Environment and Natural Resources Trust Fund
2020 Request for Proposals (RFP)

Project Title: **ENRTF ID: 113-B**

Mapping Lake Superior's Changing Biogeochemistry

Category: B. Water Resources

Sub-Category:

Total Project Budget: $ 286,192

Proposed Project Time Period for the Funding Requested: June 30, 2022 (2 yrs)

Summary:

We will develop an online and updatable atlas of water quality in western Lake Superior, which will provide stakeholders with key information about land-lake interactions to help prioritize conservation efforts.

Name: Laure Charleux

Sponsoring Organization: U of MN

Job Title: Dr.

Department: University of Minnesota Duluth

Address: 324 Cina Hall - Geography Dept - 1123 University Drive

Duluth MN 55812

Telephone Number: (218) 726-6809

Email lcharleu@d.umn.edu

Web Address:

Location:

Region: Northeast

County Name: Carlton, Cook, Lake, St. Louis

City / Township:

Alternate Text for Visual:

Visual showing increasing frequency of instense storm events, land-lake interactions, ship + satellite + GIS investigative apparatus, list of products and dissemination.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Mapping Lake Superior's Changing Biogeochemistry

I. PROJECT STATEMENT:

Using new high-resolution remote-sensing imagery, we will map the impact of storm events on water quality across western Lake Superior to help optimize soil and water conservation efforts.

As climate changes, more frequent intense rain events (z.umn.edu/48fi) and land use changes threaten the quality of the clear waters of Lake Superior. Both increase the amounts of nutrients and sediments reaching the lake, which impacts water quality and may compromise ecosystem services such as drinking water or recreation.

Water quality varies across the lake and over time. Tracking and mapping these variations is crucial to understanding how land and lake interact and how the lake system sustains and recovers from events such as snowmelt or major storms. Water quality is currently monitored along the coastal zone but not across the off-shore zone (90% of the surface of the lake in MN), due to the high cost of direct off-shore sampling and sensing from ships. Our project will try to establish off-shore monitoring by taking advantage of newly available high-resolution and high-frequency satellite imagery to drastically reduce the need for direct in-lake sampling/sensing.

The main hypothesis is that the high-resolution (small pixels) should make it easier to correlate the satellite imagery to important water quality parameters such as temperature, sediments, nutrients, organic matter, and chlorophyll. If such correlations between imagery and water samples can be well established, it will be possible to cheaply derive **high-resolution maps of water quality estimates in near real-time from new satellite images**, as well as to reconstitute maps for past events, provided images are available (**goal 1**).

Those maps will help **to understand where, when and how "hot-spots" of poor water quality form, and to link them back to contributions from specific watersheds or portions of shore** (**goal 2**). Based on this information, and building on existing work on erosion risk, we will be able **to identify critical land areas that need to be prioritized for soil & water conservation efforts (goal 3**), which might include protection from certain land uses. Deliverables will include publicly available online maps of lake and land for use by scientists, managers, as well as for the education of the general public.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1 Title: Mapping of water quality and problematic "hot-spots" in Lake Superior

We will address Goals 1 and 2 by collecting surface water-quality samples and sending in-water sensors to investigate light and temperature regimes throughout the water column in western Lake Superior in July/August 2020 (when the lake is subject to nearshore algae blooms), May 2021 (when the lake is impacted by snowmelt), and June/July 2021 (season of recent large storms in the watershed). We will sample regions visibly impacted by events ("plumes" or algae blooms) as well as clear-water portions of the lake. These field data will be matched with satellite data for the same dates, to establish correlations between remote imagery and water quality measured in the lake. These correlations will be used to create maps of water quality parameters across the lake, which can be updated based on new satellite data. These maps will highlight "hot spots" of temperature, total suspended solids (TSS), nutrients, and chlorophyll. This is a cost-effective way to get key information to managers about the current and future locations of waters impacted by TSS, high nutrient loads or algae blooms.

