Great Lakes Science for Parks Symposium 2023

Protecting, Restoring, and Reconnecting for the Next Generation: Addressing Emerging Issues in Great Lakes Parks

Sponsored by

NORTHLAND COLLEGE

This symposium highlights natural and cultural research and management occurring in, occurring around, or relevant to parks and public lands in the Great Lakes Region. It is a forum for natural and cultural resource managers, scientists and cooperators, and other interested parties to learn, network, and coordinate science and management efforts.

We hope that through expanded knowledge, capacity, and professional networks built in this symposium, tribal, federal, state, and local public lands managers and researchers are better prepared to address future questions that will support the resilience of public lands.

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1. Acknowledgements

Organizing Committee

Alan Brew – Northland College

Peggy Burkman – NPS Apostle Islands National Park

Bailey Adams – NPS Scientists in Parks Program

Marcus Key – NPS Great Lakes Restoration Initiative

Thomas Parr – NPS Great Lakes Inventory and Monitoring Network

Desi Robertson-Thompson – NPS Great Lakes Research and Education Center

Erin Williams – NPS Great Lakes Northern Forest; NPS Great Lakes Restoration Initiative

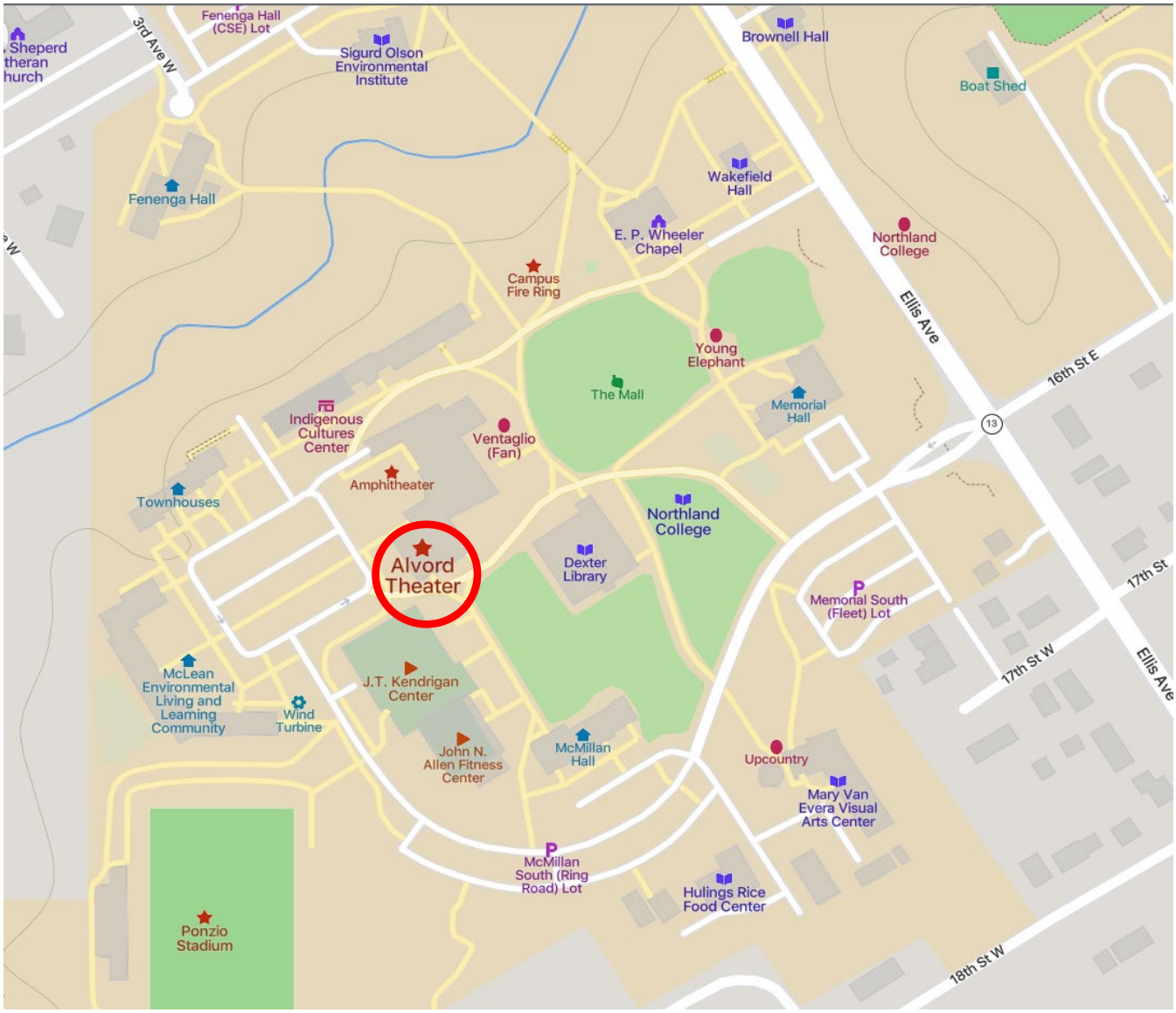
We acknowledge the broader staff support of Northland College undergraduates and staff who helped provide facilities and registration support.

2. Duration and Location

The symposium will begin at 12:00 p.m. Tuesday, March 21st, and end at 5:00 p.m., Thursday, March 23rd, 2023.

The symposium will be held at the Northland College Alvord Theater in the Ponzio Campus enter. https://mapcarta.com/N4564324839/Directions Signs will be posted to guide you to the appropriate room.

To reach Northland College, from US 2 (Lake Shore Dr), then turn onto State Highway 13 S (Ellis Avenue) and proceed ~1 mile to the main entrance of the College. See map below for navigating the campus.



3. Agenda

3/21/2023

10:00-12:30 Check-in, no on-site registration.

12:00 Opening Remarks

12:15 Plenary Talk – **Rob Kroll** (GLIFWC) - *Aanji-bimaadiziimagak o'ow aki (The world is changing)*

13:15 Break

13:25 Managing changing ecosystems

-**Kira Hefty** - *RAD Decisions in Rad Landscapes: Introducing the Isle Royale Case Study*
-**Mark Romanski** - *Status of Isle Royale National Park Wolf Reintroductions*
-**Kayla Preisler** - *Impacts on Outdoor Recreation in Wisconsin*

14:25 Break

14:35 Rare Species

-**Briana Gross** - *Hybridization between a rare arctic relict and its invasive congener on Lake Superior's north shore*
-**Sarah Johnson** - *Plants on the edge: tracking rare range-edge coastal species in two Lake Superior archipelagos*
-**Noel Pavlovic** - *Three decades of dune vegetation change among three Great Lakes national parks*
-**Chan Dolan** - *Investigating bumble bee (Bombus) nesting in three habitat types in the Upper Midwest*
-**Desi Robertson-Thompson** - *Twenty years of pollinator research in Great Lakes national parks*

16:10 Break

16:20 **Seth DePasqual** - *Where's the Beach?: A Decade of surveying Minong's Relict Nipissing Shoreline*

16:40 **Ashley Huinker** - *A brief overview of Frog Bay Tribal National Park*

17:00 Close

3/22/2023

8:00-9:00 Check-in, no on-site registration.

08:45 Housekeeping

09:00 Plenary Talk – **Kurt Kipfmueller** (UM-TC) - *Forgotten Fires: Restorying Great Lakes Red Pine Fire Regimes*

10:00 Break

10:10 Vegetation Management

- **Lynette Potvin** - *Forest Pests at Isle Royale National Park in 2022*
- **Suzanne Sanders** - *Woody species change over 11 years in Mississippi National River and Recreation Area forests*
- **Andrea Myers** - *Restoration Activities in National Parks to Mitigate Beech Bark Disease*
- **Marcella Windmuller-Campione** - *Adaptive Silviculture along the Mississippi National River and Recreation Area (MNRRA)*
- **Katie Frerker** - *Giving Nature a Nudge: Developing an Assisted Migration Plan for the Superior National Forest*

11:45 Lunch

12:45 Vegetation Restoration

- **Peggy Burkman** - *Jack Pine Cone Serotiny on a Coastal Barrier Spit*
- **Jacob Slattery** - *Ishkode (fire) - how can prescribed fire help restore manoomin (wild rice)?*
- **Steve Windels** - *The Voyageurs Wetland Restoration Project: Lessons from the First Six Years*
- **Laura Brennan** - *Defeating the odds: the challenges and successes of invasive plant control at Indiana Dunes National Park*

14:00 Break

14:15 Wildlife

- **Bijit Khadka** - *Island deer: Impacts on plants and drivers of their foraging behavior*
- **Mark Martell** - *Breeding phenology and nestling morphology of bald eagles in the upper Midwest*
- **Katy Goodwin** - *Modeling occupancy probability and acoustic activity of white-nose syndrome affected bat populations*
- **Elyse Mallinger** - *Species-specific responses to white-nose syndrome in bats of the Great Lakes regional National Parks*
- **Sarah Hoy** - *The influence of changing climate on the health of moose populations in Isle Royale National Park*

15:50 Break

16:00 Aquatic Habitats

- **Laura Bourgeau-Chavez** - *Detecting and Mapping Vernal Pools in National Parks of the Great Lakes Basin*
- **Samantha Kurkowski** - *Mapping and Characterization of Vernal Pools Across National Parks in the Great Lakes Region*
- **Harvey Bootsma** - *Net gain or net loss? Dreissenid effects on nearshore community metabolism in Lake Michigan*
- **Stephen Spear** - *Development of point of use eDNA tools for rapid invasive species surveillance*

17:15 Close

3/23/2023

08:00 –09:00 Check-in, no on-site registration.

08:45 Housekeeping

09:00 Plenary Talk – **Robert Sterner** UMD - *Lake Superior is a large, climate-stressed freshwater ecosystem*

10:00 Break

10:10 Water Quality Frameworks and Effects

- **Brenda Lafrancois** - *Place-based nearshore monitoring during a time of rapid ecosystem change*
- **Anna Baker** - *From land to lake – tributary nutrient cycling and loads and their role in Lake Superior nearshore a*
- **Mark Edlund** - *Integrating water quality and diatom trends to determine landscape-level change in protected lakes*
- **David VanderMeulen** - *Mercury in Dragonfly Larvae from the Great Lakes I&M Network*
- **Sarah Elliott** - *What's in the Water? Screening for Trace Organic Contaminants in U.S. National Parks*

11:45 Lunch

12:45 Mussels and Zebra Mussels

- **Diane Waller** - *Conservation of Native Freshwater Mussels: Federal Partners' Collaborative Research*
- **Allison Holdhusen** - *Diving for Freshwater Mussel Conservation in the Great Lakes and Big Rivers*
- **Marian Shaffer** - *Long-Term Zebra Mussel Monitoring Program at the St. Croix National Scenic Riverway*
- **Toben Lafrancois** - *A review of SCUBA based Zebra Mussel (Dreissena polymorpha) surveys in Lake Superior Parks.*

14:00 Break

14:15 Mussels and Zebra Mussels

- **Anette Trebitz** - *Characterizing potentially expanding Dreissena distribution and composition in Lake Superior*
- **Jay Glase** - *Improving Mussel and Fish Monitoring Outcomes with High-Resolution Bathymetry Data in National Parks*
- **Tyler Kunze** - *Benthic algal and macroinvertebrate response to the removal of dreissenid mussels in Lake Michigan*
- **Alex Egan** - *Chironomidae species associations with water chemistry and trace metals in coastal rock pools*

15:30 Poster Session

16:45 Wrap-up / Closing remarks

4. Abstracts – Oral Presentations

Title: Aanji-bimaadiziimagak o'ow aki (The world is changing)

Authors: Croll, Rob1[*,1]
* rcroll@glifwc.org
1 Climate Change Program Coordinator, Great Lakes Indian Fish & Wildlife Commission (GLIFWC)

Abstract:
Intertribal agencies play a significant role in climate adaptation research, planning and implementation for their member tribes and in concert with partner agencies including the National Park Service. The Great Lakes Indian Fish & Wildlife Commission (GLIFWC) is an intertribal natural resources management agency that exercises authority delegated to it by its eleven Ojibwe member tribes in Michigan, Wisconsin, and Minnesota to implement court orders and interjurisdictional agreements related to their off-reservation treaty rights. GLIFWC began its Climate Change Program in 2014 with the goal of interweaving Scientific Ecological Knowledge (SEK) and Traditional Ecological Knowledge (TEK) to provide member tribes with a more holistic and culturally appropriate approach to climate change adaptation, ecosystem resilience, and natural resource management. This presentation explores the complex interaction between treaty rights, culture, climate change, and natural resource management using examples from *Aanji-bimaadiziimagak o'ow aki* (the GLIFWC Climate Change Vulnerability Assessment*), Dibaginjigaadeg Anishinaabe Ezhitwaad* (the Tribal Climate Adaptation Menu), and *Minisan* (Connecting Ojibwe Ecological Knowledge and Climate Change in the Apostle Islands).

