2023 Water Network
Virtual Poster Symposium

Poster #1

Title: Aquatic invasive species prevention: getting the best bang for the buck!
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Theme: Challenged Water (Agriculture, Climate, Culture, Society, Ecosystems, Green Water, Food, Groundwater, etc.)

Why did you undertake this study?
As an avid angler and lover of all things aquatic, I experienced firsthand the impacts of aquatic invasive species (AIS) on the waters I know and love. This compelled me to begin grad school with a focus on better understanding how to prevent AIS from spreading to new waters.

What did you do, how did you do it and what are the results?
In this study we estimated the effectiveness and costs of AIS prevention practices performed by boaters, watercraft inspectors, and hot water decontaminators. To estimate effectiveness, participants (n=144) recruited at public water access sites in Minnesota and Wisconsin and were asked to inspect and remove AIS from a boat that had been realistically staged with macrophytes, zebra mussels, and spiny water fleas. The types of organisms and the amounts of AIS removed were used to estimate effectiveness for each prevention method. Additionally, interviews with MN county AIS managers were conducted to gather itemized spending information on the three preventions in question. Our results suggest that watercraft inspection is a cost-effective method of prevention for most boats and hot water decontamination is an important tool for high-risk boats, however decontamination protocols are difficult to effectively execute. Furthermore, boater education helps reduce risk when inspectors cannot be present at public water access sites due to limited funding and staffing.

What impacts from this work were realized or are anticipated?
As a final result of this project we are developing a new feature as part of an online tool called the AIS explorer (aisexplorer.umn.edu). This tool forecasts the spread of AIS from lake to lake. With our new feature added, managers can create hypothetical prevention scenarios and have the ability to visualize the impacts of their interventions before actually implementing them across the landscape.

Poster #2

Title: Long term Water Quality Monitoring in Lake Superior's Western Arm
Primary Author: Sandra Brovold, UMN-D staff, brovo001@d.umn.edu
Co-Authors: Sterner, Robert, UMN-D Professor and Director of the Large Lakes Observatory, Lafrancois, Brenda, National Park Service
Theme: Challenged Water (Agriculture, Climate, Culture, Society, Ecosystems, Green Water, Food, Groundwater, etc.)

Why did you undertake this study?
This research was conducted in response to an increase in harmful algal blooms occurring along the south shore of Lakes Superior's western arm and in the Apostle Islands.

What did you do, how did you do it and what are the results?
Water chemistry samples were collected at a total of 87 different locations, multiple times per year over a 6 year period starting in 2017. Locations were both in Lake Superior and in the surrounding watershed. Water samples were collected from shore or from a boat. Samples were then analyzed for Chlorophyll-a, various forms of carbon, nitrogen, and phosphorus along with silica, total suspended solids, algal community, and algal toxins. Results showed a large difference in water chemistry based on station type and time of year.

What impacts from this work were realized or are anticipated?
We anticipated that phosphorus would have been a leading contributor to the algal bloom increases. This was found to be true but other parameters were also important such as water temperature and ammonia concentrations.

Poster #3

Title: Wildfires shift primary productivity towards light limitation in forested lakes of the Upper Great Lakes region
Primary Author: Eva Hendrickson, NRRI, UMN-D, hendr786@d.umn.edu
Co-Authors: Henneck, Jerry, NRRI & UMN-D, McCullough, Ian, MSU, Filstrup, Christopher T., NRRI-UMN-D

Theme: Challenged Water (Agriculture, Climate, Culture, Society, Ecosystems, Green Water, Food, Groundwater, etc.)

Why did you undertake this study?

Wildfire regimes are changing around the U.S. due to climate change, and are becoming more frequent, larger, and more severe. While wildfires are prominent in the western U.S., wildfires are becoming more common in Midwestern forested ecoregions, and may become an increasing stressor of these remote lakes. The few previous studies on wildfire impacts on lake water quality have documented a diversity of responses, but it is unclear how these translate to resource limitation on primary productivity. Here we studied the Greenwood Fire, giving us the ability to better understand how wildfires affect the balance between light and nutrient limitation in lakes. Understanding these impacts on a local level and integrating them to future wildfire research nationwide is important to fill the gap of knowledge occurring.

What did you do, how did you do it and what are the results?