Outcome	Completion date
Measurement of in-lake water quality data (3 campaigns, about 820 samples)	October 2021
Development of predictive satellite/in-lake data correlations	January 2022
Mapping of lake "hot spots" using satellite data and in-lake to satellite data correlations	June 2022

ENRTF budget: $235,514 (82% of total budget)

Activity 2: Linking problematic "hot-spots" to contributing or at-risk land areas to promote and prioritize conservation efforts

Activity 2 will bridge the common gap between science and policy. We will work with partners, starting with local Soil & Water Conservation Districts, to develop a web site presenting the results from activity 1 through online maps and spatial analysis tools that they will use to prioritize conservation actions with the greatest impact on the lake and to educate the public. A Sea Grant outreach specialist will work on further dissemination and help to adapt the final product to varied audiences.

We will address goals 2 and 3 with two main priorities. First, we will determine with our partners which types of visualizations best identify where the materials that will form "hot-spots" of degraded water quality enter the lake after weather events (specific streams, specific portions of shore). Since in-lake water circulation is complex, larger inputs from land will not necessarily generate larger "hot-spots". Managers need efficient visualizations to identify which inputs are most harmful. Once these have been identified, the second priority will be to determine, within those specific watersheds or along those specific portions of shore, the land areas that likely contribute the most materials, as well as land areas whose contribution would greatly increase in case of unfavorable land cover changes. We will build on existing soil erosion and water quality risk datasets from the MN Board of Water and Soil Resources. Once again, we will work with our partners to create visualizations/simulations that best link what happens on land to what ends up happening in the lake.

Outcome	Completion date
Recruitment of partners/prospective users for co-development and testing of visualizations and tools	May 2021
Development of cartographic visualizations to link "hot-spots" to contributions from land	October 2022
Development of spatial analysis tools and/or cartographic visualizations to identify principal land areas contributing or at-risk to contribute to lake "hot-spots"	June 2022

ENRTF budget: $50,678 (18% of total budget)

III. PROJECT PARTNERS AND COLLABORATORS

Partners receiving ENRTF funding:

- GAC - Geospatial Analysis Center (director: Stacey Stark)
- SeaGrant (Environmental literacy educator: Marte Kitson)

Partners not receiving ENRTF funding:

- GLOS- Great Lake Observing System (via Jay Austin from the Large Lakes Observatory)
- South Saint-Louis County Soil & Water Conservation District (Manager: R.C. Boheim)
- Lake County Soil & Water Conservation District (Acting Manager: Karen Tucker)

IV. LONG TERM IMPLEMENTATION AND FUNDING

The final deliverable will be a web atlas somewhat similar to what has been created for the MN atlas of natural resources (z.umn.edu/48fg), focused on the Lake Superior region and offering more advanced visualizations and tools. It will feature maps of the lake water quality that are currently lacking and visualizations that highlight land/lake interactions. The site will be hosted by UMD's Geospatial Analysis Center for several years after the end of the project. This project is a proof of concept for a methodology that creates and disseminates actionable knowledge to a variety of constituencies interested in protecting the waters of Lake Superior, at a time where more frequent major storm events bring novel and dramatic consequences such as algae blooms. We anticipate that upon successful completion, federal agencies could be interested in prolonging and expanding this monitoring effort to the entire Great Lakes basin.

V. SEE ADDITIONAL PROPOSAL COMPONENTS: Budget Spreadsheet, Map/ Visual component, Project Manager Qualifications and Organization Description

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: **Charleux**
Project Title: **Mapping the changing biochemestry of Lake Superior**
Organization: **University of Minnesota Duluth**
Project Budget: **$ 286,192**
Project Length and Completion Date: **2 years** **30-Jun-22**
Today's Date:

