluxes varied between 0.05 mg/m^2 d (0.01 SE) at 5 ^{o}C and 0.36 mg/m^2 d (0.06 SE) at 25 ^{o}C. Regression analysis was used to predict summer diffusive P flux as a function of temperature and redox condition in Big Traverse Lake for comparison with the P budget to better understand the potential role that internal P loading may have on driving cyanobacteria blooms.

Vertical sediment profiles of total P, biologically-labile P, and redox-sensitive P (i.e., the sum of the loosely-bound P and iron-bound P fractions), determined from a sediment core collected in late August, 2014, exhibited modest concentration peaks in the upper 5- to 6-cm sediment layer and lower concentrations below this depth. This vertical pattern suggested that surface sediment in the eastern region of Big Traverse Lake has accumulated P in excess of diagenesis and burial (i.e., gross P deposition > diagenesis and burial). Surface peaks reflected elevated concentrations of iron-bound P and labile organic P, suggesting the potential for internal P loading. In contrast, more biologically-inert aluminum-bound and calcium-bound P concentrations were relatively constant with sediment depth over the upper 30-cm sediment profile and did not explain surface layer pattern. Overall, total P, biologically-labile P, and redox-P concentrations

were 0.834 mg/g, 0.375 mg/g, and 0.237 mg/g, respectively, in the upper 1-cm and a mean 0.596 mg/g, 0.179 mg/g, and 0.120 mg/g, respectively, below the 5-cm depth.

Experimental estimates of diffusive P flux and vertical P profiles from sediment collected in the eastern portion of Big Traverse Lake suggested that sediment is likely a moderate source of internal P loading. More information is needed on bottom water temperature, dissolved oxygen, and redox dynamics as well as water column mixing and exchange in order to both predict and better understand the role and magnitude of internal P loading contributions within the context of an overall P budget. Vertical sediment P profiles also suggested that past P accumulation has exceeded diagenesis and burial, resulting in the modest buildup of P that may continue to drive future internal P loading despite significant reduction in external P loads.

Brief Bio

I was a research aquatic biologist with the Engineer Research and Development Center, U.S. Army Corps of Engineers, for 32 y. I managed research at the Eau Galle Aquatic Ecology Laboratory in Wisconsin. I retired from ERDC in 2011 and am now a professor and research aquatic ecologist at the University of Wisconsin – Stout. My research interests are in lake eutrophication and management; sediment phosphorus dynamics, fluxes, and vertical characteristics; internal phosphorus loading and vertical transport; cyanobacteria blooms; alum treatment to control internal P loading.

Assessing long-term nutrient and primary production trends in embayments containing Lake Trout in Lake of the Woods, Ontario

Clare Nelligan*[1], Adam Jeziorski[1], Kathleen M. Rühland[1], Andrew M. Paterson[2], and John P. Smol[1]

[1]Paleoecological Environmental Assessment and Research Lab (PEARL), Dept. Biology, Queen's University, Kingston ON; [2]Ontario Ministry of the Environment and Climate Change, Dorset Environmental Science Centre, 1026 Bellwood Acres Road, Dorset, ON

Paleolimnological Conclusions from Lake Trout Embayments in Lake of the Woods

- Diatom assemblage changes in the three Lake Trout bays in the Lake of the Woods are characteristic of warming (Fig. 1)
  - Major assemblage shifts with increase in planktonic cyclotelloid taxa and declines in heavily silicified *Aulacoseira* taxa.
  - Timing of change varies among bays but are all post ~1970
  - The ecological significance of an increase in *Aulacoseira islandica* in Echo Bay requires further examination
- Diatom-inferred TP has decreased (or remained stable) in all three bays
- VRS-chlorophyll-*a* suggests that whole-lake primary production has increased in Cul de Sac and Echo compared to Whitefish, which has remained relatively unproductive through time (Fig. 2)

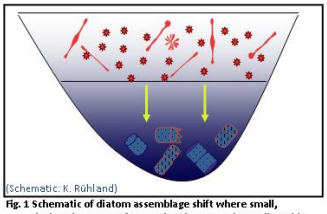


Fig. 1 Schematic of diatom assemblage shift where small, planktonic taxa are favoured under more thermally stable conditions.

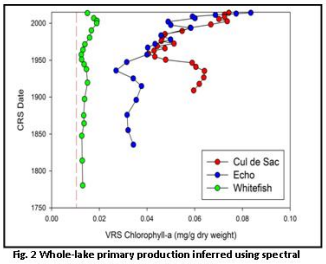


Fig. 2 Whole-lake primary production inferred using spectral analysis of sedimentary chlorophyll-*a*

Abstract

Lake Trout (*Salvelinus namaycush*) are ecologically sensitive with narrow physiological tolerances to temperature and dissolved oxygen. As a result, Lake Trout are found in the cold, well-oxygenated, and generally deeper bays of northern Lake of the Woods (LOW). The LOW Lake Trout population has historically been subjected to a variety of anthropogenic stressors including overharvesting, shoreline development, nutrient loading, and recent climate change. Ontario-wide deterioration of Lake Trout habitat quality due to the depletion of hypolimnetic dissolved oxygen (DO) has prompted concern over the amount of habitat available to Lake Trout within the water column. While declines in hypolimnetic DO are often associated with nutrient loading, increased periods of hypolimnetic anoxia have been observed in many Ontario lakes where total phosphorus (TP) concentrations have not increased. This suggests that additional stressors, such as regional warming, may be influencing DO-TP dynamics. However, due to a lack of long-term monitoring data, the relative roles of nutrient loading and climate change in driving DO changes in Lake Trout habitat are unclear. Here we use paleolimnological techniques to reconstruct trends in TP and primary-production over the past ~200 years at three LOW embayments that sustain Lake Trout (Echo Bay, Cul de Sac Bay and Whitefish Bay). Sedimentary diatom assemblages are being used to infer past water column TP concentrations and visible reflectance spectroscopy is used to reconstruct trends in past lakewater chlorophyll-*a* concentrations to assess trends in primary production. We investigate whether trends in diatom-inferred TP and sedimentary chlorophyll-*a* are indicative of regional-scale stressors (e.g. climate warming) or more localized stressors (e.g. nutrient loading/shoreline development). Understanding long-term environmental trends in LOW will better inform resource mangers on the stressors influencing Lake Trout habitat and will aid in the continued management of this species.

Brief Bio

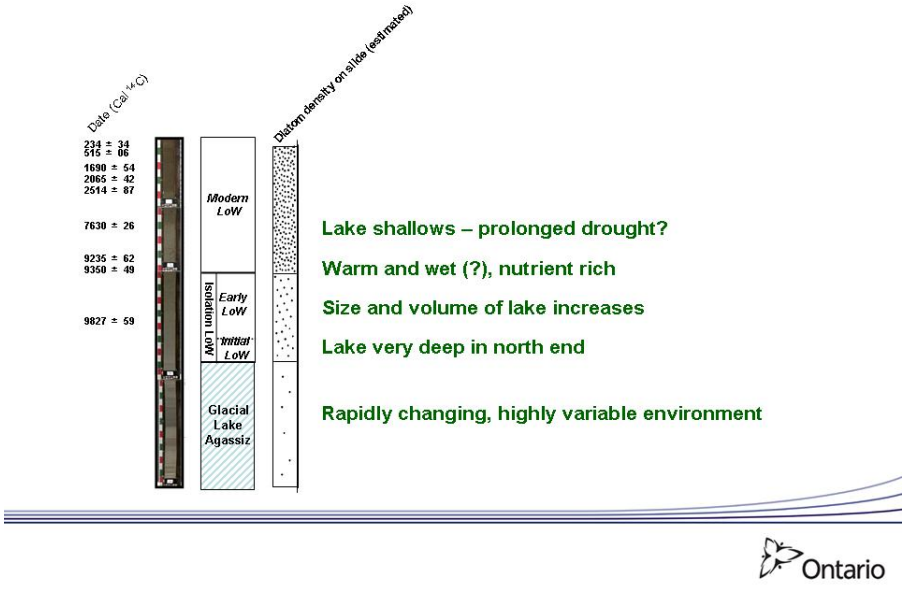
Clare is a PhD student working in the Paleoecological Environmental Assessment and Research Lab (PEARL) at Queen's University (Kingston, Ontario, CANADA). Her paleolimnological-based research focuses on using diatom assemblages to study long-term environmental trends in Ontario lakes that sustain a Lake Trout population.

Tracking the environmental and developmental history of Lake of the Woods over the Holocene using diatoms and sedimentary chlorophyll *a*

Kathleen M. Rühland[1], Andrew M. Paterson*[2], K. Rentz[1], James T. Teller[3], and John P. Smol[1]

[1] Paleoecological Environmental Assessment and Research Laboratory, Department of Biology, Queen's University, Kingston, ON, Canada;
[2] Ontario Ministry of the Environment and Climate Change, Dorset Environmental Science Centre, Dorset, ON, Canada;
[3] Department of Geological Sciences, University of Manitoba, Winnipeg, MB, Canada.