We studied water quality responses of 30 lakes (15 burned, 15 control) affected by the 2021 Greenwood Fire (near Isabella, MN) one-year post-fire to understand the impact of wildfires on resource limitation in lake ecosystems. We hypothesized that burned lakes would have higher sediment, nutrient, and dissolved organic carbon (DOC) concentrations than control lakes, which would decrease water clarity and shift conditions towards light limitation. Findings showed increases in total phosphorus (TP), total nitrogen (TN), DOC, and total suspended solids (TSS), and a decrease in water transparency in burned versus control lakes, but phytoplankton biomass (chlorophyll a) did not differ across groups. TN:TP ratios indicated that lakes were mostly TP-limited regardless of wildfire status. In a similar manner, nitrate: ammonium (NO_3:NH_4) ratios indicated that both burned and control lakes had greater proportions of ammonium with many NO_3 levels below detection limit. Despite increased nutrient availability in burned lakes, decreased water clarity and unchanged chlorophyll a suggests that conditions became increasingly light limited following the wildfire.

What impacts from this work were realized or are anticipated?

Our findings suggest that changing wildfire regimes in Minnesota may result in brownification of pristine, blue-water lakes, and potentially shift phytoplankton communities towards functional traits to overcome light limitation, such as buoyancy-controlling cyanobacteria strains. Additionally, future management strategies might consider how changing nutrient and underwater light climate may impact macrophyte growth and food web dynamics (e.g., fish production) following wildfires.

Poster #4

Title: Enhanced treatment of anaerobic digestion effluent through efficient nutrient utilization using stepwise microalgal cultivation

Primary Author: Prof. Roger Ruan, Department of Bioproducts and Biosystems Engineering, University of Minnesota (Twin Cities), ruanx001@umn.edu
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Theme: Challenged Water (Agriculture, Climate, Culture, Society, Ecosystems, Green Water, Food, Groundwater, etc.)

Why did you undertake this study?

Minnesota is the top poultry, swine and dairy producer in the United States, but the state also faces environmental pollution due to the inappropriate disposal of animal manures. Anaerobic digestion (AD) is a cost-effective traditional approach to treating animal waste; however, the AD effluent still contains high levels of toxic ammonia and chemical oxygen demand (COD), which may lead to groundwater and river water pollution and then become an environmental burden. Microalgae-based wastewater treatment is regarded as a promising alternative to conventional wastewater treatment mainly due to its ability to use wastewater nutrients for valuable biomass production, achieving both environmental and economic benefits. However, high concentrations of ammonia may lead to decreased cell growth or even death of microalgal cells, significantly reducing treatment efficiency. Moreover, the coexistence of high concentrations of toxic ammonia and COD increases treatment difficulty and process cost. Therefore, it remains challenging to efficiently treat and dispose of AD effluent containing high-concentration organic and inorganic matters.

What did you do, how did you do it and what are the results?

In this study, the strategies of short-term acclimation and microalgae-based stepwise process were investigated and applied to alleviate ammonia toxicity and finally improve the efficient treatment of AD effluent containing high concentrations of ammonia and COD. Initially, different short-term acclimation strategies such as nitrogen starvation and high ammonia concentration stress, were applied to investigate their potential effects on cell growth and ammonia uptake of Chlorella vulgaris. Furthermore, the stepwise cultivation of microalgal cells in 6L airlift photobioreactor and 4L flasks was investigated for the sequential removal of ammonia and COD for ammonia toxicity alleviation and microalgal biomass production. The results indicated that 2-day nitrogen starvation of algal cells significantly improved its capability of nutrient removal of ammonia and COD, while the proposed stepwise microalgal cultivation in different bioreactors achieved high efficiency in treating AD effluent associated with valuable microalgal biomass production.

What impacts from this work were realized or are anticipated?
This work has demonstrated that the strategies of nitrogen starvation acclimation and stepwise microalgal cultivation are powerful tools for enhancing the ability of microalgae to alleviate ammonia toxicity and utilize ammonia and COD as nutrients for biomass production. This approach provides an efficient method for using microalgae to treat wastewater, particularly anaerobic digestion effluent containing high concentrations of toxic ammonia and COD. Furthermore, this method can also be applied to treat other types of wastewater, such as animal manure-derived wastewater containing high-concentration organic and inorganic matters. The obtained algal biomass can be utilized as feedstocks for producing fish feed, biofuels, nitrogen fertilizer, and green vegetables. This work offers new insights into the low-cost and efficient treatment of various types of wastewater with the added benefits of environment improvement and economic development.