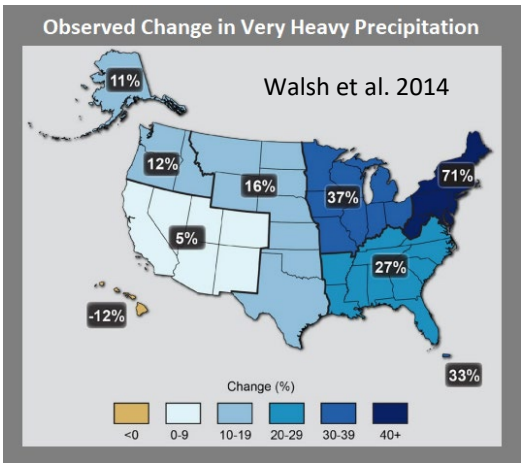
ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET		Budget	Amount Spent	Balance
BUDGET ITEM				
Personnel (Wages and Benefits)		$ 149,142	$ -	
PI Charleux ($23,085, 74% salary, 26% benefits), 8.3% FTE per year	$ 23,085			
PI Minor ($30,835, 74% salary, 26% benefits), 8.3% FTE per year	$ 30,835			
SeaGrant outreach specialist ($2770, 74% salary, 26% benefits), 2.3% FTE first year and 1% FTE second year	$ 2,770			
Science technician ($26,075, 77% salary, 23% benefits), 17% FTE per year	$ 26,075			
Senior Personnel - GIS specialist ($13340, 74% salary, 26% benefits), 8.3% FTE per year	$ 13,340			
1 graduate student research assistant 1 summer only ($7586, 86% salary, 14% benefits), 12.5% FTE 1 year	$ 7,586			
1 graduate student research assistant 1 full year ($ 45451, 56% salary, 44% benefits), 50% FTE for 1 year.	$ 45,451			
Professional/Technical/Service Contracts				
Equipment/Tools/Supplies				
Field supplies ($12,383 for filters, vials, gloves, reagents, Kimwipes, gases, etc)		$ 12,383		
Sea Grant supplies (outreach material as appropriate, e.g. handouts)		$ 855		
Capital Expenditures Over $5,000			$ -	
		$ -		
Fee Title Acquisition			$ -	$ -
		$ -		
Easement Acquisition			$ -	$ -
		$ -		
Professional Services for Acquisition			$ -	$ -
		$ -		
Printing			$ -	$ -
2 posters (1 scientific, 1 outreach)		$ 174		
Travel expenses in Minnesota			$ -	
Mileage or car rental to meetings with local partners (mileage per UMN policy)		$ 507		
Other			$ -	
shiptime (3 trips of 4 days each on the RV Blue Heron)		$ 100,535		
page costs for publications		$ 1,525		
Satellite Imagery (cost of image request processing by Planet.com)		$ 3,004		
UMD Geospatial Analysis Center services (computing services for calculation of water quality maps and web-hosting of the final online atlas)		$ 9,947		
Lab analyses (820 analyses averaging approximately $10 per analysis)		$ 8,120	$ -	
COLUMN TOTAL		$ 286,192	$ -	

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: U of M unrecovered indirect cost at 54% MTDC	secured	$ 145,909	$ -	

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
		$ -	$ -	$ -

Mapping Lake Superior's Changing Biogeochemistry

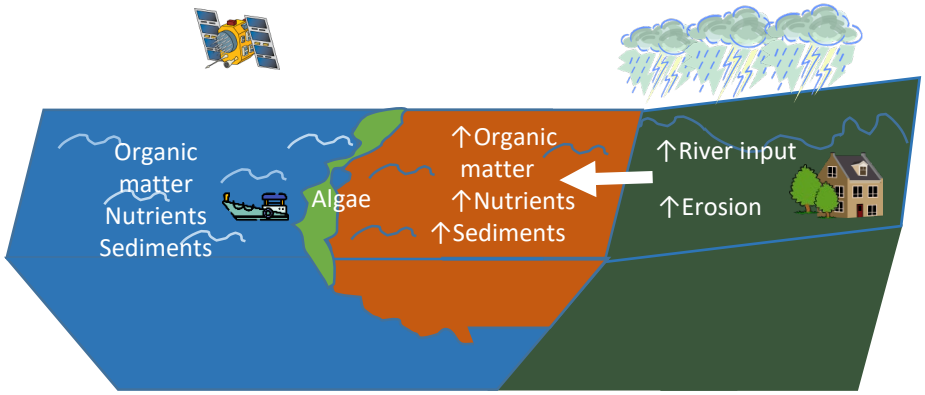
The region is getting stormier…



Historic "mega-rain"events (15 events, 152 yrs, MN DNR)