Summary



Abstract

Differential isostatic rebound and climatic changes have played major roles in structuring algal production and diatom assemblages over the past ~11,000 cal yr B.P. in Lake of the Woods (LOW). During the Lake Agassiz phase, at the base of a sediment core retrieved from the north end of LOW, conditions were likely too unstable to support diatoms, as evidenced by the near absence of diatom remains, and sedimentary chlorophyll *a* concentrations below detection levels. During this unstable phase, magnetic susceptibility readings were at their highest. As LOW became isolated from glacial Lake Agassiz, diatoms established above trace levels, chlorophyll *a* concentrations increased, and magnetic susceptibility decreased and stabilized. At this time, the diatom assemblage was dominated almost exclusively by heavily-silicified *Aulacoseira* taxa, suggesting that this relatively short-lived, initial LOW phase was characterized by a relatively deep and well-mixed water column. A sharp shift in dominance from *Aulacoseira* to small, benthic fragilarioid taxa (from ~9775 to 9350 cal yr B.P.) suggests a shallowing of LOW during its southward transgression and areal expansion during a warmer and drier climate. Moderate relative abundances of *Stephanodiscus medius* at this time, together with increases in chlorophyll *a*, suggests that this warm and dry period was also characterized by higher nutrient concentrations. The modern LOW phase (post ~9350 cal yr B.P.) commenced with a return to deeper, well-mixed conditions consistent with a warmer and wetter climate. The most prominent shift in the diatom record occurred during the modern LOW phase (~7630 cal yr B.P.), with an increase in *Aulacoseira* and *Stephanodiscus* taxa, declines in small benthic diatoms, and an abrupt increase in chlorophyll *a*, collectively suggesting a further increase in nutrients. The trend of increasing chlorophyll *a* and planktonic diatoms, concurrently with declines in benthic diatom

taxa, continued to the top of the sediment core. The data we present strongly suggest that LOW has been nutrient-rich for most of its history, with relatively high primary production levels.

Brief Bio

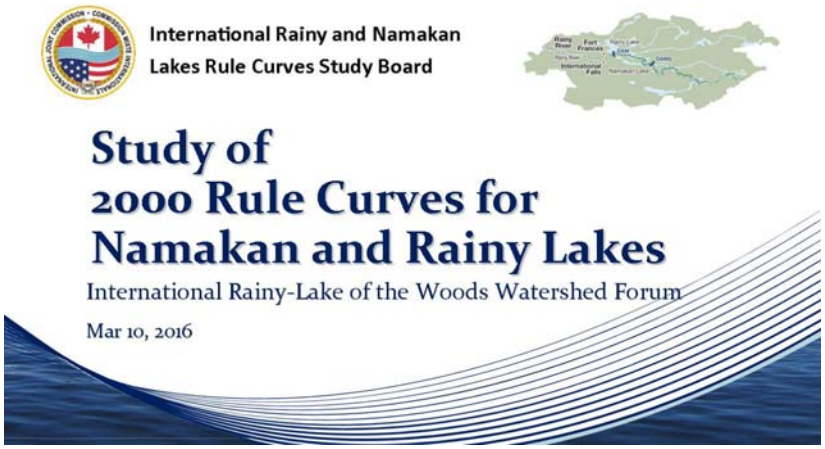
Dr. Kat Rühland is currently a Research Scientist at Queen's University with the Paleoecological Environmental Assessment and Research Laboratory (PEARL). Her research focuses on using diatom-based paleolimnological methods to study both spatial and temporal trends in climatic and environmental change, in both lakes and peatlands. Kat's research spans various temporal scales examining natural variations in the climate system throughout the Holocene as well as human-induced impacts from the turn of the 19th century to the present.

SESSION 5 – RAINY NAMAKAN RULE CURVE REVIEW

The Study of the International Rainy and Namakan Lakes Rule Curves Begins

Matt DeWolfe[1]; Col. Daniel Koprowski[2], Syed Moin[3]; Larry Kallemeyn[4]; Erika Klyszejko[1]; Pam Tomevi[5]; Scott Jutila[2]; Jean Morin[1], Bill Werick*[6]

[1]Environment Canada; [2]U.S. Army Corps of Engineers; [3]Independent Consultant; [4]Independent Consultant; [5]Koochiching Soil and Water Conservation District; [6]Independent Consultant



Abstract

Since adopting the Rainy Lake Convention in 1938, Canada and the United States have given the International Joint Commission (IJC) the authority to regulate the water levels to avoid emergency levels in Rainy Lake and Namakan Lake. The first formal regulations were established by the IJC in 1949 with the adoption of Rule Curves that described the lake elevation throughout the year which the owners of the dams that control the lake levels were required to target insofar as possible. When the most recent iteration of these rule curves were adopted in 2000, the IJC required a review of their effectiveness after fifteen years. In August of 2015, the IJC appointed the International Rainy and Namakan Lakes Rule Curves Study Board ("the Study Board"), and tasked it with conducting that review. The Board met with management agencies and stakeholders in September 2015 to launch the study.

The Study Board will review the 2000 Rule Curves using two approaches. First, it will consider the weight of evidence from nearly forty scientific studies examining what has happened regarding the lakes in the last fifteen years to judge whether the new rules met their intended objectives. The Board will also conduct a complementary Shared Vision Planning (SVP) analysis, which will allow the evaluation of the 2000 and alternative rule curves under a greater range of future water supply and climate scenarios. The Board will work closely with stakeholders and agency experts from beginning to end. The IJC created the Rule Curve Public Advisory Group (RCPAG) to review and provide comment on Study Board products and to serve as a conduit for public input and dissemination of study outcomes. The Study Board also established Resources Advisory Group (RAG) for natural resource management and protection agencies so that they can provide their expert advice on technical matters. The Study Board is in discussions with First Nations, Métis, and Tribes in the watershed that could be affected by changes to the regulation of Rainy Lake or the Namakan Chain of Lakes. The Study Board will hold public meetings in 2016 and is expected to issue a final report on its work in April 2017.

Brief Bio

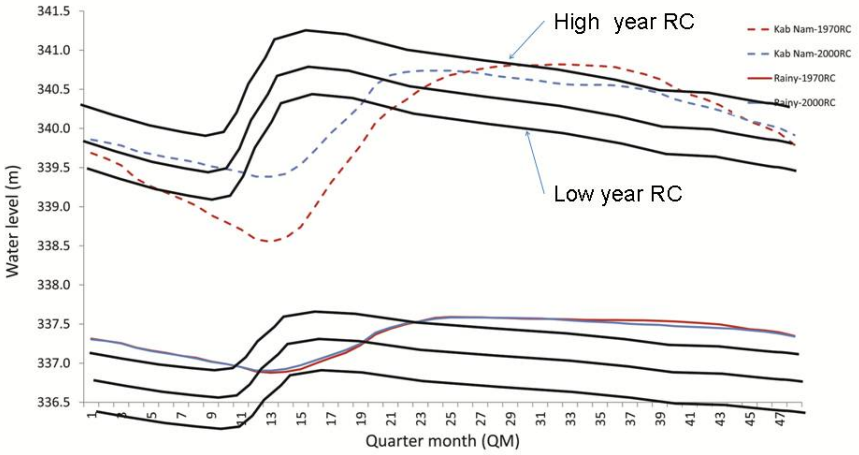
Matthew Dewolfe is Canadian Co-Chair of the International Rainy and Namakan Lakes Rule Curve Study of the International Joint Commission. Matt is also the Executive Engineer of the Lake of the Woods Secretariat, which provides water resource engineering advice to the Lake of the Woods Control Board and the Water Levels Committee of the International Rainy-Lake of the Woods Watershed Board.

Defining the Best Rule Curve for the Environment

Jean Morin* Marianne Bachand & Sylvain Martin

Meteorological Service of Canada, Environment Canada, 1550 avenue D'Estimauville, Québec City, Québec, Canada

Annual variability concept:
several rule-curves with trigger based on ice-out date



It is a difficult task to quantify the needed variability : the frequency and the amplitude…

Abstract

Rainy Lake and Namakan Reservoir are large water bodies, covering more than 1500 km² of aquatic and riparian habitats, on which water-levels have been managed since 1949. The present rule-curve (2000RC) is being reviewed in order to analyse its effect relative to the preceding rule-curve (1970 RC). Using a combination of 1D and 2D habitat models, we have developed a quantitative tool called the IERM (Integrated Ecosystem Response Model) that quantify the effect of water level fluctuations on several components of the biota. The modelling is based on a regular grid (20 m) on which several key physical variables are defined: water-levels, topography, hydroperiods (different time-scale), bottom slope and wind waves for all possible conditions at a quarter-monthly time-step. The habitat models are analysed with long term water-levels series representing historically measured levels, simulated natural levels and simulated levels based on the two rule-curves from 1950 to 2012.

In the IERM, we produced several 1D habitat models that evaluate the effect of water-level changes on wild rice, cattail, common loon nesting, walleye spawning and muskrat winter house sustainability. Based on literature, we identified the most sensitive period of their life cycle and analyzed the effects of water-level changes during these periods. We also developed spatially explicit 2D habitat models that quantify surface area of suitable habitat for wild rice, cattails, marshes, submerged and emergent plants as well as northern pike and walleye reproduction. For these models, we used a combination of logistic regressions and several time-related processes (drowning, drying, vegetation succession, etc.).