Title: RAD Decisions in Rad Landscapes: Introducing the Isle Royale Case Study

Authors: Hefty, Kira[*,1]; Taylor, Jason[1]; Parks, Sean[1]; Rushing, Jaclyn[1]; Taylor, Erana[1]
* kira.hefty@usda.gov
1 Aldo Leopold Wilderness Research Institute (ALWRI)

Abstract:
Climate change is altering how researchers and managers understand and respond to natural resource challenges on protected lands around the world. In designated wilderness areas in the United States, managers are grappling with the need to make decisions that protect/preserve the unique qualities and characteristics outlined by the Wilderness Act of 1964 while also recognizing that climate change is causing ecological transformations that may dramatically alter those same characteristics. The resist-accept-direct (RAD) framework is a decision-support framework designed to guide management decisions where ecological transformations are currently changing or expected to change the composition, structure, and function of natural systems. The RAD framework has been used to formulate alternative strategies that address management challenges in the era of anthropogenic climate change, but its utility has not yet been demonstrated in designated wilderness where management interventions may need to be restrained or altered to meet the intentions of the Wilderness Act. In this context, two dominant questions arise: 1) What kinds of management actions (resist, accept, or direct) may be required to maintain the unique socio-ecological qualities of designated wilderness; and 2) Can these actions be implemented while upholding the original intent of the Wilderness Act? Using the RAD framework and Isle Royale National Park as a case study, we will introduce the concept of RAD, discuss how we plan to engage partners in a coproduction of knowledge to develop a suite of RAD options, and highlight the socio-ecological trade-offs inherent in making a RAD decision in designated wilderness.

Title: Status of Isle Royale National Park Wolf Reintroductions

Authors: Romanski, Mark C.*[1]; Belant, Jerrold, L[2]; Brzeski, Kristin E.[2]; Potvin, Lynette R.[1]; Sovie, Adia R.[3]; Hervey, Sam D.[2]; Moore, Seth A.[4]; Verant, Michelle L.[1]; Windels, Steven K.[1]; Bonessi, Jacob M.[1]; Orning, Elizabeth K.[5]; Marneweck, David G.[6]; Hart, John P.[7]; Kellner, Kenneth F.[3]; Patterson, Brent R.[8]; Beyer, Dean E.[9]; Jonathan Pauli[10]; Mauriel Rodriguez Curras[10]

*mark_romanski@nps.gov

1 National Park Service

2 Michigan State University

3 Michigan State University

4 Grand Portage Band of Lake Superior Chippewa

5 US Geological Survey

6 Conservation Alpha

7 USDA - APHIS Wildlife Services

8 Ontario Ministry of Natural Resources and Forestry

9 Retired Michigan Department of Natural Resources

10 University of Wisconsin-Madison

Abstract:

After declining to two related individuals, the United States (US) National Park Service (NPS) made a determination to augment the number of gray wolves (*Canis lupus*) on Isle Royale National Park. Our primary goals were to re-establish a viable population of this apex carnivore and facilitate the restoration of ecosystem processes. Isle Royale National Park is a remote, wilderness archipelago and International Biosphere Reserve renowned for wolf/moose (*Alces alces*)-predator/prey relationships. During September 2018–2019, the NPS and its partners translocated 19 wolves from nearby Ontario, Canada and Minnesota and Michigan of the US. Our research and monitoring evaluating the success of this restoration program includes assessing wolf abundance, social organization, reproduction, survival and cause-specific mortality, population genomics, prey acquisition, and movements; prey (moose and American beaver [*Castor canadensis*]) abundance and distribution, wolf-mesocarnivore interactions, disease ecology, moose herbivory, and impacts of recreational human use.

Title: Impacts on Outdoor Recreation in Wisconsin

Authors: Preisler, Kayla[*,1]; Salmon-Tumas, Meghan[1]
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1 Northland College

Abstract:
Outdoor recreation is a large part of Wisconsin culture, economy, and drawing tourists to the state. Its natural environment supports a large variety of outdoor activities that are becoming vulnerable to climate change. As climate change alters Wisconsin's ecosystems and natural resources, outdoor recreation is experiencing changes and limitations. This project describes aspects of climate change relevant to popular activities such as ice fishing, skiing, hiking, and camping. We focused our literature review on the prevalence of mild-weather days, freeze-thaw cycles, and snow-making days. Finding a definition for mild-weather days as a range of daily highs at 18 C to 30 C, we discover this puts a limit on activities such as hiking and camping. Summers losing mild-weather days experience a decrease in tourism to Wisconsin National Parks and other hiking and camping locations. The literature review verified that increases in freeze-thaw cycles would cause Wisconsin's infrastructure to become weaker, and freeze-thaw cycles also rearrange soil particles affecting hiking ground. Due to winter precipitation more likely to fall as rain than snow, the need for snowmaking technology is necessary to keep a ski season. Computing changes in the number of snowmaking days with a threshold of -5 C will demonstrate the changes in a ski season whether it extends the season or adds more limitations. Using ice phenology data, we were able to show a decreasing trend in ice duration on six Wisconsin lakes, which affect ice fishing. With recent studies predicting Wisconsin Great Lakes water level, we will use this research to discover impacts on outdoor recreation. Using the combination of literature review and model outputs, we can further understand how outdoor recreation in Wisconsin will be affected by climate change.

Title: Hybridization between a rare arctic relict and its invasive congener on Lake Superior's north shore

Authors: Carlson, Ryan[1]; Vallez, John[1]; Etterson, Julie R.[1]; Gross, Briana L.[*,1]
* blgross@d.umn.edu
1 University of Minnesota Duluth

Abstract:
In North America, relict arctic plant populations from the last glacial maximum persist in disjunct locations south of their normal range. These fringe populations may be particularly threatened by stressors associated with climate change like increased temperature and decreased water availability. In Minnesota, USA, several arctic relicts of conservation concern are restricted to the rocky coast immediately adjacent Lake Superior, where they comprise an 'arctic-alpine' community in restricted areas on the North Shore. One of these species, *Euphrasia hudsoniana*, is particularly vulnerable because it is increasingly challenged by an invasive Eurasian congener, Euphrasia stricta. Here, we present a genetic assessment of hybridization between the native and invasive species, and also a comparison of the relative fitness of native and invasive populations across a drought and non-drought year. Our results indicate that interspecific hybridization is common where the two species co-occur, although there are still several genetically intact native populations. Conversely, at least one site that was previously considered to house the native species is now primarily occupied by the invasive species, with only genetic remnants of the native species remaining, consistent with a combination of demographic replacement and genetic swamping. In addition, population comparisons show that the invasive species is more resilient to summer drought conditions, which will likely result in its continued success under a warming climate. Together, these results highlight the importance of invasive species removal from these delicate habitats, especially at early stages in the invasion process.

Title: Plants on the edge: tracking rare range-edge coastal species in two Lake Superior archipelagos

Authors: Johnson, Sarah E.[*,1]
* sjohnson@northland.edu
1 Northland College

Abstract:
Many of the Great Lakes region's rarest plants are concentrated across national park islands of Isle Royale and the Apostle Islands in western Lake Superior. These two parks collectively provide impressive lengths of high and low-energy coastal habitats. In one park or another you can find sandstone or basaltic cliffs, rocky ledges, rock pools, coastal wetlands, sandscapes, and eroding bluffs. Monitoring programs for rare plants were initiated at both archipelago parks in the 1990s. Partial to semi-complete resurveys took place throughout a period of below-average Lake Superior levels, and most recently park staff, students, and I contributed to a comprehensive re-census in both parks after an extreme rise to above-average water level height. In this talk, I will synthesize findings and reflect on lessons learned—through the lens of cold-loving species—about dynamics, resilience, and potential vulnerabilities in these coastal habitats. I will also reflect on monitoring challenges.

Title: Three decades of dune vegetation change among three Great Lakes national parks

Authors: Pavlovic, Noel[*,1]; McEachern, A. Kathryn[1]; Deas, Joseph[1]
* npavlovic@usgs.gov
1 U.S. Geological Survey

Abstract:
Since the late 1800's, coastal dune vegetation has been recognized as dynamic due to the opposing forces of shoreline processes and plant succession. While Great Lakes water level changes are known to be quasi-periodic at 35- and 150-year intervals and to drive coastal sand dune dynamics, little is known about the rates of vegetation succession at decadal intervals in the coastal dunes. Rates of dune succession are important for conserving endangered species that inhabit Great Lakes sand dunes such as the federally threatened, Pitcher's thistle (*Cirsium pitcheri*). We used vegetation data collected in 1989-1990, 2008 and 2018 at Pitcher's thistle demography sites at Indiana Dunes National Park, and Pictured Rocks and Sleeping Bear Dunes National Lakeshores, to examine vegetation change over approximately 30 years timespan across a latitudinal gradient. Sites within each park were situated among different successional stages to understand how plant cover influenced Pitcher's thistle. Sampling grids with four-by-four-meter cells were superimposed over demography plots that ranged from 0.03 to 0.01 hectare in area, depending on thistle density. A 1-meter radius plot was placed at each grid intersection and the identity and cover of each plant species was recorded. We analyzed plot-and site-level vegetation change using multivariate techniques and a novel successional index, and related vegetation dynamics to landscape context and change metrics. Vegetation composition varied latitudinally among the parks. We found that vegetation change varied with coastal context and successional stage at initial sampling. Late successional plots accumulated species over time but were static relative to the abundance of dominating grasses. We discuss our results in the context of Great Lakes dune conservation and implications for rare plant restoration and viability in the context of climate change.

Title: Investigating bumble bee (Bombus) nesting in three habitat types in the Upper Midwest

Authors: Dolan, Chan[*,1]; Portman, Zach[1]; Cariveau, Dan[1]
* dolan334@umn.edu
1 University of Minnesota

Abstract:
Bumble bees (Bombus) are an important group of organisms responsible for the pollination of many crops and wild plants. However, many North American bumble bee species are facing wide-spread decline driven by habitat loss, pesticide drift, and infectious diseases. A large majority of bumble bee publications focus on foraging habitat and floral preferences. This leaves a large gap in our knowledge regarding another important aspect of bumble bee life history: Nesting habitat. Worldwide there are only ~60 published studies investigating bumble bee nesting. Only one of which takes place in the Midwestern US where the endangered rusty-patched bumble bee (*Bombus affinis*) now primarily resides. My research focuses on investigating Bombus species nesting habitat preferences and developing protocol to find bumble bee nests in an efficient and standardized fashion. In 2022, we surveyed forest, prairie, and forest-prairie edge habitats for nesting bumble bees from June to July. Here, we successfully detected 13 nests of 6 different species of bumble bees. In 2023, we plan to place a greater emphasis on monitoring bumble bee nests after they have been found to measure colony growth, reproductive success, and survival. These surveys will collect valuable natural history information on variety of bumble bee species regarding their habitat choices. The results of this study will inform management of bumble bee nesting habitat and help to develop protocol for finding nests of rare species such as the rusty-patched bumble bee.

Title: Twenty years of pollinator research in Great Lakes national parks

Authors: Robertson-Thompson, Desi[*,1]; Grundel, Ralph[2]
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1 Great Lakes Research and Education Center
2 Lake Michigan Ecological Research Station, Great Lakes Science Center, USGS

Abstract:
Understanding how pollinator communities respond to various ecological and land use scenarios is critical for management planning and action in national parks and other public lands. Great Lakes national parks offer unique opportunities to study factors that influence pollinator communities. These parks contain rare and high-quality habitats within diverse ecosystems such as prairies, oak savanna, dunes, wetlands, mesic forests, and barrens. Furthermore, information exists regarding the history of prescribed fire, invasive species work, enhancement of floral resources, and other resource management actions. For over twenty years, USGS has partnered with NPS to study how factors like landscape connectivity, habitat heterogeneity, and changes in forest structure might affect pollinators. We present an overview of these research projects, both historic and current, describe novel methods for surveying pollinators, and discuss implications for resource management and ultimately pollinator conservation.