- August 6, 1866 Southern Minnesota
- July 17-19 1867 Central Minnesota
- July 20-22, 1909 Northern Minnesota
- September 9-10 1947, Iron Range
- July 21-22, 1972 Grand Daddy Flash Flood
- June 28-29 and July 1-2, 1975, Northwest Minnesota
- July 23-24, 1987 Twin Cities Superstorm
- June 9-10, 2002 Northern Minnesota
- June 22-23, 2002 Northern Minnesota
- September 14-15, 2004 Southern Minnesota
- August 18-20, 2007 Southern Minnesota
- September 22-23, 2010 Southern Minnesota
- June 19-20, 2012 Northeast Minnesota
- July 11-12, 2016, East-central Minnesota
- August 10-11, 2016, Central Minnesota, Southeastern Minnesota

which affects Lake Superior:

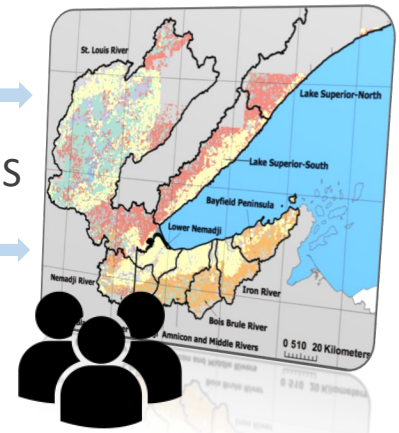


Our proposed response:

Water sampling

Remote sensing

GIS



Our proposed products:

Online atlas - predictive maps and analysis tools of:

1. Nutrient, suspended sediment, and algae "hot spots" in the lake
2. Current and future areas in the landscape that need careful management to minimize sediment and nutrient inputs

Disseminated to:

1. South Saint-Louis County and Lake County Soil & Water Conservation Districts and other managers and stakeholders
2. Academic and government researchers through peer-reviewed journal publications

Project Manager Qualifications and Organization Description

Laure Charleux (PI): Dr. Charleux is an Associate Professor in the College of Liberal Arts at the University of Minnesota Duluth. She specializes in Geographical Information Science (GIS) and data science. Dr. Charleux has completed several applied research projects with community partners and has experience delivering actionable results. She will be in charge of overall project management. She has been mentoring the GIS work of **Ellen Cooney**, GIS certificate student and PhD candidate in Water Resource Management under the direction of **Elizabeth Minor** (co-I), Professor at the Department of Chemistry & Biochemistry at UMD and at the Large Lakes Observatory. Cooney and Minor have already published a basic research article (see ref. below) that prefigures some of the methods that will be used in the current proposal. Cooney is expected to be the main graduate research assistant on the project. Minor has managed several field-intensive water-sampling research projects funded by the National Science Foundation, MN Sea Grant and other funding agencies and was a researcher in previous ENRTF funded work on Lake Superior. She will oversee the water sampling and in situ sensor work for this project. **Marte Kitson** has been leading scientific outreach, communication, and education initiatives specifically in the aquatic sciences through her appointment at Minnesota SeaGrant since 2010 and will coordinate our wide outreach efforts. **Kris Johnson**, GIS instructor at UMD, has extensive experience in shaping web-GIS products for clients and was recently involved in the development of the Minnesota Natural Resource Atlas at NRRI.

The Large Lakes Observatory has the necessary instrumentation for nutrient, TSS, and other analyses proposed here and the RV Blue Heron, an 86-foot research vessel managed by the University of Minnesota Duluth, has the appropriate sampling and sensing gear. The Geospatial Analysis Center provides GIS expertise and research support to the UMD community. They will provide our computing needs and host our web-GIS.

Cooney, E. M., McKinney, P., Sterner, R., Small, G. E., & Minor, E. C. (2018). Tale of Two Storms: Impact of Extreme Rain Events on the Biogeochemistry of Lake Superior. *Journal of geophysical research. Biogeosciences*, *123*(5), 1719-1731.