Each group has different periods of sensitivity toward water levels during the year or over several years. As an example, the loon nests are very sensitive to water level increase or decrease during spring time, during five weeks starting two weeks after ice out. The absolute level is less critical then the fluctuations during incubation. For muskrats, the most sensitive period is the variation of level during freezing months relative to the level during November. As they are building their wintering houses just before ice formation, large decrease (or increase) of water levels during winter prevent them to access their food source and remove the warming effect of water on their house resulting in muskrats' mortality. Walleye and northern pike eggs are laid in shallow water and are thus vulnerable to water level variations that could results in

eggs drying out or being in unsuitable deep water. Fish larvae are also vulnerable to water level variations because their movements are limited. They are however less sensitive than eggs as they float in the water and can thus follow increasing or receding water. Because these fish species spawn in shallow areas near the shoreline, higher water levels provide more abundant spawning habitat, especially for northern pikes which preferably lay their eggs on flooded vegetation.

From all habitat models, we can identify the characteristics of the water levels that would give the "optimal results" for each of the species or groups: minimum or maximum water levels, tolerable increase and decrease during critical periods. Once it is available for all groups, we can identify the fundamental properties of a "perfect" annual hydrogram that would be beneficial for most groups. Similarly, multiyear water levels have also to be addressed. Some species, like the invasive cattail, are favored when water levels are stable from year to year. Others, like wet meadows or wild rice, are favored by variable water levels from year to year. The "perfect" annual hydrogram can also be modulated year by year to take into account the particularity of those species or groups.

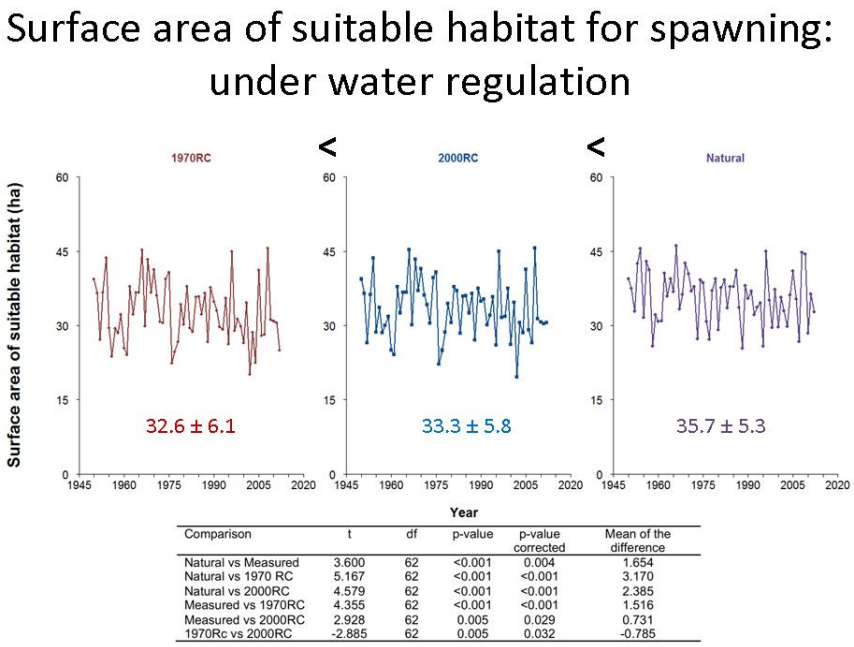
Brief Bio

Jean Morin is working for Environment Canada, as Chief Scientist for the Hydrology and Ecohydraulic section of the National Hydrological Services, since 1999. He holds a Bachelor degree in Geology from the Université Laval, a Master's degree in Earth Sciences (biostratigraphy) from the University of Ottawa and a PhD in Water Sciences from INRS. He has developed a large spectrum of ecohydraulic models in diverse aquatic environments for river, lake and riparian habitats. He is responsible for research projects on ecosystem modeling of the Rainy River, Rainy Lake and Namakan Reservoir. He is also active in the "International Rainy and Namakan Rule Curves Study Board", as member of the Technical Working Group.

Modeling the impact of water level regulation on spawning habitat of lake sturgeon in the Rainy River

Marianne Bachand*, Sylvain Martin, Olivier Champoux, Jean Morin

Hydrology and Ecohydraulic Section, Meteorological Service of Canada, Environment Canada



Comparison	t	df	p-value	p-value corrected	Mean of the difference
Natural vs Measured	3.600	62	<0.001	0.004	1.654
Natural vs 1970 RC	5.167	62	<0.001	<0.001	3.170
Natural vs 2000RC	4.579	62	<0.001	<0.001	2.385
Measured vs 1970RC	4.355	62	<0.001	<0.001	1.516
Measured vs 2000RC	2.928	62	0.005	0.029	0.731
1970Rc vs 2000RC	-2.885	62	0.005	0.032	-0.785

Abstract

Concern exists that change in the distribution of fish reproductive habitats, such as Lake sturgeon (*Acipenser fulvescens*), resulting from water level regulation could explain low recruitment in regulated water bodies. Lake sturgeon is considered threatened by water level regulation and many populations have been in decline since the early 1890s for this reason. Sturgeon abundance in the Rainy River is currently only a fraction of what it once was. Overfishing, habitat alterations, poor water quality, and damming of the river are believed to have played an important role in the decline of lake sturgeon. Water levels of Rainy River have been managed using different rule curves (RC) since 1949. The International Joint Commission (IJC) has guided the river discharge management with rule curves (RC) implemented in 1970 and 2000. The consequence of the two RC is a modification of the outflow of the Rainy Lake and the Rainy River. In order to quantify the effects on the lake sturgeon of present and past discharge management; we developed a 2D model of its spawning habitat. To do so, we first created a digital elevation model (DEM) of the river, along with a high density hydrodynamic model. The last one was used to generate a large amount of hydrodynamic scenarios that were integrated in an Integrated Ecosystem Response Model in 2D (IERM2D). We finally linked biological observations of lake sturgeon with physical variables obtained from simulated hydrodynamic variables in the 2D model habitat.

The hydrodynamic modeling was performed using the H2D2 (two-dimensional hydraulic model) from Institut National de Recherche Scientifique (INRS). The finite element mesh covers the area from the Fort Frances/International falls powerhouses to Manitou rapids. The model considers several lateral inflows such as the Little Fork River and the Big Fork River. The hydrodynamic model was calibrated and validated with 32 contrasted hydrological events. To cover all the hydrologic events possible on the Rainy River and its tributary, a total of 256 hydrodynamic simulations were produced.

The IERM2D grid covers the study area from the Manitou rapids to the International Falls dam. It is composed of nodes regularly distributed at a 10 m spacing. It is composed of 105 439 nodes where each of them represents a surface of 0.01 hectare so that the total surface covered by the grid is 1054.39 ha. The nodes are supporting the information from the seamless DEM and from the hydrodynamic results. Other physical constant variables such as slope and terrain curvature are also associated with each grid node. The IERM2D is used to compute the spawning habitat model in a quarter-monthly (QM) time-step over a long time period with discharge series. We assessed the influence of four discharge time series with QM time-steps ranging from 1950 to 2014: Measured, 1970RC, 2000RC and Natural. The 1970RC, 2000RC and Natural (absence of management) time series were simulated with a hydrologic response model balancing inflows, outflows and changes.

Using logistic regression and selection model procedures, we calibrated a model estimating the extent of suitable spawning and egg incubation habitat (SSEIH) using lake sturgeon data from the 2012 and 2013 field survey done by Adrienne Smith (team of Dr. Smokorowski). For each of the 27 surveyed sites (10 presences, 17 absences) in 2012 and the 188 sites (17 presences, 181 absences) in 2013, we interpolated relevant hydrological and environmental data during the spawning period (for example: bottom slope, water depth, velocity etc.). The calibration datasets compiled for model development were partitioned into disjoint estimation subsets (ES) and validation subsets (VS). For each such partition, only ES was used for modelling, whereas VS are involved in assessing the overall performances of the models and selection of the most suitable one, respectively.

The selected model was used to calculate a probability of spawning habitat presence. To ensure we predicted suitable habitat where conditions were appropriate for survival of lake sturgeon eggs, we limited suitable habitat using substrate and current velocity during the spawning period. Nodes where substrate was gravel, cobble or rubble, were classified appropriate for lake sturgeon eggs while nodes found in sand or vegetation were excluded. We also considered that no lake sturgeon eggs can be found in areas with water velocity exceeding 2 m/s. Finally, the total surface area of habitat suitable for spawning (SSEIH) was computed by multiplying the surface covered by each grid node for every year between 1950 and 2014 for every discharge series.