Poster #5

Title: Optimization of Environmental DNA Methods for Improving Detection Probability of Multiple Aquatic Invasive Species in Minnesota Lakes
Primary Author: Anna C Totsch, Water Resources Science Graduate Student, totsc005@umn.edu
Co-Authors: Chun, Chan Lan, NRRI, Dumke, Josh, NRRI
Theme: Challenged Water (Agriculture, Climate, Culture, Society, Ecosystems, Green Water, Food, Groundwater, etc.)

Why did you undertake this study?
I undertook this study because I am very interested in molecular biology methods on environmental DNA and how we can further use these methods for biological needs in the environment, from invasive species to endangered species.

What did you do, how did you do it and what are the results?
This study aims to test and compare different field and lab eDNA methods to determine which combinations maximize detection probability of our target AIS. Field sampling was conducted at five lakes in northern Minnesota, USA. Lake characteristics include sizes of large, medium, and small with one being a river system. AIS of interest includes Zebra mussels (*Dreissena polymorpha*), Spiny waterflea (*Bythotrephes cederstromii*), Rusty crayfish (*Faxonius rusticus*), and Common carp (*Cyprinus carpio*). These species were chosen since they have already been established in our selected lake bodies. We compared several different ways of harvesting DNA (volume, filters, sample locations), quantification of DNA (qPCR vs. dPCR), and we also compared AIS detection using eDNA methods against traditional AIS detection surveys to see which method performed better. Our findings will provide guidance and recommendations to natural resource managers who might consider eDNA as an AIS monitoring tool. Results are currently being analyzed, but overall eDNA is more sensitive then traditional field methods.

What impacts from this work were realized or are anticipated?
From this work a lot of collaboration had to happen behind the scenes. Collaboration includes researchers from the University of Minnesota Duluth Campus, University of Minnesota Twin Cities Campus, and the University of Illinois Urbana-Champaign.

What impacts does your work have on enhancing communities, inside or outside the University, or through diversity, equity or inclusion?
This work will continue as a Citizen Science project for future public engagement with people and lakes.

Poster #6

Title: Hydrologic Conditions in a Restored Peatland Driven by Surface Water and Precipitation
Primary Author: Zachary Wagner, UMN-D & NRRI, wagn0671@d.umn.edu
Co-Authors: Filstrup, Christopher (NRRI); Brady, Valerie (NRRI); Henneck, Jerald (NRRI), Bernhardt, Beth (NRRI); Hell, Robert (NRRI); Wellard-Kelly, Holly (NRRI); Beaster, Kelly (none); Magner, Joseph (University of Minnesota - CFANS)
Theme: Challenged Water (Agriculture, Climate, Culture, Society, Ecosystems, Green Water, Food, Groundwater, etc.)

Why did you undertake this study?
Wetland hydrology is critical for assessing ecosystem health and wetland function, including vegetation abundance and composition, carbon storage, and resilience to hydrologic changes. The NRRI Fens Complex was restored from a farm into its previous peat-rich wetland cover. This study is part of the effort to evaluate restoration success using multiple parameters; including hydrology, vegetation, macroinvertebrates, mammals and birds.

What did you do, how did you do it and what are the results?
Water samples were taken for oxygen and hydrogen isotopes to trace the seasonality and source. Shallow groundwater and surface water samples were initially measured, deeper wells were installed and sampled to evaluate water directly above the confining layer. We also installed pressure transducers in select wells to measure water levels. Both the isotopes and well loggers reflected recent precipitation as the main control on wetland water.

What impacts from this work were realized or are anticipated?
The hydrology of the restored area is bog-like since it is derived from recent precipitation rather than the horizontal movement of groundwater; however, the historic hydrology was more like a fen. The ditches likely cut off groundwater movement and the ground is more compacted compared to pre-farming. Future work includes comparing this site to other restoration sites or undisturbed site as well as analyzing peat growth and carbon storage in the wetland.

Poster #7

Title: Peat Derived Anion Exchange Materials for Sulfate Remediation in Mine Pit Water
Primary Author: Sergiy Yemets, UMN-D & NRRI, syemets@d.umn.edu
Co-Authors: Kolomitsyn, Igor, UMN-D & NRRI
Theme: Challenged Water (Agriculture, Climate, Culture, Society, Ecosystems, Green Water, Food, Groundwater, etc.)