Title: Where's the Beach?: A Decade of surveying Minong's Relict Nipissing Shoreline

Authors: DePasqual, Seth*,1
* seth_c_depasqual@nps.gov
1 Isle Royale National Park Abstract:

Abstract:
Since 2012, the cultural resource program at Isle Royale National Park (known as Minong to regional Anishinaabe) has conducted focused archaeological survey work on the island's Nipissing beach, a relict Lake Superior shoreline dating to approximately 5,000 BP. The 2022 field season celebrated 11 years of this annual research project, which has yielded many interesting results. To date, at least 150 relict beach locations have been surveyed island wide. Among them, 40 new Archaic period sites have been identified. One of these sites is a previously undiscovered precontact mining district comprised of mining pits and at least five occupation locales. The boundaries of this district are still being delineated, but we do know that features are spread across a 2.3 km distance. At present, this new district is a close second to the island's largest known precontact mine, the Minong Mine, which was recently designated as the Park's first National Historic Landmark. If nothing else, the totality of our work showcases that the Archaic period on Minong was as active as any other, perhaps even more so with respect to precontact copper mining activities. This presentation will discuss the methodologies and related findings associated with the Relict Shoreline Survey Project.

Title: A brief overview of Frog Bay Tribal National Park

Authors: Huinker, Ashley*,1
* Ashley.Huinker@redcliff-nsn.gov
1 Red Cliff Band of Lake Superior Chippewa

Abstract:
Established in 2012, Frog Bay Tribal National Park is the first tribal national park in the United States. A brief overview of the park's history, features, and importance to the Red Cliff Band of Lake Superior Chippewa and the surrounding community will be presented.

Title: Forgotten Fires: Restorying Great Lakes Red Pine Fire Regimes

Authors: Kipfmueller, Kurt[*,1]
* kurt@umn.edu
1 Associate Professor of Geography, Environment, & Society, University of Minnesota-Twin Cities Campus

Abstract:
While most of the attention on issues related to wildland fire in the US have been focused on western landscapes, fire has historically been a critical process in the pine forests of the Upper Great Lakes. The reduction of fire over the last 100 years, related to ignition/cultural suppression as well as direct suppression of fires has diminished the memories of past fire and led to substantial changes in the forest landscape. Coupled with a rapidly changing climate, alongside dramatic landscape modification due to widespread logging, the forgotten fires of the Great Lakes' past are likely to re-emerge within a different, changed socio-ecological context. Over the last 50 years our understanding of the role of fire in Great Lakes landscapes has become more refined with additional tree ring-based studies of fire history that better capture the occurrence of repeated, low intensity surface fires. In this presentation I'll provide an overview of a growing network of fire history sites in red pine (or former red pine) landscapes across the Great Lakes. This work provides a better context for understanding the relative roles of climate and people in driving fire over the past three centuries. A few case studies will be highlighted to illustrate the importance of understanding the particularities of place and the potential use of fire for managing resources over time. The network is helping to re-initiate, re-engage, and restory the reciprocal relationships between people, pine, and fire, particularly working toward engagement with Indigenous communities and traditional ecological knowledge (TEK).

Title: Forest Pests at Isle Royale National Park in 2022

Authors: Potvin, Lynette[*,1]; Romanski, Mark[1]
* lynette_potvin@nps.gov
1 Isle Royale National Park

Abstract: Isle Royale National Park had several insect pests cause widespread defoliation across its forests in 2022, with spruce budworm (*Choristoneura fumiferana*), white satin moth (*Leucoma salicis*), and saddled prominent (*Heterocampa guttivitta*) the most concerning species. The spruce budworm, in the 4th year of an ongoing outbreak on Isle Royale, caused needle die-back and mortality in balsam fir and to a lesser degree white spruce. The non-native white satin moth was detected at Isle Royale in July 2022. This was the first record of this species in the park. It is uncommon in the Great Lakes Region but did cause major defoliation in Thunder Bay in 2021. There was widespread defoliation of trembling aspen observed on the northeast end of the park. The saddled prominent is a native pest in the region, however it had not been documented as a major forest pest on Isle Royale prior to 2022. In mid-August, widespread defoliation of yellow birch and sugar maple was reported on the west end of the park, with the primary caterpillar reported as the saddled prominent. Isle Royale NP also had its first account of a spongy moth caterpillar, detected through an iNaturalist citizen science pollinator project. This was the first indication of spongy moth reproducing on Isle Royale. There are a few forest pests and disease present in nearby mainland areas, that have not yet reached Isle Royale, including Emerald Ash Borer and Oak Wilt. In partnership with researchers from the University of Minnesota and the US Forest Service Forest Health Protection group, Isle Royale resource managers will be increasing efforts to educate staff and visitors on preventing unwanted introductions of these threats and implementing new monitoring strategies in 2023.

Title: Woody species change over 11 years in Mississippi National River and Recreation Area forests

Authors: Sanders, Suzanne*,1; Kirschbaum, Jessica1
* suzanne_sanders@nps.gov
1 National Park Service, Great Lakes Inventory and Monitoring Network

Abstract: Forests along the Mississippi River through the urban St. Paul and Minneapolis corridor are subject to numerous stressors, including deer browse, altered flow regimes, and invasive species. We established a permanent vegetation monitoring program within the Mississippi National River and Recreation Area in 2011, establishing 31 sites at that time. These sites were resampled in 2022, and an additional 19 sites were added, bringing the total to 50. We classified sites into four broad habitat types: upland rich (three sites), upland disturbed (eight sites), box elder-dominated floodplain (14 sites), and silver maple-dominated floodplain (25 sites). Here we report on change in woody species over the 11-year interval for the 31 sites resampled. Summaries of tree data show declines in tree density in all four habitats, ranging from 17% in upland disturbed sites to 31% in silver maple floodplain sites. Filtering out and examining only small saplings, we found a similar pattern, which included a 41% decline in upland rich sites and a 62% decline in silver maple-dominated floodplain sites. While volume of coarse woody material did not appear to vary between years at upland sites, we found notable increases in floodplain sites where it rose in box elder-dominated forests from 39.7 to 66.8 m3/ha and in silver maple forests from 39.9 to 79.0 m3/ha. Overstory loss and/or recruitment failure are likely linked to several factors. At upland sites, declines may be tied to increased deer density between the two sampling events, with deer preferentially browsing on young saplings. In floodplains, declines may be linked to an extended high water period between the two sampling events. Flowing water potentially weakened mature trees while causing scour and removal of small individuals. We are scheduled to sample in the park for a third time in 2031.

Title: Restoration Activities in National Parks to Mitigate Beech Bark Disease

Authors: "Myers, Ande*,1; Panella, Tom[1]; Bal, Tara[1]
* almyers@mtu.edu
1 Michigan Technological University

Abstract:
A beech bark disease mitigation project focusing on propagating resistant American beech began in 2016 in two national park properties, Pictured Rocks National Lakeshore and Sleeping Bear Dunes National Lakeshore in Michigan. This effort is a collaboration between the National Park Service and Michigan Technological University, funded by the Great Lakes Northern Forest Cooperative Ecosystem Studies Unit (GLNF CESU). We will present the state of research on this project so far, which has led to planting grafted, beech bark disease-resistant trees in the parks in beech forests. Resistant wild trees located in both parks were identified and monitored from 2016 onwards. Surveys to describe the stage of beech bark disease in the parks were completed in 2017-2020, and there were differences between the two parks. Resistant tree scions were grafted in 2018-2022 and planting of these trees began in 2022. Challenges in active restoration in the parks will be presented and we will highlight future research directions anticipated through 2026 with opportunities for collaboration.

Title: Adaptive Silviculture along the Mississippi National River and Recreation Area (MNRRA)

Authors: Windmuller-Campione, Marcella
* mwind@umn.edu
1 University of Minnesota

Abstract: The Crosby Farms Adaptive Silviculture for Climate Change (ASCC) site is located in a Saint Paul Park and Recreation Area, owned and managed by the City of Saint Paul, that is embedded within the Mississippi National River and Recreation Area (MNRRA), a national park. Within the MNRRA, Bdote, the confluence of the Wakpa Taŋka or Haha Wakpa (Mississippi River) and Mni Sota Wakpa (Minnesota River) is a scared site for Dakota people. Along the rivers in the region, floodplains provide numerous ecosystem services. However, mortality of overstory green ash (*Fraxinus pennsylvanica*) due to the invasive emerald ash borer (EAB) and lack of regeneration by other floodplain species, threatens these forest ecosystems. Within Crosby Farms, EAB mortality created large mortality centers. We used these mortality centers to establish the first urban affiliated site within the ASCC network in 2019. Prior to overstory removal during the winter of 2019-2020, pre-treatment conditions were measured. After overstory trees were removed, 24 1/10th acre permanent plots were established and fenced included an unplanted control. We planted each plot with 3 -6 ft bare root stock at a 10-ft spacing; each plot was assigned a treatment - resistance, resilience, transition, or control. In the resistance, resilience, and transition treatments focused on planting different species from different plant hardiness zones. After 3 years average survival is greater than 85% for the resistance and resilience treatments and above 70% for the transition treatments. We will share which species had high survival across the 3 years, as well as, some early results from growth. Finally, throughout the talk we will share how this project has been a collaboration among numerous organizations and individuals and how that has strengthened our project.

Title: Giving Nature a Nudge: Developing an Assisted Migration Plan for the Superior National Forest

Authors: Frerker, Katie*,1
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1 USDA Forest Service, Superior National Forest

Abstract: The Superior National Forest (SNF) is preparing forest ecosystems for the challenges of continued climate change. Covering over 3 million acres in northern Minnesota, the SNF consists of boreal-temperate transition forests including several species expected to decline over the next century, such as jack pine, black spruce, and quaking aspen. As one possible adaptation action, silviculturists on the SNF have been implementing small-scale pilot projects to test assisted migration of tree species, including reforesting with new seed sources of existing species as well as introducing novel species to the forest. These pilot efforts have been limited by a lack of consistent guidance and direction. To ensure that the forest pursues assisted migration decisions in a consistent, informed, and coordinated manner, the SNF collaborated with over 20 partner organizations to create a formal Assisted Migration Plan. This plan is designed to help SNF staff determine areas on the forest that are appropriate for assisted migration, tree species that may be most suitable for assisted migration, monitoring and logistical considerations, and effective processes for engaging tribal nations and other partners. This presentation will describe the process of creating the Assisted Migration Plan, the contents of the plan, and recommendations for other land managers interested to pursue a similar effort. Assisted migration has the potential to gradually re-shape forest ecosystems as we know them, and collaborative planning processes can help ensure that national forests continue to meet the needs of all partners when deciding how to go forward with these actions.

Title: Jack Pine Cone Serotiny on a Coastal Barrier Spit

Authors: Burkman, Peggy*,1
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Abstract: Serotiny is the ability of some tree species to retain seeds in their crowns for years until a disturbance, such as fire, creates conditions that promote their release. Nonserotinous types also exist and cones release seeds more regularly in response to site conditions. Jack pine displays this adaptive genetic tendency which allows species to maintain populations under variable site conditions and disturbances. The current study compared jack pine cone serotiny in coastal habitats at different successional stages (open beach and forested).

Long Island is the primary location with jack pine in the park. The island formed between 1,050 and 1,700 years ago, and it is very dynamic. The tip has accumulated 36 acres of new habitat on the north side since 1938. We completed plot sampling (10-m radius) in this new beach habitat (n=4) and in older forests (n=15) to the south. We collected tree cores and recorded the number and species of trees, the bole diameter, and distance between trees and the plot center. Cones from upper branches were classified into open (non-serotinous), closed (serotinous), and new cones categories.
Most cones were of the non-serotinous type in both zones. The percent of open cones in the beach zone ranged from 61-83% and 29-93% in the forested zone.

The greater percent of open cones indicates that the trees have been responding to the dry and harsh site conditions rather than past fires for reproduction. A single crown fire can promote more serotinous cones and quickly reduce this polymorphic genetic variability. Maintaining a mix of both reproductive strategies ensures continuity of jack pine in both lower and higher fire regimes and is “crucial for their conservation”. This is especially important considering climate change, which will likely influence historic fire regimes."

Title: Ishkode (fire) - how can prescribed fire help restore manoomin (wild rice)?

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Abstract: A major question facing the Bad River community is whether we can develop and conduct environmentally friendly, culturally respectful restoration practices to enhance the abundance of manoomin. One possibility is the implementation of Ishkode. Ishkode moves beyond Western scientific concepts of fire ecology and prescribed fire techniques. It empowers a cultural closeness so tribal members might heal and (re)connect with the landscape and rekindle a spiritual relationship with all Creation. In short, Ishkode decolonizes conventional prescribed fire thinking. This technique deserves attention because the Kakagon and Bad River Sloughs, where wild rice is harvested, are culturally and spiritually significant, and could have positive impacts if planned in a good way. This talk will cover the challenges and learning opportunities developing Bad River's prescribed fire management plan, including topics such as forest management and fire policy, traditional fire knowledge and non-local beings. This presentation will also discuss accomplishments and next steps developing a collaborative partnership focused on implementing traditional fire practices to protect treaty natural resources.