The best model explaining the distribution of spawning habitat was able to correctly classify 89.7% of the points used in the calibration. A good performance of the model was also suggested by a high The Cohen's kappa at 0.742, such as a high MacFadden Rho^2 at 0.591. The RMSE was low at 0.321; which also indicate a good performance of the model. The best model contained several variables averaged over the duration of spawning and incubation period: the terrain slope and curvature, Bottom Slope in Flow Direction (BSFD), water depth, and velocity. More precisely, lake sturgeon selected areas of shallow water, where the BSFD is low such as the velocity of the water, and where the river bottom slope is steeper and more convex compared to what is available.

We computed the SSEIH from 1950 to 2014 between International Falls dam and the Little Fork River outlet (limited by the substrate data layer). Results from the Measured water-level series can be split in two periods of different water-level management: 1975-2000, when discharge were managed according to the 1970RC, and 2000-2014, when water discharge were managed according to the 2000RC. The average amount of SSEIH during each period (respectively 35.3 ha ± 5.7; 34.3 ha ± 4.8 and 32.4 ha ± 6.5) and the temporal trends of SSEIH over the entire period suggest that these habitats have been relatively stable over the last 60 years. Also, our results show that SSEIH is around 35 ha in the study area for every managed time series (Measured: 34.2 ha ± 5.5; 1970RC: 32.6 ha ± 6.1; 2000RC: 33.3 ha ± 5.8). A slightly significant difference is detected even under the Natural time series (35.7 ha ± 5.3). Natural condition would have been more favorable for the availability of suitable habitat for spawning of the lake sturgeon.

Our model suggests that RC does not seem to reduce drastically the availability of suitable spawning sites for lake sturgeon. Trying to manage water discharge of Rainy River closer to natural conditions would improve availability of suitable spawning site for lake sturgeon. Our

model works in QM and discharge variations can vary quicker than this period of time. In consequence, some impacts may be not sizeable by the model. Also, since sturgeon abundance in the Rainy River had faced an important decrease historically, we propose to look at the impact of water level management on the habitat and survival of young-of-the year and on the water quality, important components of lake sturgeon survival and wealth.

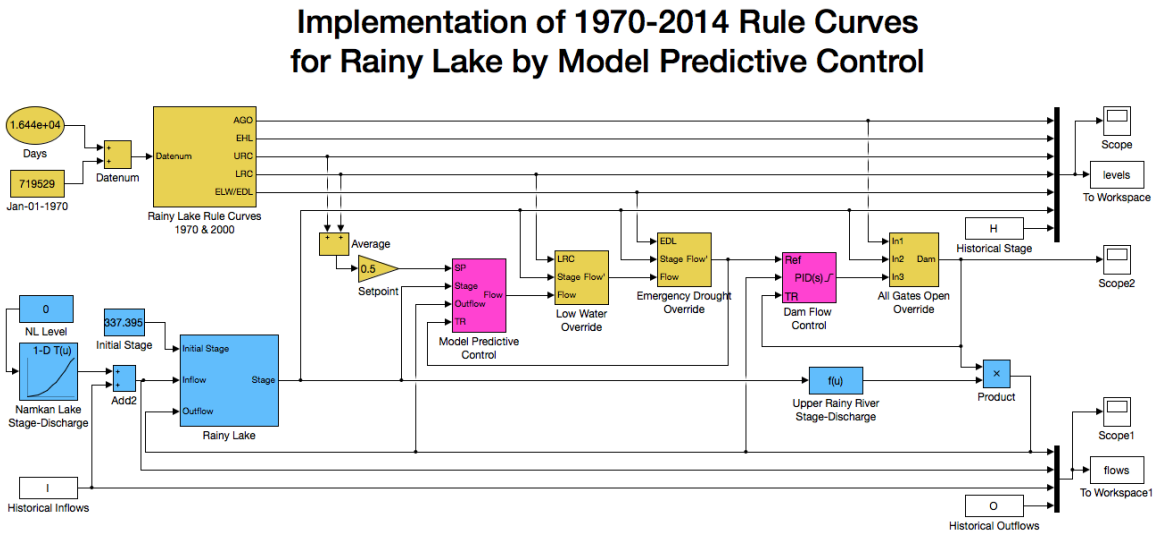
Brief Bio

Marianne Bachand is currently working as a postdoc in ecosystem modeling at Environment Canada. She holds a Bachelor degree in Biology from the Université de Sherbrooke (2001-2004) where she also completed a Master's degree in Environment in 2008. During her master she evaluated the impacts of tapir on vegetation dynamic in the Brazilian Atlantic forest. She later obtained a Ph.D. in plants biology at Université Laval. In her thesis she investigated the effects of white-tailed deer on the diversity of balsam fir stands. She has also contributed to research projects on ecosystem modeling of the Rainy Lake and Namakan Reservoir.

Multivariable Control of Lake Levels and Stream Flows in the Namakan Reservoir/Rainy Lake Watershed

Jeffrey C. Kantor*

Department of Chemical and Biomolecular Engineering, University of Notre Dame



Abstract

The purpose of this presentation is to demonstrate the utility of advanced, multivariable control to better regulate lake levels and stream flows in the complex system of lakes and control points comprising the the Rainy Lake of the Woods watershed.

Previous work presented at the 2015 RL/LOW watershed forum demonstrated the construction and tuning of Kalman filters for estimating unmeasured inflows to Rainy and Namakan lakes, and demonstrated the benefit of coordinating control of the dams at International Falls and Kettle Falls for the purpose of regulating lake levels within existing rule curves.

This study extends that work by implementing advanced control strategies to control lake levels subject to current rule curves. Model predictive control is a strategy that uses available measurements of Rainy Lake and Namakan Lake levels, a tracking filter to measure ungaged inlet flows, a model of the two reservoir system, and a prediction horizon to estimate an optimal control trajectory. In this instance the control variables are the daily configurations of the dams located at International Falls, Kettle Falls, and the Seine River system. Realtime feedback control is achieved by daily updates of the optimal control trajectory in response to new measurements.

Model predictive control is a proven, robust method for multivariable control, and should provide significantly improved control of Rainy Lake levels with minimal changes to current rule curves. Simulation demonstrates improved performance is a result of coordinating the control among dams, of the use of reservoir models to anticipate need changes in outflows, and incorporating realtime measurements of lake levels and river flows.

This is ongoing work. Current status of this work is available at this site: http://jckantor.github.io/Rainy-Lake-Hydrology/.

Brief Bio

Jeffrey C. Kantor is Professor of Chemical and Biomolecular Engineering at the University of Notre Dame. His research interests are in the application of control theory to a range of engineering applications including the integrated finance and control of process operations, network analysis, and model predictive feedback control. His teaching interests are in Chemical Engineering, and the ESTEEM program at Notre Dame.

SESSION 6 – REMOTE SENSING, MONITORING & MODELING

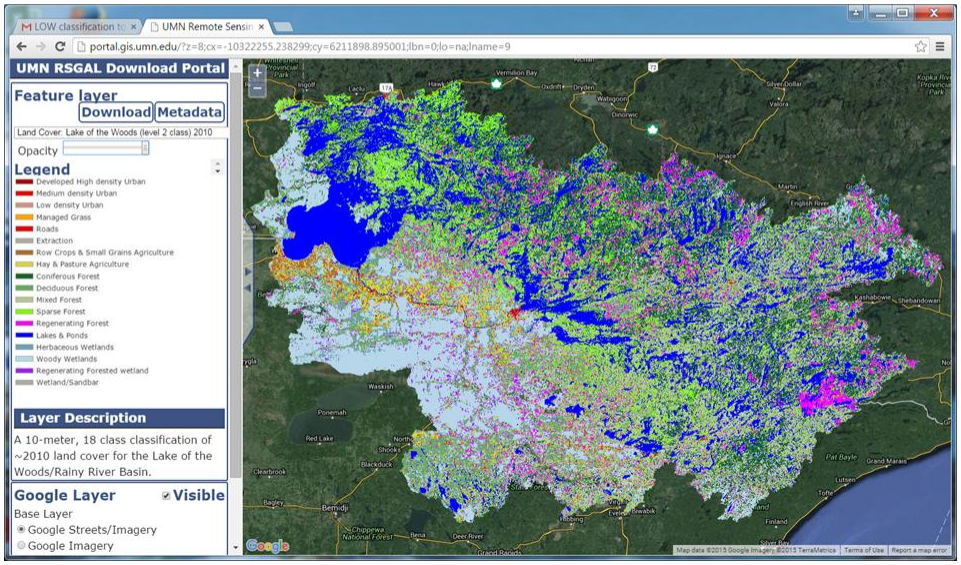
Improved land cover classification of the Lake of the Woods/Rainy River Basin for 1990 and 2010: by integrating Landsat imagery with LiDAR and object-based image analysis

Leif G. Olmanson* and Marvin E. Bauer

Department of Forest Resources and Remote Sensing and Geospatial Analysis Laboratory, University of Minnesota, St. Paul, Minnesota 55108

Data Available to View or Download at the Remote Sensing and Geospatial Analysis Laboratory New Data Portal

http://portal.gis.umn.edu/



Abstract

The recent availability of LiDAR data throughout Minnesota U.S.A. has opened up many opportunities for improved land cover classification and mapping. To utilize information such as multispectral data from Landsat TM imagery and LiDAR point cloud and topographic metrics we utilized an object-based image analysis (OBIA) implemented in eCognition software with random forest classification. By using objects instead of pixels we were able to utilize multispectral data along with spatial and contextual information of objects such as shape, size, texture and LiDAR-derived metrics to distinguish different land cover types. While OBIA has become the standard procedure for classification of high resolution imagery we found that it works equally well with 30-meter Landsat imagery.