Why did you undertake this study?
Increased sulfate levels in Minnesota's waters are a widespread problem. Most existing technologies allow lowering sulfate levels to 250 ppm which is the Environmental Protection Agency's recommended standard for drinking water. However, Minnesota administrative rules prescribe even stricter water quality standards for agriculture. Class 4A waters should have sulfate concentrations not higher than 10 ppm for production of wild rice. Such technologies as distillation and membrane filtration (reverse osmosis and nanofiltration) to reduce sulfate to very low levels are expensive, energy consuming, and challenging to implement. The purpose of the study is design of materials and processes that will help to create efficient technologies for reduction of sulfate concentration in challenged water to 10 ppm level.

What did you do, how did you do it and what are the results?
Anion exchange materials can be very effective for sulfate removal from challenged water. A number of new natural peat derived anion exchange materials were developed in our laboratory. A batch testing of these new anion exchange materials were conducted. Recently we have demonstrated that peat derived anion exchange materials have strong binding affinity to per- and polyfluoroalkyl substances (PFAS). The initial positive results prompted us to investigate their efficiency to remove sulfate anions from mine pit water. Isotherms for chloride to sulfate exchange in a selected material fit Langmuir and Freundlich adsorption models. The practical limiting retention capacity was found to be 108 mg/g for the material (SY2205165) and 167 mg/g for the commercial anion exchange resin (Resinex). The new materials demonstrate their potential for the sulfate removal from the contaminated water sources.

What impacts from this work were realized or are anticipated?
Further experiments on evaluation of selected peat lignin derived anion exchange material as well as sulfate selective commercial anion exchange resin in the column environment will be performed for the practical implementation. A bench top system with anion exchange column involving sulfate removal and column regeneration cycles will be developed. This approach to sulfate removal alone or in combination with other approaches will create technologies for effective reduction of sulfate concentration in challenged water to 10 ppm level.

Poster #8

Title: Leveraging Minnesota's Stormwater Data for Improved Water Quality Management
Primary Author: Ben Janke, University of Minnesota, janke024@umn.edu
Co-Authors: Finlay, Jacques, University of Minnesota; Trojan, Mike, MPCA; Wilson, Bruce, University of Minnesota; Marek-Spartz, Mary, University of Minnesota
Theme: Engineered Water (Drinking, Waste, Storm, Urban, Reuse)

Why did you undertake this study?
To make better use of the vast stormwater monitoring data being collected by cities and agencies across the state, which represents a scientifically and financially valuable resource that could be leveraged into better understanding of climate and landscape drivers of stormwater pollution.

What did you do, how did you do it and what are the results?
Aggregated stormwater monitoring data from roughly 15 agencies, representing close to 100 storm drain sites and over 13,000 sampled events, spanning from 2000 to present. Data are being cleaned and summarized using statistical methods, and will be analyzed with landscape predictors derived from spatial data to build predictive models of stormwater concentrations (and eventually volumes and/or loads).

What impacts from this work were realized or are anticipated?
We anticipate that the metadata (inventory of who is collecting what kind of data, where, and when) will be incredibly valuable, along with the scientific outputs in the form of Minnesota-relevant stormwater characterization, equations to predict stormwater concentrations in ungauged watersheds from readily-available, statewide GIS data, and improved understanding of drivers of stormwater pollution. The work should also support future studies of hydrology and pollutant loads, as well as of temporal patterns, including long-term trends, impacts of BMP implementation, land use or climate change, etc.

Poster #9

Title: People Want Parks: Results from a Lincoln Park Climate Resilience Survey
Primary Author: Tiffany Sprague, NRRI, tsprague@d.umn.edu
Co-Authors: Rodman, Madison, MN Sea Grant; Sowers, Maia, Ecolibrium3
Theme: Social Water (Culture, Society, Value of water, Water justice & equity, others?)

Why did you undertake this study?
The Lincoln Park neighborhood in Duluth, Minnesota is historically underserved, redlined and polluted from heavy industry. Residents of this neighborhood are also impacted by urban

flooding, yet have little resources to recover. We are working with the Lincoln Park community to increase climate resilience through implementation of multi-beneficial green infrastructure.