Title: The Voyageurs Wetland Restoration Project: Lessons from the First Six Years

Authors: Windels, Steve K.[*,1]; Warmbold, Jerry[1]; Plumb, Reid T.[1]; Olson, Bryce T.[1]
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1 Voyageurs National Park

Abstract: Non-native hybrid cattails (Typha x glauca) are known to disrupt ecosystem balance by creating dense monotypic stands, displacing native species, and reducing biological diversity. Hybrid cattail is the dominant plant species in most large lake wetlands in Voyageurs National Park, MN. We initiated a restoration project in 2016 to reduce cattail abundance and restore wetlands to more diverse natural states. Lakes in Voyageurs National Park are designated as "Outstanding Resource Value Waters" where the use of herbicide is prohibited. Using 5 different treatment methods, we have treated a total of 75 acres of invasive cattails in Voyageurs National Park. We conducted pre- and posttreatment vegetation surveys of wetlands and compared percent vegetative composition for each treatment type. Total removal of cattail was the most effective treatment method for floating cattail mats with cattail being reduced from 98% composition to 0%. Underwater cutting of rooted cattail stands was also an effective method of removing cattail. We saw significant reductions of invasive cattail and increases in native vegetation from most treatment methods. Where remnant wild rice stands were present, we saw a significant increase in wild rice composition post cattail removal. Here we will present an overall project update, including project findings, management recommendations, and our direction of future work.

Title: Defeating the odds: the challenges and successes of invasive plant control at Indiana Dunes National Park

Authors: Brennan, Laura*,1
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1 Indiana Dunes National Park

Abstract: Indiana Dunes National Park is one of the most botanically diverse parks in the nation. It is also a place where globally imperiled habitats, smokestacks and neighborhoods are woven together in a surprising mosaic along the shoreline of the southern tip of Lake Michigan. The juxtapositions offered by the urban and natural landscape mirror the complexities biologists face in ecological restoration at this park. Invasive plant control has been a critical component of restoring this unique landscape. While complete eradication remains unlikely, great progress has been made despite temporary funding, turnover of seasonal staff, and other challenges. An NPS biologist will share their perspective of nearly twenty years of vegetation management in one of the most botanically diverse, fragmented, and disturbed parks in the nation.

Title: Island deer: Impacts on plants and drivers of their foraging behavior

Authors: Khadka, Bijit[*,1]; Olson, Erik[2]; Van Deelen, Timothy[1]
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Abstract: Forests in the Great Lakes are susceptible to multiple stressors that include overabundant deer, pests, and climate change. Knowledge of the biotic and abiotic factors that influence vegetation communities is important for effective forest management. Here, we combined vegetation survey data on white-tailed deer (Odocoileus virginianus) browsing and behavioral data from camera-traps to understand deer impacts on plants and drivers of deer foraging behavior on two island systems on the Laurentian Great Lakes. We found that average age of woody saplings was negatively associated with deer browsing and positively associated with overstory canopy cover. Understory forbs were predominantly influenced by variation in canopy cover. Deer foraging behavior was predominantly driven by intraspecific interactions and breeding phenology. In addition, seasonal differences also varied by age-sex status. Our results suggest that deer make foraging decisions based on multiple factors associated with intraspecific interactions and seasonality. Therefore, deer impacts on the vegetation in these islands may be compounded by additional environmental stressors.

Title: Breeding Phenology and Nestling Morphology of Bald Eagles in the Upper Midwest

Authors: Martell, Mark[*,1]; Route, William[2]; Dykstra, Cheryl[3]; Williams, Kelly[4]; Campbell-Spickler[5]; Key, Rebecca[6]

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Abstract: From 2006 to 2011, and in 2014, and 2015 we banded, measured, and took biological samples from nestling bald eagles in and adjacent to Apostle Islands National Lakeshore, the Upper St. Croix National Scenic River, and the Mississippi National River and Recreation Area. Based on 656 egg-laying and hatching dates, we documented that egg-laying advanced from south to north beginning in late January and continuing through mid-April; and hatching began in late February and ended in mid-May. Mean annual hatching dates were correlated with the average dates of ice break-up each spring at two ice-monitoring sites (n=8 yr, r2=0.90). We found no significant long-term trend or shift in hatching dates over the 10 years. Male and female nestlings overlapped in weight, footpad length, bill depth, and culmen and hallux claw chord length; however, by 35 days these features had diverged sufficiently to allow estimation of the sex of nestlings due to the larger size of females. Our models suggest that most of the nestling traits we measured continued to grow beyond the 70 days for which we had measurements, except for footpad, which reached predicted full size by about 46 days after hatching. Footpad length and bill depth were important traits for determining the sex of nestlings >35 days old. We developed a classification tree that uses footpad length and bill depth to estimate the sex of nestlings. Overall accuracy of this classification tree was 91%. Individuals with footpad length >132 mm and bill depth >29mm (46% of our sample) had a 0.95 probability of being female and individuals with footpad length >132 mm and bill depth ,30 mm (41% of our sample) had a 0.92 probability of being male, making our classification tree unbiased and robust for assigning sex for most nestlings >35 days old.

Title: Modeling occupancy probability and acoustic activity of white-nose syndrome affected bat populations

Authors: Goodwin, Katy[*,1]; Hunninck, Louis[2]; O'Keefe, Joy[2]; Kirschbaum, Alan[3]; Gillam, Erin[1]; Heyd, Cindy[4]; Romanski, Mark[5]; Route, William[3]; Windels, Steve[6]

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5 National Park Service Isle Royale National Park
6 National Park Service Voyageurs National Park

Abstract: The fungal disease white-nose syndrome (WNS) is a major threat to North American hibernating bats. Our objectives were to assess trends in occupancy and activity of 4 WNS-affected bat species in the Great Lakes region: little brown bat (*Myotis lucifugus*), northern long-eared bat (*Myotis septentrionalis*), tricolored bat (*Perimyotis subflavus*), and big brown bat (*Eptesicus fuscus*). We analyzed acoustic survey data spanning five years, collected at over 200 sites in 9 national parks. Combining acoustic detection data with site-specific covariates, we developed park- and species-specific models for both occupancy probability and activity level – a proxy for relative abundance. Occupancy and activity vary on different temporal and spatial scales and are not necessarily correlated. We hypothesized that both occupancy and activity would decline for little brown, northern long-eared, and tricolored bats, but increase or remain stable for big brown bats. We further hypothesized that the magnitude of decline would be more dramatic for activity than for occupancy. For little brown, northern long-eared, and tricolored bats, occupancy declined on average by 22%, but activity declined on average by 66%. In contrast, occupancy and activity levels for big brown bats changed less; on average, occupancy decreased by 9% while activity increased by 16%. Furthermore, when analyzing park-species occupancy rates in relation to activity levels, we found that observed occupancy can remain above 75% while relative activity levels decrease sharply. We showed that while WNS-affected bats are still present in many locations on the landscape, their relative abundance has likely decreased precipitously. We conclude that activity and occupancy analyses provide different but complementary information. The choice of analytical approach may influence what conclusions are drawn, thus affecting how management decisions are made and how species conservation and recovery efforts are implemented.

Title: Species-specific responses to white-nose syndrome in bats of the Great Lakes regional National Parks

Authors: Elyse C. Mallinger[*,1]; Katy R. Goodwin[2]; Alan Kirschbaum[3]; Yunyi Shen[4]; Erik R. Olson[2]
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3 Great Lakes Inventory and Monitoring Network
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Abstract: White-nose syndrome is a fungal disease that is threatening bat populations across North America. The disease primarily affects cave-hibernating bats by depleting fat reserves during hibernation. Since it was first detected in 2006, the disease has killed millions of bats and is responsible for extensive local extinctions. To better understand the effects of white-nose syn-drome on various bat species, we performed acoustic surveys from 2016-2020 at nine U.S. National Parks within the Great Lakes region. We examined the effect that white-nose syndrome, time of the year, habitat type, and regional variation (i.e., park) have on the acoustic abundance of six bat species. As expected, little brown bat (*Myotis lucifugus*) and northern long-eared bat (*Myotis septentrionalis*), both hibernating species, experienced a significant decline in acoustic abundance following white-nose syndrome detection. We observed a significant increase in acoustic abundance as white-nose syndrome progressed for hoary bats (*Lasiurus cinereus*) and silver -haired bats (*Lasionycteris noctivagans*), both migratory species that are not directly impacted by the disease. Contrary to our predictions, we observed an increase in big brown bat (*Eptesicus fuscus*; hibernating) acoustic abundance and a decrease in eastern red bat (*Lasiurus borealis*; migratory) acoustic abundance. We also found that at for parks located at higher latitudes, little brown bat and northern long-eared bat were more likely to experience a greater decrease in acoustic abundance. Our work provides insight into species-specific responses to white-nose syndrome at a regional scale and provides insight into the factors influencing the resiliency of different bat species populations to the impacts of white-nose syndrome.

Title: The influence of changing climate on the health of moose populations in Isle Royale National Park

Authors: Hoy, Sarah[*,1]; Peterson, Rolf[1]; Vucetich, Leah[1]; Vucetich, John[1]
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Abstract: Climate change is expected to have a wide range of adverse effects on the health and viability of many wildlife populations, making it a growing concern for wildlife managers. Moose (*Alces alces*) are thought to be especially vulnerable to climate warming because they have evolved to thrive in cold landscapes with seasonal snow cover. Climate warming is expected to have the greatest impact on moose populations residing near the southern limit of their species' geographic range, such as those in the Great Lakes region. To better understand how climate change is influencing the health of moose populations in the Great Lakes region, we assessed the extent that changes in seasonal temperatures and precipitation have impacted the nutritional condition of moose over a 29-year period and burdens of winter ticks (*Dermacentor albipictus*), an important parasite for moose, over a 19-year period in Isle Royale National Park.

Our analysis revealed that moose tended to be more nutritionally stressed during winters with deep snow and during winters that followed warm summers. We also found that tick burdens tended to be greater for moose following warmer summers, presumably because warmer temperatures accelerate the development of tick eggs and increase egg survival. An adverse effect of deep snow on the nutritional condition of moose most likely arises because it is more difficult for moose to travel and find food when the snow is deep. The adverse effect of warmer summers on the nutritional condition of moose maybe partly due to warmer summers increasing tick burdens for moose. Alternatively, warmer summers may also have negatively affected the growth of balsam fir, the primary winter forage species for moose in this region, as well as reducing summer energetic intake. Overall, our results are consistent with the general expectation that climate warming will negatively affect the health of moose populations.

Title: Detecting and Mapping Vernal Pools in National Parks of the Great Lakes Basin

Authors: Bourgeau-Chavez, Laura*,[1]; Battaglia, Michael[1]; Vander Bilt, Dorthea[1]; Chimner, Rodney[1]; Kurkowski, Samantha[1]

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Abstract:

Vernal pools are small (usually <2 acres), shallow, isolated, seasonal water bodies that generally occur in forested landscapes and are typically inundated in spring and draw down in the summer. They are well known as biologically rich repositories for numerous fauna and flora, harboring many amphibian and invertebrate species that depend on these fishless habitats for breeding. Due to their small size, topographic position, isolation, and ecological processes, vernal pools are extremely vulnerable to alteration or loss as a result of land use and climate change. Thus, it is important to know where they are for conservation and remediation. Since vernal pools are forest covered and small, they are difficult to map using traditional field or air photo methods. Through a cooperative agreement with the National Park Service, we have been refining remote sensing methods that use airborne LiDAR data, satellite L-band (23 cm wavelength) radar, and leaf-off spring aerial photography to detect and map vernal pools in six National Parks (Sleeping Bear Dunes, Indiana Dunes, Voyageurs, Isle Royale, Apostle Islands, and Pictured Rocks). We use LiDAR DEM data to conduct depressional analysis of the parks and surrounding areas, and then use 3 sources of imagery to determine if the depressions have water in the spring: 1) high resolution leaf-off color-IR imagery; 2) LiDAR intensity data; and 3) L-band radar. Lastly, with the radar data we are able to determine if the ponds dry out in the summer because the wavelength (23 cm) is able to penetrate a forest canopy. Due to the ephemeral nature of the pools and limited remote sensing data, we have created an uncertainty metric for each pool based on the number of sensors detecting the pools as full of water in spring. Field sampling to verify vernal pool status has shown 73-75% accuracy.