These methods were utilized to create land cover maps and land cover change maps for the ~1990 and ~2010 time periods of the LOW/Rainy River Basin to use for inputs to hydrologic models and analyses of land cover and land cover change. The LOW/Rainy River Basin covers around 70,000 km^2 in northern Minnesota U.S.A. and south western Ontario, Canada and requires four paths of Landsat imagery (26, 27, 28 and 29). Although the LiDAR data was the most beneficial for the Minnesota portion (45% of the basin) of the 2010 classification, accuracy for each time period and for the entire basin improved for some land cover classes due to better identification of training data in the Landsat imagery.

To classify the land cover for the LOW/Rainy River Basin we used multitemporal Landsat imagery from spring and summer. DEMs were used to derive slope, compound topographic index (CTI) and dissection while the point cloud data were used to create vegetation height layers. We used eCognition to segment the imagery and extract the spectral and derived spatial and contextual information for each object. Decision tree classification using random forest enabled taking advantage of the unique differences in these data and determination of the most significant data features for distinguishing among cover types.

The presentation will describe the methods and results of this project, including the features found to be most significant for land cover classification, accuracy of the classification with and without LiDAR, and land cover changes from 1990 to 2010 for the Lake of the Woods/Rainy River Basin. The land cover and change maps are available for download and to view in a "Google Maps" type interface in our data portal at http://portal.gis.umn.edu/.

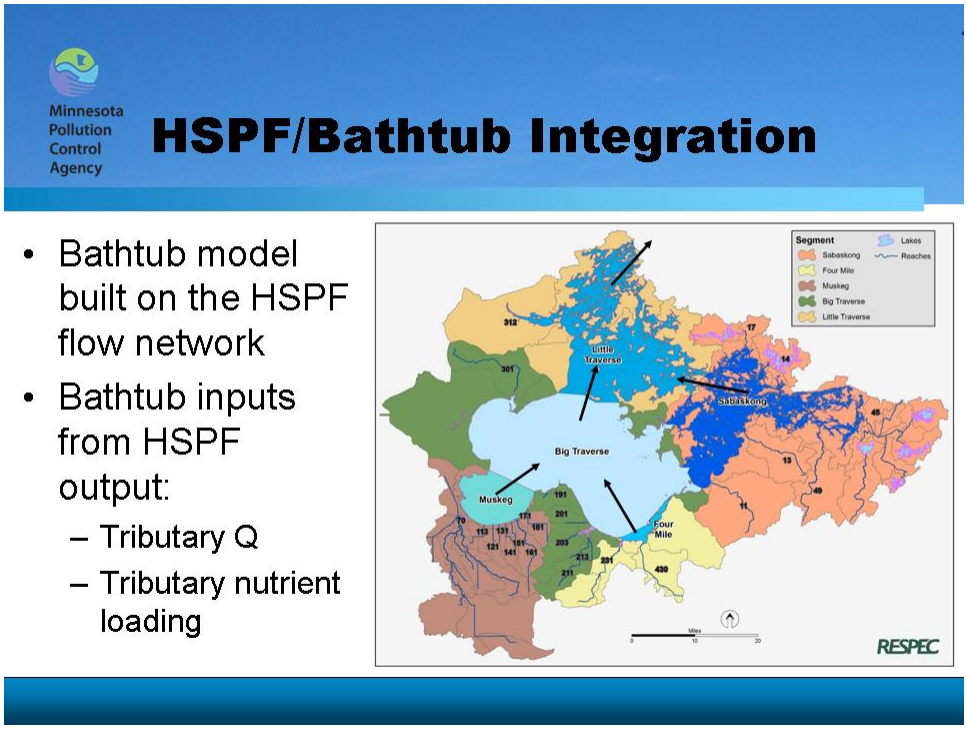
Brief Bio

Leif Olmanson is a Researcher at the University of Minnesota with 20 years experience developing remote sensing applications to create temporally and spatially rigorous datasets of water and land resources for large area ecosystem characterization. Applications include land cover mapping using multispectral imagery and lidar data with object based image analysis in conjunction with random forest classifier and lake and river water quality and aquatic plant assessment using multispectral and hyperspectral imagery. His current research is focused on utilizing new enhanced satellite systems such as Landsat 8 and Sentinel-2 for comprehensive measurement of CDOM, chlorophyll and mineral suspended sediments in optically complex inland waters. He is particularly interested in utilizing cutting edge geospatial analysis to gain a better understanding of the natural environment.

Lake Of The Woods Total Maximum Daily Load Study: A progress report

Hernandez C.*[1], Hirst M.[2], Kramer, G.[3]

[1]Minnesota Pollution Control Agency, Detroit Lakes, MN; [2]Lake of the Woods Soil and Water Conservation District; [3]RESPEC Water & Natural Resources, Roseville, MN



Abstract

In 2008, the United States Environmental Protection Agency placed the Lake of the Woods on the "Impaired Waters List" for failing to comply with water quality standards conducive to aquatic recreation. The United States Clean Water Act requires states to perform Total Maximum Daily Load (TMDL) studies on their impaired waters. TMDL studies identify water quality standards and goals/targets for U.S. waterbodies, recommend pollutant load allocations where waters do not meet standards, and provide opportunities for stakeholders and communities to engage in the process of watershed management planning to adopt protection and restoration practices. In 2015, the Minnesota Pollution Control Agency, in partnership with the Lake of the Woods Soil and Water Conservation District and RESPEC Water and Natural Resources, began working on the Lake of the Woods TMDL study.

The Lake of the Woods TMDL study utilizes two different models, both updated with the most recent available data. The Hydrologic Simulation Program – Fortran (HSPF) is a calibrated watershed model of the Rainy River and immediate Lake of the Woods Watersheds. The HSPF model is used to assess pollutant sources and source contributions. The HSPF model results are subsequently used as inputs into the BATHTUB lake model. The BATHTUB lake model is used to determine the loading capacity of the lake, including internal loading. Combined, the two models are used to develop allocations for pollutant load reductions, margins of safety, and future growth. This presentation will provide an update on the methodology, results, and preliminary findings of the TMDL study's modeling efforts to date.

Brief Bio

Cary Hernandez is a Watershed Project Manager working out of the Minnesota Pollution Control Agency's (MPCA) Detroit Lakes Office. He works with watersheds throughout the Red River

Valley and the Lake of the Woods/Rainy River Basin. Cary has been with the MPCA for the past 25 years.

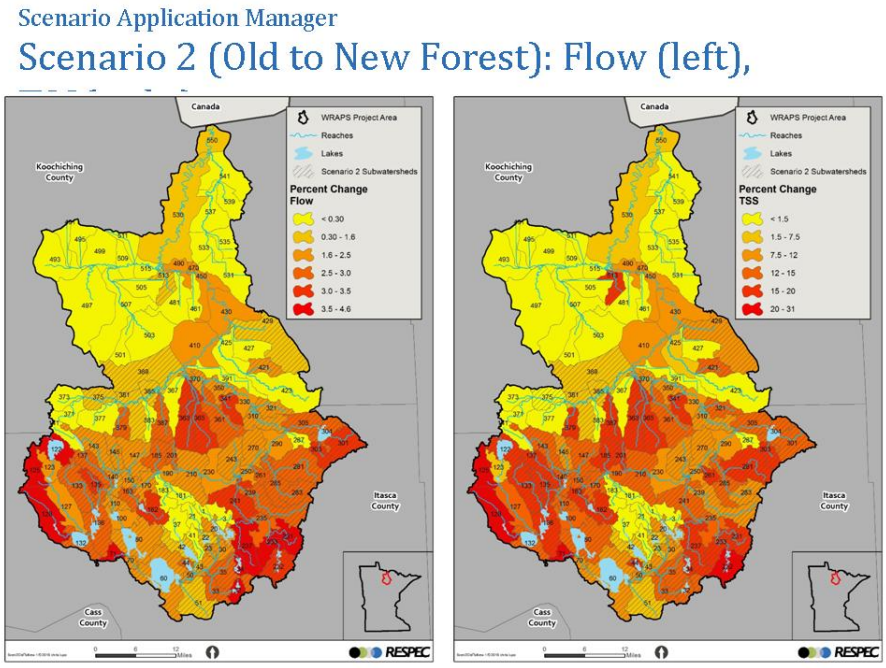
Mike Hirst holds a B.S. in Geology and Technology from the University of North Dakota and has been employed for LOW SWCD for 12 years. His background in natural resources conservation includes: water quality monitoring, calculating annual loading rates on streams, local water management planning, wetland conservation, aquatic invasive species, working with private landowners on water quality projects and compliance with regulations, education and outreach and serving on local and international boards and committees for water quality in the Rainy – Lake of the Woods Watershed. As a native to northern Minnesota, Hirst is very familiar with the local, state and international resources of Lake of the Woods.