What did you do, how did you do it and what are the results?
We conducted a community survey of 100 residents from Lincoln Park (Duluth, MN) to understand the climate and water challenges they face, the types of urban green spaces they valued, and what types of green spaces they would like to see in their community. 74% of respondents felt it was important to reduce community water damage and 55% were concerned about changes to future water quality. The three most important urban green spaces to residents were parks, bodies of water and trails.

What impacts from this work were realized or are anticipated?
This work was part 2 of 4: part 1 was a background assessment of community and climate vulnerabilities for the neighborhood; part two was this survey and the next steps will be a series of visioning session with a focus group to identify potential green infrastructure practices and locations, culminating in implementation of a small-scale green infrastructure project(s) within the neighborhood during the summer-fall 2023.

What impacts does your work have on enhancing communities, inside or outside the University, or through diversity, equity or inclusion?
This work focuses on a community that experiences higher rates of social vulnerability than many other neighborhoods across Duluth, and thus has the fewest means to adapt to our changing climate.

Poster #10

Title: Examining inequality in aquatic ecosystem services: Evidence from large-scale monitoring programs
Primary Author: Sergey Ilyushkin, NRRI, ilyus003@d.umn.edu
Co-Authors: Kovalenko, Katya, NRRI
Theme: Social Water (Culture, Society, Value of water, Water justice & equity, others?)

Why did you undertake this study?
Many studies support human health benefits of blue spaces and their associated ecosystem services, but these benefits are often inequitably distributed. Better understanding of large-scale relationships between vulnerability gradients and coastal and lake condition is the first step towards resolving this inequality.

What did you do, how did you do it and what are the results?
Using data from large-scale monitoring programs (National Coastal Condition Assessment and National Lakes Assessment, US EPA), we analyzed relationships between aquatic ecosystem

condition and environmental justice indices. We used high-performance computing (Minnesota Supercomputing Institute) for geospatial modeling and a variety of statistical and visualization approaches. Our results show that lower aquatic habitat quality was observed in proximity to higher minority populations for some WQ metrics but not others, and that minority communities could be more equitably represented in monitoring.

What impacts from this work were realized or are anticipated?
These findings have implications for improving representation of vulnerable communities in large-scale water quality monitoring programs.

Poster #11

Title: Contaminant sources, fate, and transport in the Laurentian Great Lakes: an update of the Great Lakes Sediment Surveillance Program
Primary Author: Christopher T. Filstrup, Natural Resources Research Institute (NRRI), University of Minnesota Duluth (UMN-D), filstrup@d.umn.edu
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Theme: Big Water (Mississippi & Red Rivers, Great Lakes, Groundwater)

Why did you undertake this study?
Anthropogenic contaminants have been detected throughout the Laurentian Great Lakes (LGL), with many contaminants being resistant to environmental degradation and potentially bioaccumulative and toxic to aquatic organisms. While the effects of many legacy contaminants (e.g., mercury, PCBs, DDT) in aquatic ecosystems are well-documented, there remain critical knowledge gaps in sources, fate, and transport of legacy and emerging contaminants (e.g., PFAS, flame retardants, synthetic fragrances), as well as their interactions with ecosystem components (water column, sediments, aquatic organisms) and functions (biogeochemical cycling, productivity). The aim of the USEPA Great Lakes Sediment Surveillance Program (GLSSP) is to assess the fate and transport of contaminants in the LGL in an effort to better understand the complex, interdependent relationships among spatiotemporal patterns of sediment contaminant fingerprints, biogeochemical sediment characteristics, and overall ecosystem health. Here, we present results for spatial distributions of sediment grain size, organic matter content, and metals (arsenic, copper, lead) for Lake Superior.

What did you do, how did you do it and what are the results?
We collected surface sediment samples (top 1 cm) from 30 stations located throughout Lake Superior in 2021. Samples were analyzed for grain size (laser diffraction particle size analyzer), organic matter content (loss-on-ignition), and a suite of 27 elements (inductively coupled plasma - optical emission spectrometry (ICP-OES) following microwave-assisted nitric acid digestion). Arsenic was highest near Silver Bay and at western stations, lowest at eastern stations, and undetectable along South Shore nearshore stations. Copper and lead were highest at stations between Isle Royale & Keweenaw Peninsula, and lowest at nearshore and eastern stations. One eastern station had higher concentrations of arsenic, copper, and lead compared to nearby stations, potentially due to abnormally high clay and organic matter content.