Title: Mapping and Characterization of Vernal Pools Across National Parks in the Great Lakes Region

Authors: Kurkowski, Samantha[*,1]; Chimner, Rodney[1]; Bourgeau-Chavez, Laura[2]; Battaglia, Michael[2]; Vander Bilt, Dorthea[2]

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Abstract:

Vernal pools are small, ephemeral wetlands that become inundated each spring and provide many ecosystem services to the surrounding upland forests. They also provide critical habitat to amphibians and invertebrates, as their temporary nature keeps them free of fish and reduces the populations of predators. We mapped vernal pools using remote sensing and collected field data on vernal pool characteristics throughout five Great Lakes National Parks: Pictured Rocks National Lakeshore, Sleeping Bear Dunes National Lakeshore, Apostle Islands National Lakeshore, Isle Royale National Park, and Voyagers National Parks. We sampled 139 pools during spring of 2021 and 2022 where we collected data on pool characteristics related to hydrology, soils, vegetation, geomorphology, and indicator species. This baseline data shows that vernal pool characteristics do vary between the different parks. Many vernal pool qualities are driven by the type of substrate they occur on and their overstory canopy species and amount of cover. The vegetation and canopy species present reflect the dominant vegetation of each park. We also created a classification system that describes which characteristics were most highly correlated to indicator species presence, resulting in a three-class system based on overstory species composition: Deciduous (>50% deciduous canopy), Coniferous (<50% deciduous canopy), and Open (<30% canopy cover). Indicator species were more likely to occur in pools with either a deciduous or open canopy than pools with a coniferous canopy. This information can be used to inform land managers within the Great Lakes of vernal pool characteristics they can expect as well as which characteristics should be prioritized in habitat conservation.

Title: Benthic algal and macroinvertebrate response to the removal of dreissenid mussels in Lake Michigan

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Abstract: Dreissenid mussels have changed the fundamental community structure and biogeochemical processes of the Lake Michigan nearshore zone. There is evidence that dreissenids promote the growth of benthic algae and provide habitat and food for other benthic macroinvertebrates. The goal of this project was to further our understanding of the relationship between dreissenids, benthic algae, and benthic macroinvertebrates in the Lake Michigan nearshore zone. This was done by removing the mussels from a 140 m2 area of rocky substrate and subsequently monitoring the response of the benthic community over a one-year period. Measurements included benthic algal biomass, productivity, taxonomic composition, phosphorus content, and stable isotope composition, as well as benthic invertebrate abundance and taxonomic composition. While algal biomass on the mussel-free site remained comparable to that on a control site, algal P content and productivity were significantly lower on the mussel-free site, and there were major differences in algal taxonomic composition between the two sites. Invertebrate abundance was also much lower on the mussel-free site. These findings can be used to explore the effects of any future large scale dreissenid removal efforts on nuisance benthic algae and nearshore food web structure.

Title: Development of point of use eDNA tools for rapid invasive species surveillance

Authors: Spear, Stephen[*,1]
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Abstract: Environmental DNA approaches have become a regular tool for wildlife and invasive species surveillance and monitoring, yet most methods require a laboratory component. This requirement is a challenge to apply eDNA for time sensitive screening, such as early detection of invasive species that require immediate management action for effective control. Several methods have been developed for rapid DNA amplification, primarily through the medical field, that can be applied to eDNA detection of wildlife. One such approach, isothermal (single temperature) DNA amplification protocols, can be set up and easily run by end users without formal genetic training or access to labs. I will provide an overview of the steps involved in developing a portable isothermal DNA amplification protocol (i.e. Loop-Mediated Isothermal Amplification) for eDNA testing and discuss the advantages and disadvantages of the method compared to lab-based approaches like quantitative PCR. I will conclude by outlining an initiative that is underway to further develop these field-based protocols for a variety of invasive species and points of entry. This project will provide an opportunity for personnel to test and evaluate eDNA for early detection of invasive species to allow for a rapid response.

Title: Lake Superior is a large, climate-stressed freshwater ecosystem

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1 Director, Large Lakes Observatory and Professor, Department of Biology, University of Minnesota Duluth

Abstract: The Laurentian Great Lakes are one of Earth's largest freshwater systems and serve as the backdrop to multiple NPS properties. Some of the degraded environmental states within the Great Lakes are well-known, for example, nutrient runoff, invasive species, and certain toxins. Often referred to as "relatively pristine", Lake Superior has suffered less from certain fewer anthropogenic than some of the other Great Lakes. What is less widely known, however, is that Lake Superior is more rapidly warming than the other Great Lakes. This surprising trend arises because of its size, depth, and location on Earth. A well-established trend, for instance, is declining ice conditions. With its cold-water adapted ecosystem, there are reasons to be concerned about warming of the lake. Newly arising cyanobacterial blooms offer perhaps the most striking example so far of how climate warming may degrade this immensely valuable reservoir of freshwater. My talk will explain why climate is such an important stressor to Lake Superior and how a close partnership my lab has with the National Park Service has helped us untangle why cyanobacterial blooms are now a concern in Lake Superior and why we think climate is an important driver. We might be able to use Lake Superior to help us understand climate drivers in other large lakes.

Title: Place-based nearshore monitoring during a time of rapid ecosystem change

Authors: Lafrancois, Brenda[*,1]; Bootsma, Harvey[2]; Sterner, Robert W.[3]; Brovold, Sandy[3]; Miller, Todd[2]; Jeffrey Nuese[2]; VanderMeulen, David[1]; Glase, Jay[1]

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Abstract: The Great Lakes are a defining feature for many national park units in the region, and their nearshore ecosystems are uniquely important to humans as well as fish and aquatic life. Nearshore ecosystems are also uniquely vulnerable to emerging stressors (nutrient and sediment inputs, climate change, species invasions) but often have been overlooked in the development of monitoring programs. Since 2012, Great Lakes policy makers and managers have increasingly emphasized the need for a "nearshore framework" with accompanying monitoring and assessment structures. With support from the Great Lakes Restoration Initiative, NPS has worked with academic and agency partners to establish place-based nearshore monitoring and research sites at Apostle Islands (APIS) since 2015 and Sleeping Bear Dunes (SLBE) since 2010. At both parks, nearshore monitoring is focused around fixed stations, with both continuous sensor-based data collection and periodic sampling of water quality and biological features. At APIS, monitoring has clarified the role of tributary influences on nearshore nutrient concentrations and water clarity and provided real-time insights into harmful algal bloom development. At SLBE, monitoring has captured long-term trends in invasive mussel and goby populations, characterized seasonal patterns in nuisance algal sloughing and accumulation on beaches, and provided an experimental control for invasive mussel removal work. Using examples from work at APIS and SLBE, we explore how place-based monitoring can complement ongoing off-shore monitoring, create new platforms for outreach and engagement, and serve as a critical support structure and catalyst for Great Lakes research. We highlight how research at these sites is driving new management and restoration opportunities within and beyond park boundaries.

Title: From land to lake – tributary nutrient cycling and loads and their role in Lake Superior nearshore a

Authors: Baker, Anna[1]; Kreiling, Rebecca[2]; Givens, Carrie[1]; Kiesling, Richard[1]; Dantoin, Eric[1]; Perner, Patrick[1]

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1 U.S. Geological Survey Upper Midwest Water Science Center

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Abstract: Lake Superior is regarded as the most oligotrophic of the Laurentian Great Lakes because of low nutrient concentrations and low algal biomass in the open lake. However, over the past decade, repeated nearshore cyanobacterial blooms have occurred along the southwestern shore. Previous studies have indicated that event-driven loading of nutrients, sediment, and cyanobacteria from tributaries may be important drivers of blooms in nearshore Lake Superior. To understand how tributary loads of nutrients and sediment contribute to nearshore blooms, the U.S. Geological Survey participated in a large multi-institution partnership under the Collaborative Science and Monitoring Initiative by measuring nutrient and sediment loads from two south-shore watersheds. Building on previous investigations, we examined how two key tributaries in the vicinity of recurring cyanobacterial blooms, Bois Brule and Siskiwit Rivers, impact nearshore waters. Continuous and discrete water quality and streamflow data collected at gaging stations on Bois Brule River and Siskiwit River will be used to develop regression-based models of total nitrogen and phosphorus as well as suspended sediment to the nearshore waters. Sediments collected from the water column and streambed were analyzed for phosphorus binding and release and denitrification parameters, which provide insight into how sediment loading may serve as a temporary sink or long-term source of phosphorus to the nearshore. Preliminary data show total-phosphorus ranged from below detection (0.006 milligrams-per-liter) to 0.538 milligrams-per-liter, and total-nitrogen from below detection (0.05 milligrams-per-liter) to 2.4 milligrams-per-liter during this low-flow dominant period. Preliminary findings including spatial and temporal variation in nutrient availability and relationships between concentration and discharge will be presented.

Title: Integrating water quality and diatom trends to determine landscape-level change in protected lakes

Authors: Ramstack Hobbs, J.M[1]; Heathcote, A.J.[1]; VanderMeulen, D.D.[2]; Edlund, Mark*[,1]
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Abstract: Lakes in protected or remote regions are not immune to anthropogenic impacts and face stressors ranging from atmospheric deposition of pollutants to global climate change. Monitoring programs in remote and protected lakes can be constrained by sampling logistics, leaving an incomplete picture of how the systems may be changing. Here, we use diatoms as early indicators of change in relatively undisturbed lakes from five national park units across the Great Lakes region (USA). Even with their protected status, the most remote and isolated of these lakes have been showing signs of change in recent years, including nuisance cyanobacterial blooms. To determine which environmental parameters were having the biggest effect on lake ecology, surface sediment samples were collected repeatedly over more than a decade to analyze diatom community turnover. The diatom community change was compared to measured water quality data collected over the same period in order to identify the predominant drivers of ecological change. The most striking result of this study was the synchrony of diatom change across lake types within most parks. Many of the stressors found to be affecting lake ecology at the primary producer level in these protected lakes were acting on a landscape scale and across biomes. Changes in thermal regime and water-column mixing appeared to drive much of the change across parks, although much of the diatom turnover also followed a sulfate or pH gradient. Nutrients did not appear to play a major role in diatom community change. This method of using diatoms in conjunction with water quality monitoring allows for an integrated response over a number of years and provides managers with a complementary biomonitoring tool to determine which environmental parameters are having the biggest effect on lake ecology.

Title: Mercury in Dragonfly Larvae from the Great Lakes I&M Network

Authors: VanderMeulen, David[*,1]; Flanagan-Pritz, Colleen[2]; Ko, Katherine[2]; Eagles-Smith[3]
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1 NPS Great Lakes I&M Network
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Abstract: The Dragonfly Mercury Project (DMP) uses dragonfly larvae as biosentinels for a nationwide assessment of mercury bioaccumulation in national parks. Mercury is a potent neurotoxin that can harm human and wildlife health. Mercury monitoring in dragonfly larvae occurred at six GLKN parks from 2008/9-2012 by the University of WI La Crosse as part of a larger project to assess mercury in a variety of media in park aquatic ecosystems. Monitoring continued in a few parks and starting in 2016 all nine parks began monitoring mercury in collaboration with the DMP, and with fieldwork support from Northland College. Findings show that within GLKN parks mercury in dragonfly larvae levels can vary widely from site to site, sometimes by an order of magnitude or more. Also, sites adjacent to or downstream from wetlands typically have higher levels of mercury. Last, 64 percent of the site-year data from GLKN parks fall in the moderate impairment category, suggesting fish may exceed human consumption thresholds and wildlife may be at risk from elevated mercury. The DMP engages the public in providing actionable information about mercury in freshwater ecosystems to reduce risk to public health, inform policy and resource management, and advance science and public understanding of mercury pollution.