Geoff Kramer holds and M.S. in Biosystems and Agricultural Engineering from the University of Minnesota. He has extensive experience with hydrologic and water quality modeling in diverse areas such as snowmelt modeling and lake nutrient modeling. He has extensive experience with agricultural drainage design, policy, and related water quality BMPs. He also has experience with economic analysis and complex analysis related to cost effectiveness of BMPs and BMP treatment trains.

Implementing the Scenario Application Manager (SAM) in the Big Fork Watershed

Christopher D. Lupo*

RESPEC Water & Natural Resources, Rapid City, SD



Abstract

Watershed managers have few tools at their disposal for developing the best strategies to prevent degradation of high quality waters while also examining restoration strategies for impaired waters. The Scenario Application Manager (SAM) is a watershed-scale, decision-support tool developed on behalf of the MPCA that consists of a Geographic Information System (GIS) for targeting protection and implementation activities, a Hydrologic Simulation Program – Fortran (HSPF) model application to simulate nutrient fate and transport, and a best management practice (BMP) database. SAM assists in developing custom strategies for protection, prioritization, and BMP implementation plans by combining individual and/or suites of BMPs and land use changes to develop scenarios that simulate the potential changes to water quality and quantity. The combination of the graphical interface, a state-accepted watershed model, practical BMPs, flexible scenario development, and cost optimization bridges a gap between watershed characterization by water resource engineers and the water resource managers who ultimately develop protection, implementation and nutrient reduction plans. SAM was used in the Big Fork Watershed Restoration and Protection Strategy (WRAPS) project to investigate the potential impact of intensification of agriculture, forest harvest rates, mining, and increases in lake shore development on water quality. Climate change scenarios are in development. This presentation will give an overview of SAM, explain how it was implemented in the Big Fork Watershed, and provide initial results of the landuse change and climate change scenario analysis.

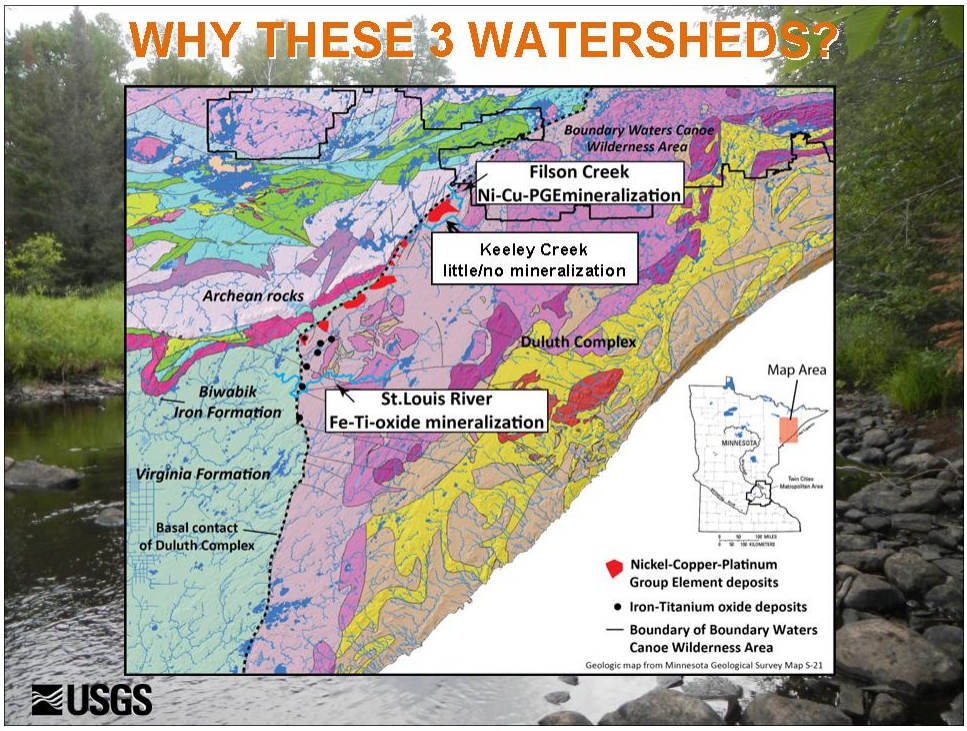
Brief Bio

Mr. Lupo is an environmental engineer with several years' experience modeling several of Minnesota's major river basins. As a member of RESPEC's HSPF Modeling Team, he has been responsible for development of basin models for the Lake of the Woods, Minnesota River, Mississippi River Headwaters and Rum River Basins. His experience covers a wide range of watershed types ranging from pristine forest and lake-dominated systems in northern Minnesota, to the heavily cropped, eutrophic systems throughout the Minnesota River and Missouri River Watersheds.

Assessing the influence of copper-nickel-bearing bedrock on baseline water quality in three northeastern Minnesota watersheds

Jones P.M.[1], Elliott S.M*,[1], Woodruff L.G.[1], Seal, R.R. II[2], Piatak N.[2], Runkel R.L.[3], Hauck S.[4], Monson Geerts S.[4], Jennings C.[5]

[1]U.S. Geological Survey, Mounds View, MN; [2]U.S. Geological Survey, Reston, VA; [3]U.S. Geological Survey, Boulder, CO; [4]Natural Resources Research Institute, University of Minnesota Duluth; [5]Minnesota Department of Natural Resources



Abstract

Researchers from the U. S. Geological Survey, the Natural Resources Research Institute, and the Minnesota Department of Natural Resources conducted a three-year study to 1) assess copper, nickel, and other metal concentrations in surface water, bedrock, streambed sediments, and soils in watersheds where the basal part of the Duluth Complex is exposed or near the land surface; and 2) determine if these concentrations, and metal-bearing deposits, are currently influencing regional water quality in areas of potential base-metal mining. Surface-water, streambed sediment, soil, and bedrock samples were collected and analyzed in three largely undisturbed watersheds with different mineral-deposit settings: (1) copper-nickel-platinum group metal mineralization (Spruce Road deposit - Filson Creek watershed), (2) iron-titanium-oxide mineralization (Skibo deposit – upper part of the St. Louis River watershed), and (3) no identified mineralization (Keeley Creek watershed).

Within each watershed, surface-water samples were collected from multiple sites at 10 different sampling times over a three-year span. Surface-water samples were analyzed for 12 trace metals (dissolved and total concentrations), 14 inorganic constituents (dissolved concentrations), alkalinity, $^{18}O/^{16}O$ and $^{2}H/^{1}H$ isotopes, and total and dissolved organic carbon. Streambed-sediment samples were collected at each water-quality site, and 10 to 15 bedrock samples and 15 nearby soils samples were collected per watershed and analyzed for 47 major and trace elements. Streamflow was monitored in the three watersheds at continuous streamflow gages and through discharge measurements conducted at all sites during each water-quality sampling event. A tracer test was conducted in Filson Creek watershed where copper concentrations in stream waters were relatively high, ranging from 4 to 12 micrograms per liter (µg/L), to determine streamflow characteristics.

The geochemistry of surface waters and streambed sediments reflects the geochemistry of underlying rock types and glacially transported unconsolidated material. Preliminary interpretations of water-quality data also suggest that streamflow influences concentrations of major constituents, such as Ca, Mg, and K, with lower concentrations during high flow, but has little apparent influence on metal concentrations. Copper-nickel mineralization in the northern Filson Creek watershed contributes both metals to stream waters and streambed sediment. Dissolved and total organic carbon (DOC and TOC) concentrations in surface waters are very high compared to most surface waters in Minnesota, ranging from 13.7 to 41.4 milligrams per liter (mg/L) in all watersheds. Results from preliminary biotic-ligand modeling suggest that the high DOC content may exert some control on copper concentrations in water, such that complexation with DOC may reduce the bioaccessibity of copper. In the Filson and Keeley watersheds, glacial transport distances of sediments were interpreted to be short, and soil chemistry can be related to nearby bedrock contributions to soil parent materials. For example, mineralized bedrock has relatively high copper concentrations greater than 4,500 milligrams per kilogram (mg/kg) and soil contains has copper concentrations greater than 1,000 mg/kg over the footprint of the Spruce Road deposit in the Filson watershed. The upper part of the St. Louis watershed has thick glacial cover with minimal bedrock exposure, and soil chemistry is more indicative of glacial transport processes.

Brief Bio

Perry Jones is a hydrologist for the U. S. Geological Survey, Minnesota Water Sciences Center where he has conducted water resources research for 19 years. He received his B.S. in Geology from State University of New York at Cortland and his M.S. in Geology at the University of Minnesota. He previously worked for 7 years at the U.S. Bureau of Mines. Besides his hydrologic research into baseline characterization of potential mining areas in northern MN, Perry is assessing groundwater/surface water interactions in White Bear Lake and other Twin Cities Metro lakes.