What impacts from this work were realized or are anticipated?
This project improves our knowledge of contaminant fate and transport in Lake Superior, as well as current surface distributions of arsenic, copper, and lead throughout the lake. Arsenic, copper, and lead concentrations reflect the underlying geology and anthropogenic sources (e.g., mining, forestry and forest products) in the Lake Superior watershed. The depositional environment and sediment characteristics (sediment grain size, organic matter content) strongly influenced elemental concentrations in surface sediments. While high nearshore elemental concentrations can signal high tributary loads, low concentrations may reflect either dilution by high sedimentation rates or transport to deeper offshore stations sorbed to clays and organic matter. The relatively high elemental concentrations at one eastern station compared to nearby stations suggest that contaminant distributions in the Laurentian Great Lakes may be localized and will require adequate spatial resolution of samples to characterize contaminant spatial heterogeneity.

Poster #12

Title: Contrasting limiting factors in Great Lakes algal blooms
Primary Author: Reane Loiselle, UMN-D Large Lakes Observatory (LLO), loise031@d.umn.edu
Co-Authors: Sterner, Robert, UMN-D LLO. Adhikari, Anjana, UW Milwaukee School of Freshwater Science
Theme: Big Water (Mississippi & Red Rivers, Great Lakes, Groundwater)

Why did you undertake this study?
To better understand how Cyanobacteria and the other major phytoplankton phyla respond to nutrients and temperature in the Great Lakes, particularly considering climate change.

What did you do, how did you do it and what are the results?
Field sampling and bioassays were conducted 4-7 times throughout 2022 and included multiple nutrient treatments at two temperatures with additions of phosphate, nitrate, ammonia, and

urea. Short incubations were 2 days in Lakes Erie and Michigan, and 5 days in Superior. Response ratios of fluoroprobe measured algal concentration (RR = log (E/C) / day) were used to determine effects of nutrients and temperatures. Algal toxin analyses were conducted using an LC-MS/MS. Lake Superior had the most significant growth response to P, especially when combined with elevated temperatures. Lakes Michigan and Erie on the other hand had highest responses to nitrate, with little temperature effect. Toxins and peptides such as Microcystin Congener RR, cyanopeptolin and anabaenopeptins B and F were detected in both Lakes Michigan and Erie and are directly linked to nutrient concentrations.

What impacts from this work were realized or are anticipated?
These results contribute to our broader understanding of blooms and indicate that increased temperature has a larger impact on Lake Superior phytoplankton than other Great Lakes. Nitrate seems to be the most relevant nutrient affecting blooms in Lake Michigan and Lake Erie, likely due to sustained internal phosphorus loading from sediments in both of those lakes. The preference for nitrate over the other N species is an ongoing question. Toxin production in Lake Michigan also appears to be influenced by nitrate, particularly in ambient temperatures. In contrast, phosphorus seems to be the most relevant nutrient in Lake Superior, indicating the need for continued emphasis on P reduction for bloom control.

Poster #13

Title: The Role of Trace Metal Nutrient Limitation in Oligotrophic Harmful Algal Bloom Communities
Primary Author: Robert (Rob) McManus, UMN-D, mcman247@d.umn.edu
Co-Authors: Sterner, Robert, UMN-D
Theme: Big Water (Mississippi & Red Rivers, Great Lakes, Groundwater)

Why did you undertake this study?
This work will be my master's thesis. I selected it due to the breadth of marine literature on the impact of iron nutrient limitation in the oceans, but very sparse literature on trace metal nutrient limitation in lakes. I am particularly interested in the role iron, and other trace metals play, in the recent prevalence of Lake Superior harmful algal blooms. Additionally, this study aims to further our understanding of cyanobacterial cellular responses to differential iron concentration via a targeted gene expression analysis, as well as attempting to quantify how cellular ionomes shift in different environmental chemical conditions.

What did you do, how did you do it and what are the results?
I am planning to conduct these experiments in August and September of this year (2023), therefore there are currently no results. However, I am planning to sample five sites from an inland lake, stream, and then three sites in Lake Superior. For each site at each day, factorial nutrient addition bioassays with phosphorus and iron will be conducted, targeted gene

expression and ionomic sampling will also occur, in addition to a suite of biogeochemical analyses at each site.