Title: What's in the Water? Screening for Trace Organic Contaminants in U.S. National Parks

Authors: Elliott, Sarah[*,1]; VanderMeulen[2]; Kerensa, King[3]
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Abstract: The presence of trace organic contaminants (TrOCs) in aquatic environments has been well documented. While TrOCs tend to be more prevalent in locations influenced by human activities, they have also been detected in locations that are not. The National Park Service's Inventory and Monitoring (I&M) Network Program conducts routine water-quality monitoring, but TrOC monitoring is either not considered or is completed with differing objectives, methods, and parameters of interest across parks. From 2009 to 2019, 9 I&M networks participated in TrOC monitoring at 230 surface water sites and 40 groundwater sites across 47 parks in the western and midwestern U.S. using consistent field and laboratory methods. Samples were characterized for up to 350 TrOCs including pharmaceuticals and personal care products (PPCPs), and pesticides. Among all sites, a total of 73 PPCPs and 48 pesticides were detected at least once, but only 2 were detected in ≥20% of samples. Compared to other networks, a greater number of PPCPs and pesticides were detected within the Great Lakes I&M Network (GLKN); 4 PPCPs and 5 pesticides were detected in ≥20% of samples. Observed concentrations were compared against bioactivity information from the U.S. Environmental Protection Agency's ToxCast database to estimate potential bioeffects from exposure to detected TrOCs. More pesticides were identified as having a higher potential for eliciting bioeffects, compared to PPCPs. The potential for bioeffects was lower at several GLKN parks compared to others included in the study, except for Indiana Dunes National Lakeshore, Mississippi National River and Recreation Area, and St. Croix National Scenic Riverway where pesticides were detected at concentrations that may warrant further study. Results from this study fill important knowledge gaps and can be used to inform future TrOC monitoring efforts.

Title: Conservation of Native Freshwater Mussels: Federal Partners' Collaborative Research

Authors: Waller, Diane[*,1]; Bartsch, Michelle[1]; Knowles, Susan[2]; Wang, Ning[3]; Shaffer, Marian[4]; Shapansky, Rebecca[5]; Leis, Eric[6]; Richard, Jordan[7,8]

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Abstract:

Freshwater mussels are a foundational species in aquatic systems, providing vital ecosystem services, such as water filtration, nutrient and energy transfer, and substrate stabilization. Unfortunately, the fauna is highly imperiled with more than 50% of Midwest species listed as state endangered or threatened. U.S. Geological Survey and our partners in the National Park Service and Fish and Wildlife Service are collaborating on research to advance conservation of federally endangered mussels in high value waters and to identify potential causes for their decline. A multi-agency Mussel Health team is investigating causes of mass mussel mortalities across the U.S., including five in the Great Lakes Basin. We are developing diagnostic tools which can be applied in mussel health assessments across water bodies to identify microbes and parasites associated with die-offs. For example, a USGS - NPS project in the Obed Wild and Scenic Riverway is finding suitable restoration sites for the federally endangered Purple Bean (*Venustoncha trabilis*) using health condition measures of resident mussels and contaminant and microbial analysis of water and sediment. We will use these health measures to monitor the condition of juvenile mussels at select sites over a growing season. Another area of collaborative research is understanding life history and propagation requirements for endangered mussel species. In the St. Croix National Scenic Riverway (SACN), we are tracking movements of the host fish of Spectaclecase (*Cumberlandia monodonta*) and Winged Mapleleaf (*Quadrula fragosa*) to determine the potential distribution of each mussel species within the SACN. These studies will guide future mussel surveys and selection of suitable sites for augmentation or restoration activities. USGS and partners are also evaluating various propagation methods for Winged Mapleleaf to optimize conditions for juvenile survival and growth to help restocking efforts and reestablish this species in suitabl

Title: Diving for Freshwater Mussel Conservation in the Great Lakes and Big Rivers

Authors: Holdhusen, Allison[*,1]
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Abstract:
Mississippi (MISS) and Saint Croix Rivers, two National Parks in Minnesota and Wisconsin, are home to some of the richest and most intact native mussel communities in the world. Join Allie Holdhusen, Biological Science Technician with MISS and Program Diving Officer for the NPS Great Lakes Big Rivers Dive Program, as they share all about the fascinating and unique, freshwater mussel species of these large river Parks, and see some of the ways the NPS scuba diving program supports multi-agency efforts to protect and restore native, freshwater mussel species throughout the Great Lakes Region.

Title: Long-Term Zebra Mussel Monitoring Program at the St. Croix National Scenic Riverway

Authors: Shaffer, Marian
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1 National Park Service, St. Croix National Scenic Riverway

Abstract:
The Saint Croix National Scenic Riverway, a unit of the National Park System, was established by the Wild and Scenic Rivers Act in 1968. The Riverway encompasses 255 miles of unpolluted waters which flow through some of the most pristine country in the Upper Midwest. Unfortunately, the zebra mussel (Dreissena polymorpha) found its way into the St. Croix River in 1995 and were first discovered reproducing in the river in 2000. Since 1996, NPS has instituted a Zebra Mussel Control Point prohibiting boat travel (includes motor and non-motorized boats) upstream from river mile 29.5 (at the High Bridge) to prevent the spread of zebra mussels. To track changes overtime and better understand the invasion of zebra mussels in the Riverway, annual measurements of densities within the known infestation zone (the lower 22 miles of the river) have been collected since 2004. Passive substrate samplers are deployed on the river bottom at strategic locations from Stillwater, Minnesota to Prescott, Wisconsin, reflecting the range of habitats and hydrology found in the infestation zone. Concurrently, early detection (presence/absence) methods are deployed and include plate sampling at various sites within the Upper Riverway and veliger sampling at connecting lakes within the watershed. In 2022, numbers of zebra mussels detected on substrate samplers increased at most locations dramatically. Cinder blocks at Lake St. Croix Beach (Pool 2) saw the heaviest recruitment (45,858 per m2) of any of the pools in 2022. We also saw new positive zebra mussel veliger detections at lakes within the watershed. These aquatic invasive pests remain a significant threat with the potential to drastically alter the river ecosystem and devastate native mussel populations. In this talk, we will discuss our monitoring strategies and results in detail, along with challenges faced.

Title: A review of SCUBA based Zebra Mussel (Dreissena polymorpha) surveys in Lake Superior Parks.

Authors: Lafrancois, Toben[*,1]; Hove, Mark[2]; Glase, Jay[3]; Moraska Lafrancois, Brenda[3]
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Abstract: National Park Service dive team members, including partners from Northland College and the University of Minnesota, first discovered Zebra Mussels (D. polymorpha) at Isle Royale National Park (ISRO) and Apostle Islands National Lakeshore (APIS) in 2009 and 2015 respectively. Subsequent SCUBA based surveys have evolved from large scale timed searches to transects on GIS identified sentinel shoals. Across APIS we found broad Zebra Mussel distribution but very low densities that decrease west to east across APIS (e.g., 0.067/m2 at Eagle Shoal, 0.006/m2 at Rocky Island Shoal). This pattern corroborates EPA work on veliger drift from Duluth on dominant currents. Hotspots in popular APIS mooring areas suggest human transport as a secondary vector. No Zebra Mussels were found on Gull Is. Shoal at the eastern edge of APIS or in native mussel beds near Long Island. Our easternmost detection was at Kron's Reef, near a site EPA has found dreissenids in dredge samples. Zebra Mussels on some but not all APIS docks have been reduced to zero by diver removal. ISRO Zebra Mussels were found on and near docks, but not shoals. Two small specimens on the ramp at the Grand Portage Marina are concerning, although none were found near the Point de Chapeau docks. Preliminary biometry was conducted as community outreach (regional high school science competition). Analysis of length, dry mass, and digitized periostracum wear show Zebra Mussels at ISRO (Mott Island dock) were significantly smaller than those from APIS (Rocky Island dock). APIS specimens had significantly more periostracum wear than those at ISRO. Periostracum wear and size were not correlated. In the next few years, we will continue biometry on a broader range of samples, generate biomass estimates and continue quantitative population tracking. Comparisons with other methods confirm dive surveys are an essential component of early Zebra Mussel detection.

Title: Characterizing potentially expanding Dreissena distribution and composition in Lake Superior

Authors: Trebitz, Anett[1]; Hatzenbuhler, Chelsea[2]; Hoffman, Joel[1]; Larson, Courtney[3]; Peterson, Greg[1]; Szczepanski, Aubree[4]

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Abstract: Lake Superior stands as an exception to the other Laurentian Great Lakes when it comes to Dreissena mussels, with these invasive species established in the St. Louis River estuary (SLRE) since 1989 but seeming not to colonize the lake proper. In the last few years, however, Dreissena have been appearing on shipwrecks and reefs around the Apostle Islands National Lakeshore (APIS), prompting the National Park Service (NPS) to undertake removal efforts and us to better characterize their distribution. In 2017, we conducted intensive sampling in APIS that found no new settled Dreissena but low-density planktonic veligers in almost half the zooplankton samples, with a spatial distribution suggesting they were not locally spawned but rather transported to APIS from the direction of the SLRE. In 2019 we followed up with sampling the SLRE to APIS gradient, which yielded declining veliger density west to east consistent with SLRE as the source and longshore current as the transport mechanism. Veligers cannot be morphologically identified to species, but our 2019 work employed a new DNA marker that showed veligers to be a mix of *D. polymorpha* (zebra) and *D. bugensis* (quagga) mussels. The quagga DNA was unexpected, since previous SLRE data reported almost all Dreissena to be zebras, so in 2022 we revisited the SLRE species distribution using DNA markers to analyze water, zooplankton, and settled mussels. Also in 2022, we extracted DNA from a large set of open-lake zooplankton samples to look for veligers further out into Lake Superior. Finally, in both 2021 and 2022 we deployed veliger settlement traps at APIS reefs -- also analyzed with DNA markers -- to complement NPS monitoring for larger mussels. Collectively, these efforts are advancing understanding of Dreissena sources, abundance, and distribution within Lake Superior generally and APIS in particular.

Title: Improving Mussel and Fish Monitoring Outcomes with High-Resolution Bathymetry Data in National Parks

Authors: Penrod, Nathaniel H.[*,1]; Lafrancois, Brenda M.[2]; Glase, Jay[2]; Lafrancois, Toben D.[3]
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Abstract: The lack of high-quality bathymetric and lake-floor habitat data is one of the foremost challenges to effective management of submerged natural and cultural resources in the Great Lakes. Beginning in 2010, the U.S. National Park Service (NPS) began collecting bathymetry data in and around NPS park units with multibeam sonar to map the lakebed in high-resolution. Combined with publicly available topo-bathymetric lidar data, these bathymetry datasets allowed NPS staff to not only discover previously unknown cultural resources, such as uncharted wrecks, but to map potentially suitable habitats for several species of interest. Some of these species include invasive Dreissena mussels which pose significant challenges to managers of Great Lakes benthic ecosystems. Our ability to monitor current and emerging dreissenid infestations is critical in efforts to mitigate fouling of native Unionidae mussel and fish habitats as well as preventing damage to coastal infrastructure. Monitoring fish spawning and rearing habitat is key to promoting sustainable management of Great Lakes fisheries. This presentation will overview a suitability modeling study which identified sites most at risk of dreissenid mussel colonization and potentially suitable native mussel and fish spawning habitat in Lake Superior U.S. national parks. The model outputs were utilized by the NPS to guide site selection at Apostle Island and Isle Royale to monitor invasive mussels near these habitats during the summer of 2022. By utilizing high-resolution bathymetry data, the NPS was able to double their field work efficiency, increase the spatial coverage of their dive monitoring network, identify potential new monitoring site targets, and develop a method to assure statistically robust quantitative population data. Initial results from these monitoring efforts and future model applications will be discussed.

Title: Chironomidae species associations with water chemistry and trace metals in coastal rock pools

Authors: Egan, Alexander*,1; Burge, David R. L.2; Edlund, Mark B.2; Ferrington, Leonard C., Jr.3; Lafrancois, Toben4,

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Abstract:
Coastal rock pools of Lake Superior are a mosaic of biologically rich ecosystems that vary in their physical morphology and chemistry. Occurring in bedrock depressions between the forest edge and the lake, the aquatic communities in these pools are susceptible to both international shipping lane traffic and changing climate patterns. While individual pools are small, the number of pools across the coastal landscape provide an expansive network of variable habitats, with over 70,000 pools found in just the 48 km of shoreline in our study area. We analyzed how Chironomidae diversity and abundance were influenced by seasonality, habitat, and environmental factors (water chemistry and trace metals) using NMDS. Most chironomid species are associated with habitat type based on chemical characteristics and physical location on the shoreline. Conductivity and pH were significantly higher in pools near the lake, while temperature and dissolved oxygen varied seasonally. Nutrients and metals differed between study sites and pools at each site. At two sites, naturally occurring copper and aluminum were found at concentrations that exceeded chronic toxicity for sensitive aquatic invertebrates, which may be an important driver for chironomid occupancy and survival in certain pools.