POSTER SESSION ABSTRACTS

Cattail invasion and the re-establishment of wild rice

John Kabatay*[1], Kristi Dysievick[2], Dr. Peter Lee[2]

[1]Seine River First Nation; [2]Department of Biology, Lakehead University

Abstract

The exotic narrowleaf cattail, *Typha angustifolia* and the hybrid *T. glauca* (*T. latifolia x T. angustifolia*) are extremely successful invasive wetland plant species. Due to their overlap in habitat preference, the cattails have displaced large amounts of native wild rice populations in the Seine River and Rainy Lake Watersheds. In 2014 Rat River Bay a once thriving wild rice site had a cattail population that dominated large sections of the bay. In the fall of 2014, SRFN conducted cutting trails of cattails in Rat River Bay using a cutting bar apparatus attached to an airboat. The cutting bar is lowered into the water and cuts cattails just above the sediment:water interface. The theory to support this procedure is that the dead above water stems of the cattails provide oxygen to the rhizomes in the anaerobic sediment in the winter. Without the stems, the rhizomes die off and are unable to reproduce vegetatively the next spring. This cutting procedure proved to be remarkably successful with little to no cattail re-establishment within the treated areas. Adding to the success was the cut area being re-established with wild rice the next growing season with no need for reseeding.

Brief Bio

John Kabatay is a councillor for Seine River First Nation. He is also responsible for supervising natural resources development projects and works closely with Lakehead University

Kristi Dysievick is a Master student in the department of Biology at Lakehead University. Miss. Dysievick completed her honours bachelors of water resource at Lakehead University in 2013. Kristi has experience working in Lakehead University Environmental Laboratory, which is an ISO 170025 accredited Laboratory. Her thesis is focusing on the re-establishment of Wild Rice and the potential influence of cattails on sediment characteristics which may be detrimental for Wild Rice development, growth and productivity.

A multi-disciplinary examination of the effects of climate change in the *deciduous-boreal forest* ecotone of northern Minnesota and northwestern Ontario

N. Baratono*[1], A. Paterson[2], K. Rühland[3], M. Edlund, L. Frelich, W. Herb, P. Jacobson, T. McDaniel, S. Malick, T. Pascoe, E. Reavie, M. Seeley and S. Windels

[1] Minnesota Pollution Control Agency (retired), International Falls, MN, USA; [2] Ontario Ministry of the Environment and Climate Change, Dorset Environmental Science Centre, Dorset, ON, Canada; [3] Paleoecological Environmental Assessment and Research Laboratory, Department of Biology, Queen's University, Kingston, ON, Canada.

Abstract

The International Rainy-Lake of the Woods (IRLOW) Basin, bounded on the east by the Lake Superior Basin and the west by the Red River Basin, straddles the border between Canada and the United States. Coincidentally, the basin also straddles the ecotone between the deciduous forest and boreal forest biomes in northern Minnesota and northwestern Ontario. Although ecological responses to climate change have been observed worldwide, they can be particularly well expressed at ecotonal boundaries because this is where many species are living near their ecological (physical, competitive) limits. At forest ecotones, strong responses in terrestrial and aquatic systems to past climate change have been recorded by paleoecological studies.

Researchers and resource managers from across the Basin have reported changes to aquatic and terrestrial ecosystems that are directly attributable to recent climatic change. Altered precipitation patterns, increases in air temperature, various phenological changes, and changes to aquatic and terrestrial communities have occurred since the late-1970s. Paleolimnological data suggest that these changes are recent and unique to the last several hundred years.

This synthesis summarizes multidisciplinary data documenting changes attributable to climate change that are occurring to the terrestrial and/or aquatic environments within the IRLOW Basin. The collaborators have summarized data from published works and works in progress. This synthesis documents the warming that has occurred in the IRLOW Basin and provides a benchmark for researchers to use for future research.

Brief Bio

Nolan started his career in environmental science in 1969 teaching marine biology at an outdoor school on the California coast. He got sidetracked along the way with several years as an owner/operator of a whitewater guide service among other things. In the 1980s he returned to environmental science working for local governments in Minnesota. In 1996 he moved to the Minnesota Pollution Control Agency (MPCA). In 2015 Nolan retired from his position as a watershed ecologist with the MPCA. He is currently enjoying retirement and keeping a hand in watershed ecology as a consultant.

Results of the Seine River Temperature Project

Ryan Haines*

Seine River First Nation, P.O. Box 124, Mine Centre, ON P0W 1H0

Abstract

In 1926, the Sturgeon Falls Generating Station was constructed along the Seine River to create hydroelectric power and this facility is currently operated by H2O Power. One of the major threats to lake sturgeon is the impact of peaking hydroelectric developments on the water levels during the spring spawning season. The purpose of the Seine River Temperature Project is to help define the spring spawn for Seine River sturgeon through surrogate environmental indicators and note any effects of peaking on spawning. In addition, a goal of the project was to determine if the increases in water levels at the Seine River First Nation community are due solely to the flow from the Seine River, or if the dam at the outlet of Rainy Lake affects the water levels resulting in the Seine River functioning as a reservoir.

Between 2011 and 2015, Seine River First Nation community technicians studied the spawning timing of lake sturgeon at two important spawning sites in Seine River below the Sturgeon Falls dam to help determine the environmental indicators (temperature, photoperiod, flows) for lake sturgeon spawning. In addition, work was done with Seine River First Nation Elders and knowledge holders in the fall of 2012 to identify Traditional Ecological Knowledge (TEK) indicators for lake sturgeon spawning in Seine River. This TEK study resulted in field observations of poplar leaf size and tiger swallowtail butterflies during the spring of 2013, 2014, and 2015 to determine the relationship between these environmental indicators and the lake sturgeon spawning timing. Adult and juvenile lake sturgeon netting and tagging was conducted in partnership with Ontario Ministry of Natural Resources and North-South Consultants.

The project results indicate that water temperature, photoperiod, and observations of tiger swallowtails are three environmental indicators of lake sturgeon spawning on the Seine River. The lake sturgeon spawning occurred as soon as the water temperature reached 13˚C as long as this temperature was reached when the photoperiod was between 15 hours, 49 minutes and 15 hours, 52 minutes. Tiger swallowtails were first observed each season approximately at the time of the lake sturgeon spawn and no more than four days from the peak spawning activity on Seine River. The peaking water levels/flows from the Sturgeon Falls dam did have the potential to negatively impact upon the spawning success of lake sturgeon in the Seine River in 2011 and 2014, which was one-half of the spawning seasons where data was available (no data for 2013). The results of the juvenile and adult lake sturgeon netting/tagging data from 2011 to 2015 provides strong evidence that the Seine River provides important spawning and rearing habitat for lake sturgeon but appears is only used by adult lake sturgeon for spring spawning. Water level data collected during this project provides evidence that the dam at the outlet of Rainy Lake does affect the water levels in Seine River, and that the Seine River from its outlet to Rainy Lake at Kettle Point upstream to the Highway 11 bridge does function as a reservoir, particularly during years of high levels on Rainy Lake.

Brief Bio

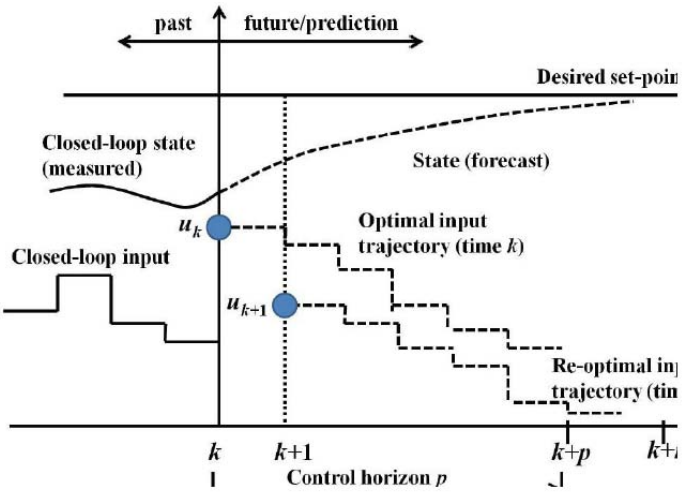
Seine River First Nation has always acted as the stewards of the natural resources in our traditional territory. In recent years, we have begun to reach out to the scientific community to blend our Aboriginal Traditional Knowledge (ATK) with Western Science to better protect the fish, animals, and plants in the Seine River watershed. Initiatives such as the Seine River Contaminants Project (conducted in partnership with Lakehead University), wild rice studies, and the lake sturgeon projects on Seine River and Turtle River are important steps to bridging the gap between two world views and ensure that all available information is utilized to enable the protection of existing populations and recovery of threatened ones in our traditional territory.

Multivariable Control of Lake Levels and Stream Flows in the Namakan Reservoir/Rainy Lake Watershed

Jeffrey C. Kantor*

Department of Chemical and Biomolecular Engineering, University of Notre Dame

Abstract



The purpose of this presentation is to demonstrate the utility of advanced, multivariable control to better regulate lake levels and stream flows in the complex system of lakes and control points comprising the the Rainy Lake of the Woods watershed.

Previous work presented at the 2015 RL/LOW watershed forum demonstrated the construction and tuning of Kalman filters for estimating unmeasured inflows to Rainy and Namakan lakes, and demonstrated the benefit of coordinating control of the dams at International Falls and Kettle Falls for the purpose of regulating lake levels within existing rule curves.