What impacts from this work were realized or are anticipated?
This work anticipates deeper understanding in oligotrophic cyanobacterial responses to iron in both growth response as well as specific cellular responses to an abundance or limitation of iron. It also aims to be a novel contribution to phytoplankton meta-ionomics by providing first insights into the range and plasticity of trace metals within phytoplankton communities under shifting environmental conditions. Finally, this research anticipates enhanced understanding of spatial and biogeochemical demographics which could occur during poorly understood, Lake Superior, harmful algal blooms.

Poster #14

Title: R/V Blue Heron - The University of Minnesota's Research Vessel
Primary Author: Doug Ricketts, UMN-D, ricketts@d.umn.edu
Co-Authors: Lee, Rual, UMN-D
Theme: Big Water (Mississippi & Red Rivers, Great Lakes, Groundwater)

Why did you undertake this study?
The RV Blue Heron supports researchers and educators that work on the Great Lakes. We have a wide array of scientific instrumentation that can be used to study the sediment deposited below the lakes, the water in the lakes, and the atmosphere above the lakes.

What did you do, how did you do it and what are the results?
The Blue Heron has supported research and education on the Great Lakes for 25 years with over 1700 days on Lakes Superior, Huron, Michigan, and Erie.

What impacts from this work were realized or are anticipated?
The vessel has assisted biologists, chemists, geologists, and physicists in their efforts to gain a better understanding of the Great Lakes. The vessel and its highly trained crew are ready to assist anyone with their work on the lakes.

Poster #15

Title: Vanishing winter promotes summer cyanobacterial blooms in Earth's largest lake
Primary Author: Robert W. Sterner, Large Lakes Observatory, UMN-D, stern007@d.umn.edu
Co-Authors: Brenda Moraska Lafrancois, National Park Service and Byron A. Steinman, LLO, UMN-D
Theme: Big Water (Mississippi & Red Rivers, Great Lakes, Groundwater)

Why did you undertake this study?
Prior evidence indicated that climate change was an important driver of new Lake Superior algal blooms. This study investigated the seasonality of this impact more carefully than had been done before.

What did you do, how did you do it and what are the results?
Examined records of air and water temperature from 2011 to 2021 and looked for differences between bloom and non-bloom years. The major result is that cold winters precede blooms while air temperatures during bloom season is not different from non-bloom season. Cold winters are shown both for air temperature and for lake ice coverage.

What impacts from this work were realized or are anticipated?
The results point to deleterious climate change impacts of so-called "vanishing winter" and open up the possibility of meaningful ecological forecasts months ahead of events.

What impacts does your work have on enhancing communities, inside or outside the University, or through diversity, equity or inclusion?
The work addresses an issue of widespread concern.

Poster #16

Title: Long term trends and periodic fluctuations in Minnesota lake water quality driven by changes in climate and land use
Primary Author: Alexis Ward, Water Resources Science program, UMN-D & NRRI, ward0799@d.umn.edu
Co-Authors: Filstrup, Christopher, UMN-D & NRRI
Theme: Smart Water (Remote Sensing, Big Data, Computational, AI, Low-cost DIY)

Why did you undertake this study?
This is my master's thesis research, and I'm interested in expanding upon current knowledge of long-term changes in Minnesota lake water quality and the climate and landscape drivers of such changes to better inform management practices.

What did you do, how did you do it and what are the results?
I studied long-term trends of MN lakes using a large water quality monitoring dataset collected by the Minnesota Pollution Control Agency. I applied the Mann-Kendall test for monotonic trends and used changepoint analysis on a subset of lakes to evaluate its potential for capturing non-linearities in trends, i.e. those caused by climate cycles. Monotonic trends are not consistent across all metrics for individual lakes nor across lakes within ecoregions.

What impacts from this work were realized or are anticipated?
Preliminary findings suggest local characteristics are likely important in modulating lake response to stressors. Understanding these trends and their drivers will help management agencies confront future challenges with water quality under multiple stressors imposed by climate change and land use modification.