5. Abstracts – Poster Presentations

Title: Reproductive effort and reproductive success in dwarf bilberry in the Superior National Forest

Authors: Hainlen, David R.[*,1]; Greenlee, Jack[2]; Gross, Briana L.[1]
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Abstract:
Northeastern Minnesota is home to multiple species of blueberries and their close relatives, all of which are native, wild, and produce edible berries. For many species of Vaccinium, flower and fruit production are highest in an open canopy. These conditions have historically been generated by natural or human-mediated fires, and this technique has been used traditionally by indigenous tribes and more recently by state and federal land managers. Controlled burns are now often a part of the timber harvest regime when a harvest is followed by a burn to promote vegetative regeneration. While the relationship between an open canopy and a robust berry crop is well documented, some of the basic mechanisms underlying the increase in berry production are still unknown. While an open canopy is generally correlated with an increased investment in sexual reproductive effort (i.e., more flowers/ramet) in many Vaccinium species, there is very little known about how sexual reproductive success (i.e., the % fruit set, or the number of flowers that produce berries) changes under these conditions. In this study, we examined standardized measures of sexual reproductive effort and success in 12 populations of dwarf bilberry (*Vaccinium cespitosum*) from the Superior National Forest near the north shore of Lake Superior. We found wide variation in both reproductive effort and success, including some populations that did not produce any flowers during the 2022 study season. Reproductive effort and success were not always predicted by population land management histories, indicating the complexity of this trait, and suggesting interesting avenues for further research.

Title: Bacterial communities associated with invasive bittersweet plants along a dunal chronosequence

Authors: Byappanahalli, Muruleedhara[*,1]; Pavlovic, Noel[1]; Nakatsu, Cindy[2]; Shively, Dawn[1]
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Abstract:
Invasive plants such as Asiatic bittersweet (*Celastrus orbiculatus Thunb.*) are a significant problem for land managers as they impact plant species composition, disrupt nutrient dynamics and structure of native ecosystems, and are difficult to eradicate. Recently, ecologists have been investigating the role of plant-soil-microbe interactions contributing to plant invasion. We hypothesize that, despite differences in the geologic age of soils where Asiatic bittersweet has established in the Indiana Dunes region, there are sufficient common factors contributing to common bacterial taxa in their rhizosphere. Our objectives were to determine differences and commonalities in the soil chemistry, plant community and bacterial communities of Asiatic bittersweet plants. At thirteen locations across the region, we compared soil chemistry, soil age (150 to over 14500 years), plant cover, and the 16S rRNA gene amplicon sequence of rhizosphere bacterial communities associated with bittersweet plants. Asiatic bittersweet coverage of sampling sites ranged from 2 to 77% averaging 52 ± 2 %. There were statistically significant differences ($p < 0.05$) in alpha diversity (Shannon, Faith's PD and Pielou's evenness) and beta diversity (Bray Curtis, Jaccard, unweighted Unifrac, weighted Unifrac) among the samples when grouped by soil age or habitat. Despite these differences in the bacterial communities among different soil ages and habitats, in every sample we discovered bacterial taxa (e.g., Bacillus, Streptomyces, Sphingomonas and Rhizobiales) previously found in other studies to be beneficial to plant growth. These microbes provide insight into a possible contributing factor to the success of this invasive plant at the Indiana Dunes National Park, and strategies for future work to reduce the impact of Asiatic bittersweet establishment.

Title: Considerations for Managing Phosphorus in Wisconsin's Nearshore Waters of Lake Superior

Authors: Thornburg, Bridget[*,1]; Hudson, Matt[1]; Levi, Peter[1]; Coffman, Ellen[2]; Sterner, Robert[3]
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Abstract:
Lake Superior is the largest and most pristine of the Great Lakes by many metrics. Despite this, cyanobacterial blooms have recently emerged along portions of Wisconsin's shoreline of the lake and recent proposed developments within the watershed have raised questions about how phosphorus should be managed to protect water quality in this complex system, particularly as it relates to interactions between nearshore and offshore waters. Currently, Wisconsin's total phosphorus criteria for open and nearshore waters of Lake Superior is 5 ug/L, which is driven by federal criteria for the open waters of the lake. Wisconsin's criteria for streams flowing into Lake Superior is 75 ug/L. Significant questions face scientists, managers, and regulators as to what an appropriate total phosphorus criteria should be to protect nearshore waters of the lake given the complex and dynamic interactions between tributaries, nearshore, and offshore waters. Until recently, little phosphorus data existed for nearshore waters to aid in this discussion. Recent studies have shed new light on spatial and temporal trends of phosphorus and other water quality parameters in Wisconsin's nearshore waters of Lake Superior. Total phosphorus concentrations from these studies span nearly three orders of magnitude, ranging from <1 ug/L to 629 ug/L, reflecting the episodic influence of tributary runoff on nearshore phosphorus concentrations, particularly magnified following a series of large precipitation events over the past decade. We will present results from these studies and discuss considerations related to phosphorus management in Wisconsin's nearshore waters of Lake Superior.

Title: Status and precision in the census of four rare Arctic-Alpine plants in Isle Royale National Park

Authors: Thornburg, Bridget R[*,1]; Potvin, Lynette R.[2]; James, Tyrease T.[1]; Sonora, Isabel M.L.[1]; Anderson, Claire I.[1]; Johnson, Sarah E.[1]

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Abstract:

Isle Royale has a high concentration of rare plants at the southern edge of their range and species with disjunct populations from Arctic or alpine regions. This study examined 28-year trends in population structure (number of genets, ramets, and reproductive stems) of *Pinguicula vulgaris*, *Saxifraga tricuspidata*, and *Saxifraga paniculata*, and changes in ocular cover of *Vaccinium uliginosum*. We restricted our analyses of census data for each species to the sites consistently visited multiple time periods between 1993-94 and 2021-22. Population counts for the four target species increased from 1993 to 2022 despite a period of below-average low water levels followed by an extreme rise in Lake Superior water levels. We considered that census counts in plant population monitoring can be subject to imprecision, so we conducted double counts of up to seven subsamples. We calculated imprecision with the coefficient of variation and absolute difference between double counts. Despite being easy to detect, *Pinguicula vulgaris* had the greatest coefficient of variation of 25.4% in the number of ramets counted between observers, and the second greatest mean absolute difference of 75.7 ramets between observers. Both *Saxifraga tricuspidata* and *S. paniculata* had similar coefficients of variation in all metrics at 9.1% and 5.3% for ramets, 16.2% and 13.1% for genets, and 4.9% and 5.6% for reproductive stems respectively. Observer error for these species is similarly relatively low despite numerous ramets in some genets of *S. tricuspidata*. Accounting for imprecision among different observers is helpful in interpreting magnitude differences in plant counts over time. Sustained monitoring of these range-edge species could serve as early indicators of climate change impacts and other drivers of change to the dynamic coastal habitats of Lake Superior. Or, these four cold-loving species may continue to exhibit patterns of resilience, reflecting their adaptations to dynamic coastal habitats

Title: Zaaga'igan Ma'iinganag - Lakewolves: Anatomy of Immersion

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Abstract:
The Apostle Islands National Lakeshore (APIS) has consistently invested in multiple efforts for local youth to access, enjoy, and be part of the park. Here we share one of these programs that is an immersive Park experience in both the figurative and literal sense. The Zaaga'igan Ma'iinganag (Lakewolves) program was created by giving high school students the tools to safely snorkel and photograph the Apostle Islands and its watershed. The Lakewolves embraced photography and underwater exploration to shatter barriers between personal expression, cultural connections, art, and science. In this poster we outline the process of handing kids power to define their own approach using these particular tools. The details of the evolution from the first student brainstorm session into a curriculum is outlined and we discuss some of the challenges of sustaining support. Central to our successes are multi-agency cooperation and the willingness of APIS staff to adapt Park missions to local needs. We outline the programmatic features that have led to years of high intensity student engagement directly in the freshwater environment as an example of the kinds of things that might work well in other Parks. We also review safety practices and how National Park Service blue card diving practices are combined with NOAA and Coast Guard recommendations to create a safe environment for students who have challenges with concentration, anxiety, and other barriers that would otherwise prevent them from experiencing aquatic environments. Finally, we outline how the program fits into upcoming projects like the APIS virtual tour, improving Anishinaabemowin place names awareness, and various scientific outreach projects that concern the community. Elements of our approach may be useful across the region to bridge generations, cultures, and connect kids to their best selves by connecting them to water.

Title: Long-term Lake Temperature Monitoring in Lakes: Exploring multi-depth data

Authors: Damstra, Richard[*,1]; Arno, Hallie[1,2]
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1 National Park Service Great Lakes Inventory and Monitoring Network
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Abstract:
National Park Service Great Lakes Inventory and Monitoring Network has been recording continuous lake temperature profile data since 2010 using strings of temperature loggers, called “temperature arrays”. Temperature arrays are deployed in a total of eight lakes at four national parks in the Great Lakes region: Isle Royale National Park (ISRO), Voyageur’s National Park (VOYA), Pictured Rocks National Lakeshore (PIRO), and Sleeping Bear Dunes National Lakeshore (SLBE). Arrays are suspended vertically in the water column from the surface to the bottom at the deepest part of a lake, with a temperature logger attached at each meter of depth. Loggers collect a data point every hour, allowing collection of high-resolution temperature data with many potential research and management applications. We are using this data to discern climate driven trends in temperature and lake thermal structure. We will also explore future directions of study for this project, such as linking changes in thermal structure to ecological changes in lakes.

Title: Forest regeneration is negatively impacted by ungulates, post spruce budworm outbreaks

Authors: Rootes, Jessica*,1; Aukema, Brian1
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Abstract:
The eastern spruce budworm (*Choristoneura fumiferana*) is a native defoliating moth found in Isle Royale National Park on Lake Superior. This insect demonstrates a cyclical outbreak pattern in which populations increase dramatically from endemic to epidemic levels for six to ten years. During these outbreaks, spruce budworm may kill 70% of mature balsams (*Abies balsamea*) and 40% of white spruce (*Picea glauca*), resulting in canopy gaps within the forest. Regeneration in these canopy gaps may be impeded by dense moose populations thus affecting forest recovery from natural insect disturbance. We compared regenerating areas 15 years post budworm outbreak in both Minnesota (an area with average moose densities) and Isle Royale National Park (an area with higher moose density). Our study results showed that regenerating trees on Isle Royale in these spaces were shorter, more proportionately browsed, and had experienced more altered growth from frequent re-browsing events. Our current work compares outbreak dynamics of spruce budworm between Minnesota and Isle Royale, focusing on natural enemy abundance and diversity as well as mating success of adult moths.

Title: Ash Forests 10 Years after Initial Infestation by Emerald Ash Borer: Lessons for Adaptive Management

Authors: Keller, Gwendolen[*,1]; Acharya, Kirk[1]; Schafer, Nicole[2]
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Abstract:
Since its arrival in 2011, emerald ash borer (EAB) (*Agrilus planipennis Fairmaire*) (*Coleoptera: Buprestidae*) has created a massive disturbance in the forests of Sleeping Bear Dunes National Lakeshore (SLBE). Fourteen vegetation community types at SLBE contain ash species (*Fraxinus americana L., F. pennsylvanica Marshall, and F. nigra Marshall*), representing roughly 82% of forested area at the Lakeshore. Given the important roles ash play in the forests of SLBE, and the ability of EAB to decimate ash stands 5-7 years after infestation, managers at the Lakeshore responded quickly to this forest health threat with a multifaceted approach. One strategy was to monitor the impact of EAB on SLBE forests to inform adaptive management practices as the infestation evolves. Monitoring plots were established and surveyed in 2014 and then resurveyed in 2021. Canopy cover of the most common overstory and midstory tree species on site were recorded. In addition, the number of living overstory ash per acre and number of identifiable downed ash logs were noted. These metrics allow for an estimation of the impact EAB has had on ash populations specifically and begin to reveal the change in forest community composition occurring at SLBE. The change in these metrics over time in addition to summaries of several other metrics surveyed in 2021 will be presented for three of the ash forest types at SLBE. The use of these findings for adaptive management and the planning of an ash forest restoration project will be discussed.

Title: Bioacoustic Monitoring in the Western Great Lakes

Authors: Casper, Gary[*,1]; Parr, Thomas[2]; Kirschbaum, Alan[2]
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Abstract:
National Park Service, Documented changes in the abundances of amphibian and bird species around the world are attributed to a variety of anthropogenic stressors ranging from contaminants to climate change. Our research uses acoustic monitoring to track occupancy and activity of amphibian and breeding bird species in U.S. national parks and throughout the western Great Lakes region. We utilize a dual survey approach to minimize error rates and derive metrics on occupancy and abundance to better understand long-term trajectories of species, and to conduct rigorous species inventories. We will present results from parks in the Great Lakes Inventory & Monitoring Network amphibian monitoring program, and from monitoring breeding birds and frogs throughout the region. Analyses will explore changes in occupancy and activity over time that can be related to changes in environmental conditions. Examples will discuss metrics used to explore trends and annual variation of species, compare acoustic to traditional manual survey results, and address how acoustic metrics are used to inform habitat management decisions for species of conservation interest by public, tribal and private landowners.