This study extends that work by implementing advanced control strategies to control lake levels subject to current rule curves. Model predictive control is a strategy that uses available measurements of Rainy Lake and Namakan Lake levels, a tracking filter to measure ungaged inlet flows, a model of the two reservoir system, and a prediction horizon to estimate an optimal control trajectory. In this instance the control variables are the daily configurations of the dams located at International Falls, Kettle Falls, and the Seine River system. Realtime feedback control is achieved by daily updates of the optimal control trajectory in response to new measurements.

Model predictive control is a proven, robust method for multivariable control, and should provide significantly improved control of Rainy Lake levels with minimal changes to current rule curves. Simulation demonstrates improved performance is a result of coordinating the control among dams, of the use of reservoir models to anticipate need changes in outflows, and incorporating realtime measurements of lake levels and river flows.

This is ongoing work. Current status of this work is available at this site: http://jckantor.github.io/Rainy-Lake-Hydrology/.

Restoration of Hybrid Cattail Dominated Wetlands in Voyageurs National Park

Bryce T. Olson* & Steve K. Windels

National Park Service Voyageurs National Park, 360 Highway 11 E, International Falls, MN 56649

Abstract

The non-native narrowleaf cattail (*Typha angustifolia*) has the ability to hybridize with native broadleaf cattail (*Typha latfolia*) creating what is commonly known as 'hybrid cattails' (*Typha x glauca*). This aggressive hybrid is known to disrupt ecosystem balance by creating dense monotypic stands which displace native species and reduce biological diversity. Hybrid cattail is the dominant species in most wetlands in Voyageurs National Park, MN. A new project starting in 2016 aims to reduce cattail abundance to help restore these wetlands to more diverse, natural states to improve habitat for wildlife, fish, and other taxa. We plan to test various methods to remove invasive cattails and restore native plant species in Rainy and Kabetogama Lakes, designated as "Outstanding Resource Value Waters" where the use of herbicide is prohibited. Proposed methods of treatment include: harvest barges, hand tools, burning, freezing, and combinations of these methods timed with water level changes which are regulated under specific rule curves. We also are exploring the role of muskrats (*Ondatra zibethicus*) as natural biocontrol of cattails, including their role in creating and maintaining open water in large patch of cattails.

Brief Bio

Bryce Olson is a biologist for Voyageurs National Park where he has worked since 2008. He holds a Bachelor of Science in Fish & Wildlife Biology and a Master of Science in Biology. At Voyageurs, Bryce has worked on a variety of projects including forest restoration, air quality monitoring, and multiple wildlife research studies on moose, deer, bears, wolves, beaver, cormorants, and eagles. He is currently involved in a project to reduce exotic cattail abundance to help restore wetland habitats to a more diverse natural state.

Developing a stressor-response model for Red River of the north

Tony Miller[1] and Julie Blackburn[2]

[1]RESPEC, Lexington, KY; [2]RESPEC, Roseville, MN

Abstract

The purpose of this project was to define potential nutrient management thresholds based on biological stressor-responses for nutrients, suspended sediments and other parameters for the Red River of the North (RRN) mainstem sites from its headwaters to Lake Winnipeg. An international team of experts helped direct this International Joint Commission sponsored project along with representatives from North Dakota, Manitoba, Minnesota and the two federal governments. The RRN, a major North American river flowing from the US to Canada, contributes about 16% of the flow and 68% of phosphorus loading to Lake Winnipeg. While the RRN's contribution to eutrophication in Lake Winnipeg is well documented, it has been the general belief that light limitation due to the river's turbid nature limits a eutrophication response in the river itself. A conceptual model of potential stressor-response relationships for the Red River was developed. Then to further investigate the relationship between the nutrient gradient in the river and algal response, extensive river algal (periphyton and phytoplankton) and water quality monitoring was collaboratively conducted by North Dakota, Minnesota, Manitoba, and the Canadian federal government over the summer of 2015. Data collected were analyzed with various indices of pollution tolerance and statistical approaches to determine algal response to stressors. Once key stressors are identified, biological thresholds along a stressor gradient will be determined through statistical analysis tools. This information will be submitted to the International Red River Board's Water Quality Committee which is tasked with developing a plan and process for developing a nutrient management strategy for the RRN.

Note: This is a project that is currently active. The results of this project are expected to be substantially complete by March 2016.

Brief Bio

Tony Miller holds a M.S. in Zoology, North Dakota State University, Fargo, ND. His specific interests lie in watershed-scale assessments and remediation with an emphasis on the ecology of streams, rivers, lakes, and wetlands as well as the ecology of endangered bats. He is a trained wetland and stream delineation expert with an emphasis on design, and he is well-versed in the water quality certification process for 401, 402, and 404 permits. Mr. Miller routinely provides ecological data analysis services through Microsoft Excel, Canoco, PC-ORD, and Hyperniche

Julie Blackburn holds a M.S. in Environmental and Forest Biology - System Ecology Emphasis, State University of New York College of Environmental Science and Forestry, Syracuse University, Syracuse, NY. She has over 17 years of professional experience working in a leadership capacity in watershed protection and implementation, water resource management, and providing overall strategic management of natural resource programs.

Mine-Impacted-Water Threats from the St Louis River Watershed to the Lake of the Woods

Tom Myers*

Hydrologic Consultant, 6320 Walnut Creek Road, Reno NV 89523

Abstract

The Peter Mitchell Pit (PMP) straddles the Laurentian Divide between the St Louis River and Rainy River Headwaters watersheds and create a surface water connection across the divide allowing water from the St Louis River watershed to ultimately drain to the Lake of the Woods. The PMP will be dewatered until about 2070 with water levels drawn down to less than 1400 feet above mean seal level (amsl). After 2070, a pit lake with water levels recovering to 1500 feet amsl, or about 100 feet lower than Polymet and near the same elevation as the Embarrass River headwaters, will discharge into the Birch Lake watershed. A groundwater flow and transport model of the St Louis River headwaters, modified to simulate dewatering and development of a long-term pit lake in the PMP, simulated contaminant releases from the proposed Polymet Mine and potential tailings impoundments near the Embarrass River flowing to the PMP. Contaminants could reach the PMP from Polymet in less than 100 years with a flux in 2070 of approximately 1200 m^3/d (220 gpm). The groundwater divide between Partridge and Embarrass River watersheds would shift north and add a large area of the Embarrass River watershed to a PMP capture zone for up to 50 years. This would draw more than 1100 m^3/d (202 gpm) with contaminants south to the PMP for about 50 years centered near the end of PMP mining operations. Contaminants entering the PMP would flow northward into the Rainy River Headwaters and beyond.

Brief Bio

Tom Myers is a hydrologic consultant who researches and consults on water resources and hydrogeology issues including mining and energy development, groundwater modeling, contaminant transport, and water rights. His clients include conservation groups and local governments. Tom has been working mine dewatering and contamination issues since 1993. He has M.S. and Ph.D. in Hydrology/Hydrogeology from the University of Nevada, Reno. Tom has recently published a paper in the *Journal of Hydrology* concerning the Rainy River Headwaters titled *Acid Mine Drainage Risks – A Modeling Approach to Siting Mine Facilities in Northern Minnesota USA*.

Meetings of Other Research / Working Groups Co-Located Around The Forum Program

The following invitational meetings of collaborative groups are co-scheduled independently around the Forum program

MARCH 8

10:30 – 12:30 **Lake of the Woods Total Maximum Daily Load Technical Advisory Committee**

- Room H-100, Rainy River Community College

13:00 – 14:00 **Rainy-Namakan Rule Curve Review Public Advisory Group**

- Room H-118, Rainy River Community College

14:00 – 16:30 **Rainy-Namakan Rule Curve Decision Workshop #1**

- Room H-118, Rainy River Community College

16:00 – 18:00 **International Multi-Agency Arrangement Technical Advisory Committee**

- Room H-100, Rainy River Community College

18:30 – 20:00 **Public Meeting – Rule Curve Review/Rainy-Lake of the Woods Watershed Board Water Levels Committee**

- Auditorium, Rainy River Community College

MARCH 9

10:00 – 12:00 **International Multi-Agency Arrangement Working Group**

- AmericInn Hotel

10:00 – 12:00 **IJC Rainy-Lake of the Woods Watershed Board Community Advisory Group**

- Room H-118, Rainy River Community College

10:00 – 12:00 **IJC Rainy-Lake of the Woods Watershed Board Industry Advisory Group**

- Room H-100, Rainy River Community College

10:00 – 12:00 **IJC International Watersheds Initiative Stressor Index Project (TBD)**

- Room SC-114, Rainy River Community College

Rainy-Lake of the Woods Watershed Forum
March 9 (12:00 – 21:00)

MARCH 10

Rainy-Lake of the Woods Watershed Forum
March 10 (08:00 – 17:00)

18:00 – 20:00 **Heart of the Continent Welcome Reception & Poster Session**

- AmericInn Hotel

MARCH 11

08:00 – 16:00 **Heart of the Continent Science Symposium**

- Auditorium, Rainy River Community College