Poster #17

Title: Developing low-cost sensing systems for urban trees
Primary Author: Xiating Chen, UMN-TC Department of Civil, environmental and Geo-Engineering (CEGE) and St. Anthony Falls Laboratory (SAFL), chen7090@umn.edu
Co-Authors: Indigo Davit-Liu, UMN-TC CEGE; Xue Feng, UMN-TC CEGE & SAFL
Theme: Smart Water (Remote Sensing, Big Data, Computational, AI, Low-cost DIY)

Why did you undertake this study?
We want to quantify urban trees' stormwater and heat reduction benefits, by measuring the water flux along the soil-plant-atmosphere continuum. In this specific poster, we want to measure how much water urban trees take up in the process.

What did you do, how did you do it and what are the results?
We designed a decentralized tree sensing system that can be deployed in an urban setting. Most importantly, we built and tested sap flux sensors that measure tree transpiration. We are in the process of testing our sensors against commercially available sensors in the Plant Growth Facilities on St. Paul campus.

What impacts from this work were realized or are anticipated?
By quantifying urban trees' water uptake ability, we hope to better support the adoption of the urban tree planting as green infrastructure here in MN and beyond.

Poster #18

Title: Advanced water quality monitoring of optically variable lake systems using Landsat 8 OLI and Sentinel 2 MSI imagery in an automated high-performance computing environment
Primary Author: Leif Olmanson, Department of Forest Resources, University of Minnesota, olman002@umn.edu
Co-Authors: Porter, David, Minnesota Supercomputing Institute, University of Minnesota
Theme: Smart Water (Remote Sensing, Big Data, Computational, AI, Low-cost DIY)

Why did you undertake this study?
In lake-rich regions, like Minnesota USA, protecting water quality is critically important because of the ecological and economic importance of recreational activities and tourism. To ensure the

health of inland aquatic ecosystems on both a local and regional scale, more comprehensive monitoring techniques to complement conventional field sampling methodologies are needed for effective management. For over 25 years, we have used Landsat imagery for water clarity measurements on 10,000+ lakes at five-year intervals but with recent advancements in spatial, spectral, radiometric, and temporal resolution of satellite imagery we can measure more water quality variables more often.

What did you do, how did you do it and what are the results?

We developed field-validated methods and implemented image processing techniques in an automated pipeline built in a high-performance computing environment that generates satellite data products for lake water quality monitoring and management. Machine-to-machine access to ESA Copernicus and U.S. Geological Survey servers allows for the synergistic acquisition of Sentinel-2 and Landsat-8 imagery to supply the demand for near-real-time data. Newly acquired imagery can be immediately sent through multiple scripted processing modules, which include: Identifying and omitting clouds, cloud shadows, atmospheric haze, wildfire smoke, and specular reflection. Classifying water pixels to delineate a scene-specific water mask. Using a modified SWIR-based aerosol atmospheric correction to retrieve remote sensing reflectance (Rrs) data that are used to develop water quality models. Using calibrated water quality models (water clarity, CDOM, and chlorophyll-a) that rely on field data to account for optically complex lake systems of the region.

The data are made available to the public in the Minnesota LakeBrowser, an online map viewer linked to a spatial database that allows for statistical summaries at different spatial delineations (including pixel-level and lake-level), temporal analyses, and visualization of water quality variables. For Minnesota, the lake-level (2017-2022) data include 1,017,891 daily measurements of chlorophyll, clarity, and CDOM (3,053,673 total) that are updated regularly.

What impacts from this work were realized or are anticipated?

The data are being used for geospatial and temporal analysis of lake water quality, greenhouse gas emissions, and societal costs of anthropogenic eutrophication. Using this data we know which lakes are impaired and how lakes are changing in relation to watershed activities. The Minnesota Department of Natural Resources uses the data for the Watershed Health Assessment Framework (WHAF) which provides an organized approach to understanding natural resource conditions and challenges and identifying opportunities to improve the health and resilience of Minnesota's watersheds.

What impacts does your work have on enhancing communities, inside or outside the University, or through diversity, equity or inclusion?

The Minnesota LakeBrowser is available to everyone and allows easy access to historical and recent lake water quality information for all lakes in Minnesota.

Acronyms

CEGE = Department of Civil, Environmental and Geo-Engineering
LLO = Large Lakes Observatory
MNDNR =- Minnesota Department of Natural Resources
NRRI = Natural Resources Research Institute
SAFL = St. Anthony Falls Laboratory
UMN-D = University of Minnesota - Duluth
UMN-TC = University of Minnesota - Twin Cities