Title: A comprehensive forest health monitoring program in nine Great Lakes national park units

Authors: Sanders, Suzanne*,1; Kirschbaum, Jessica1
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1 National Park Service/Great Lakes Network

Abstract:
Long-term monitoring of forests, with regular return intervals, provides numerous benefits for land managers. It can elucidate patterns of change in vegetation that might not be noticed by the common observer, it can provide scientifically defensible data on which to base management actions, and the data can be examined retroactively to help explain or elucidate emerging issues. The Great Lakes Inventory and Monitoring Network implemented a long-term forest vegetation monitoring program at nine national park units, sampling the first round in parks from 2007 through 2011. The second round was carried out between 2012 and 2022. Across the nine parks, 445 total sites have been established. This monitoring protocol has several characteristics that distinguish it from other forest monitoring efforts. Data collection on trees extends to very small size classes (≥ 2.5 cm in diameter at breast height), providing parks with robust estimates of regeneration. Further, we collect extensive data on the herbaceous layer, identifying all species present in quadrats and sites. This allows us to fully characterize the community, as a whole, rather than just tree composition. Our work has been used to demonstrate deer browse impacts on both woody and herbaceous species (Sleeping Bear Dunes), reveal problems with cottonwood regeneration (Mississippi River), and show changes in species richness following escalating moose density (Isle Royale). We have also demonstrated changes in overstory composition in the absence of fire. We have valuable baseline data on park forests prior to the arrival of several key pests and pathogens, including data on American beech at Pictured Rocks and Sleeping Bear, prior to the arrival of beech bark disease, as well on three ash species, distributed over all nine parks, prior to the arrival of the emerald ash borer. In the summer of 2023, we will begin the third sampling round.

Title: The Future of Wilderness Research: Science Priorities from the 2022-32 ALWRI Science Charter

Authors: Taylor, Jason[*,1]; Hollingsworth, Teresa[1]; Hefty, Kira[1]; Olga Helmy[1]
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1 Aldo Leopold Wilderness Research Institute (ALWRI), Rocky Mountain Research Station, USDA Forest Service

Abstract:
The Aldo Leopold Wilderness Research Institute (ALWRI) is an interagency, national research facility whose mission is advancing wilderness stewardship through transformational science. In 2021 and 2022, through a collaborative ground-up engagement, we developed a new strategic plan and science charter that addresses high priority wilderness research needs nationally and internationally. Over 175 participants representing the USFS, BLM, FWS, NPS, indigenous communities, universities, and others identified research needs using a rank-ordering exercise informed by their personal and professional experiences. Five public workshops were then conducted to share preliminary results and to learn more about the nuances and context within partner priorities. The resulting science charter is founded on the intersection of ALWRI's expertise and capacity and the highest priorities from this inclusive partner engagement.

Over the next decade, the following five interrelated Research Priority Areas will form the basis of the Institute's research.

1. Biodiversity Conservation: Develop an understanding of the values, opportunities, and challenges for wilderness to support biodiversity conservation in an era of unprecedented change.

2. Climate Change and Disturbance: Improve knowledge about the impacts and consequences of climate change and climate-disturbance interactions, including wildland fire, relevant to wilderness stewardship.

3. Stewardship Effectiveness: Examine the effects and effectiveness of wilderness stewardship decisions, including the potential for and effects of management interventions.

4. Relevance and Inclusivity: Expand our understanding of wilderness relevance, experiences, inclusivity, and use amid social-ecological change.

5. Shared Stewardship: Improve our understanding of co-production approaches and abilities to harmonize multiple knowledge systems toward more inclusive wilderness stewardship.

Title: Voyageurs National Park: 2022 Was Gonzo … And 2023 Will Be, Too

Authors: Brian, Harmon[*,1]
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1 Harmon, Brian C.

Abstract: 2022 was an extraordinary and extraordinarily productive year at Voyageurs National Park. Wetland restoration, standing up zebra mussel decontamination operations, and assessing impacts to archeological sites from historic flooding: above and beyond our routine monitoring we did all this last year. This year we're building on these and throwing forest health into the mix as well.

Title: Trends in regional wet mercury deposition and lacustrine mercury concentrations in four lakes in Voyageurs National Park—an update

Authors: Mark E. Brigham (retired)[1], David VanderMeulen[2], and Ryan Maki[3]
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3 U.S. National Park Service, Voyageurs National Park, 360 Highway 11 E, International Falls, MN 5664

Although anthropogenic mercury (Hg) emissions to the atmosphere have been substantially lowered in the United States and Canada since 1990, concerns remain for elevated contamination in fish that inhabit lakes and rivers even in areas where atmospheric deposition is effectively the only source of mercury. The question arises: how have aquatic ecosystems responded? A previous analysis reported decreases in wet Hg deposition in northeastern Minnesota from 1998-2012, and mixed trends in Hg and methylmercury (MeHg) in lake water and fish from four remote lakes within Voyageurs National Park from 2001-2012 (Brigham, M.E. and others, 2014, Environmental Science & Technology, vol. 48, pp. 6115-6123. DOI: 10.1021/es500301a) [open access at: https://pubs.acs.org/doi/10.1021/es500301a]. Here, we report updated trends for the same study area for monitoring through 2018. Wet Hg deposition at two regional Mercury Deposition Network sites (Fernberg and Marcell, MN; http://nadp.slh.wisc.edu/mdn/) declined by an average of 22.5 percent from 1998-2018, with much of the decline occurring prior to 2011. In the four remote lakes, epilimnetic MeHg concentrations declined by an average of 42 percent and total Hg by an average of 27 percent.

Title: Role of the Interagency Ecological Restoration Quality Committee in Supporting Ecological Restoration Projects in the Great Lakes region

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Abstract:
The Interagency Ecological Restoration Quality Committee (IERQC) was formed in 2012 to support the Great Lakes Restoration Initiative (GLRI). The central role of the Committee is to serve as a 'think-tank' focused on advancing applications of Quality Assurance (QA) and Quality Control (QC) into ecological restoration (ER). The IERQC is chaired by the U.S. Environmental Protection Agency's Great Lakes National Program Office and is composed of representatives from federal, tribal, state, and non-governmental organizations. The Committee provides a collaborative environment for the development and advancement of quality best practices and includes the development of guidance publications and factsheets and virtual- and in-class workshops, symposia, and presentations at scientific meetings. Published in 2019, "Application of Quality Assurance and Quality Control Principles to Ecological Restoration Project Monitoring," EPA-905-K-19-001 (https://www.glri.us/node/250) represents the Committee's flagship publication. This publication, in short, is a comprehensive treatise on QA/QC best practices fundamental to planning, implementation, and assessment of ER projects. Other resources developed by the Committee, include an annotated bibliography on quality concepts applied to adaptive management (AM), an online Zotero Group® reference database on AM, and a synopsis publication describing a variety of online tools and resources on AM. In addition, recent efforts by the Committee includes the development of guidance on quality oversight specific to ER projects that involve a construction phase (e.g., installation of engineered solutions, elevational contouring, capping, grade contouring, among others). As this document is currently undergoing review, we are seeking feedback from our committee members, including the NPS, on the content of this guidance document.

6. Logistics

COVID precautions: Northland College does not currently require masking. For safety, we recommend screening yourself with a home test kit prior to attending the symposium. We also suggest that you have a mask with you in the event you feel you need it. If you feel ill once on site for the symposium, we recommend you isolate.

Symposium Registration – Please remember to register for the symposium at https://www.northland.edu/event/great-lakes-science-for-parks-symposium/#register. The registration fee is $100.

When – The symposium will begin at 12:00 p.m. Tuesday, March 21st and end at 5:00 p.m., Thursday, March 23, 2023.

Location - The symposium will be held at the Northland College Alvord Theater in the Ponzio Campus Center. https://mapcarta.com/N4564324839/Directions Signs will be posted to guide you to the appropriate room.

Parking - There will be free parking available at Northland College. We suggest that you carpool from your hotel to the Alvord Theater.

Travel - Winter travel conditions in Ashland, WI and the roads leading to the area are typically good, but the weather in the northland can be unpredictable. We encourage you to check local conditions at https://511wi.gov/ and look at the long-range forecast. We will update registered attendees if a major weather event is predicted during the week of the symposium.
Air travel – John F Kennedy Memorial Airport is a small regional airport located in Ashland, WI. Duluth International Airport (1.5 hours away in MN) is the closest airport served by commercial carriers.

Hotels – A room block is not reserved. The symposium will occur in the off-season, and we do not anticipate any issues with attendees finding lodging. Major hotels are listed below and organized by distance from downtown Ashland dining establishments.

Walking

- Best Western the Hotel Chequamegon
- Cobblestone Inn & Suites

A little further of a walk

- Super 8 by Wyndham

Short Drive

- Quality Inn Ashland – Lake Superior (Mexican Restaurant adjacent)
- AmericInn by Wyndham Ashland
- There are many other small motels and AirBnB establishments a short drive from the college.

Native-owned

- Bad River Lodge & Casino (Odanah, 17 mins)
- Legendary Waters Resort & Casino (Red Cliff, 40 mins)

Food – Lunch on Wednesday and Thursday is provided with a paid registration. We will update you on Tuesday lunch. For dinner, there are a wide variety of local restaurants in the downtown or a short drive from downtown.

Internet - A guest WIFI is available at the symposium site for Northland College.

7. Restaurants

2nd Street Bistro
201 E. Main Street
Ashland, WI 54806
715-682-6444
Serving fresh, seasonal ingredients prepared simply.

Ashland Baking Company
212 Chapple Avenue
Ashland, WI 54806
715-682-6010
An artisan bakery featuring breads and pastries, gourmet desserts, sandwiches, and salads.

Chequamegon Family Restaurant
620 E. Lake Shore Drive
Ashland, WI 54806
715-682-4543
Open daily at 6 a.m. to 9 p.m. year-round. Homemade soups, pastries and more.

Black Cat Coffeehouse
211 Chapple Avenue
Ashland, WI 54806
715-682-3680
Offering espresso, coffees, microbrew beer and a healthy vegetarian menu.

Breakwater Restaurant
1808 E. Lake Shore Drive
Ashland, WI 54806
715-682-8388
A full menu along with daily specials and a friendly atmosphere. Open daily from 5 a.m. until 10 p.m., serves breakfast all day.

Chequamegon Food Cooperative - Deli
700 West Main Street
Ashland, WI 54806
715-682-8251
Grab-and-go deli meals, sandwiches.

Chequamegon Grill
Located in the Best Western - The Hotel Chequamegon
101 Lake Shore Dr West
Ashland, WI 54806
715-682-6727

Deep Water Grille/South Shore Brewery
808 West Main Street
Ashland, WI 54806
715-682-4200
Combines unique fine dining and pub fare with the South Shore Brewery's six microbrews on tap.

El Charro Mexican Bar & Grill
30580 Hwy 2
Ashland, WI 54806
715-292-6564

El Tarasco Mexican Restaurant
2320 West Lake Shore Drive
Ashland, WI 54806
715-682-9658
Authentic Mexican food. To-go orders are available.

Frankie's Pizza
1315 E. Lake Shore Drive
Ashland, WI 54806
715-682-9980
Dine in or take out. Pizza and sandwiches.

Hugo's Pizza
221 Sanborn Ave.
Ashland, WI 54806
715-682-8202
Pizza, burgers, sandwiches, homemade soups, and salads. Delivery & carry-outs available.

New China Restaurant
300 W. Lake Shore Drive
Ashland, WI 54806
715-682-6601
Restaurant and bar serving both Chinese and American cuisine. Daily lunch specials are served from 11 a.m. to 3 p.m., and a full dinner menu is offered each day from 11 a.m. to 8:30 p.m. We also deliver.

Pizza Pub
1402 E. Lake Shore Drive
Ashland, WI 54806
715-682-6641

Taqueria La Monarca
311 Main Street East
Ashland, WI 54806
715-292-6535
Our menu is a combination of authentic Mexican dishes, delicious street tacos, and some great local favorites. We have something for everyone.

The Alley/South Shore Brewery
806 West Main Street
Ashland, WI 54806
715-682-4208
Adjacent to the South Shore Brewery and the Deep-Water Grille, features gourmet pizza, juicy burgers and much more.

The Sandbar at the Blue Wave
2521 West Lake Shore Dr
Ashland WI 54806
715-685-2583
Casual coffee shop serving coffee, sandwiches, soup, and full bar.