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

Project Title: **ENRTF ID: 070-B**

Unprecedented Change Threatens Minnesotas Pristine Lakes

Category: B. Water Resources

Sub-Category:

Total Project Budget: $ 849,392

Proposed Project Time Period for the Funding Requested: June 30, 2023 (3 yrs)

Summary:

Why are Minnesota's nicest lakes turning green? We determine what's causing this change and which lakes are most at risk.

Name: Mark Edlund

Sponsoring Organization: Science Museum of Minnesota

Job Title: Dr.

Department: St. Croix Watershed Research Station

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St. Paul MN 55102

Telephone Number: (612) 965-6946

Email medlund@smm.org

Web Address:

Location:

Region: Central, Northwest, Northeast

County Name: Cook, Itasca, Koochiching, Lake, St. Louis

City / Township:

Alternate Text for Visual:

Why are Minnesota's nicest lakes turning green? We determine what's causing this change and which lakes are most at risk.

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

PROJECT TITLE: Unprecedented change threatens Minnesota's pristine lakes

I. PROJECT STATEMENT

Minnesota's most pristine lakes are changing unexpectedly and we don't know why! Where we expect to find hundreds of our most beautiful and remote lakes—with little development or protected within state and national forests and parks—we instead often find green lakes, thick with noxious blooms of algae. Lakes turn green when we add nutrients to them, but in protected or remote settings, typical sources of excess nutrients (land use change, erosion, sewage) are not obvious. Based on our past work, we predict that climate change is working in concert with atmospheric deposition of nurients to drive the changes that have already begun to affect our pristine lakes. ***Importantly****, it is possible that by missing climate and atmospheric effects on lakes we could be misattributing the causes of blooms and misdirecting resource-management efforts and dollars.*

Summary: We will determine why Minnesota's nicest lakes are unexpectedly turning green using:

1) a ***first of its kind in-lake and atmospheric monitoring system*** for Minnesota
2) historical sediment analysis to show ***how, when, and why pristine lakes are changing***
3) lake simulations to determine ***which lakes are most at risk***
4) communication of findings with resource managers and lake users on how and why nice lakes are changing.

***This project will fundamentally change lake management strategies everywhere in Minnesota*.**

Climate, weather and atmospheric deposition change everything.Sediment cores from wilderness lakes show two causes of unprecedented noxious algae growth. First, climate change results in longer ice-free season, stronger thermal stratification, increased inputs of dissolved organic carbon ("tannins"), and correlates with an alarming increased frequency of blue-green (cyanobacteria) blooms. Second, in lakes with no watershed runoff we find large increases in mineral matter and greater growth of algae (see visual). If that mineral matter and its nutrients did not come from the watershed, it must be coming from dustfall or precipitation.

Nutrients in lakes can originate from many sources—local, regional, and global. The 16 lakes (deep vs shallow lakes, across watershed size, and along an E-W transect) selected for this study will be entirely within northern Minnesota's protected areas, so we can rule out local landuse inputs. Climate change along with regional and global landuse changes well beyond Minnesota may be working in concert to change our pristine lakes. Climate affects lakes directly and indirectly to change how nutrients are cycled within lakes and their watersheds. In other regions of the US and world, dustfall is linked to eutrophication and biological changes in alpine and arctic lakes. We need to know if Minnesota's lakes are similarly imperiled by climate change and dust-borne nutrients, and rule out other potential causes of wilderness lake change so our management dollars are not wasted.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: ***Use water and air quality monitoring to assess the cause of changing water quality in our "pristine" lakes***

Description: Water quality in remote lakes is rarely monitored and air quality monitoring in Minnesota does not measure dry deposition (dustfall). We will do high resolution monitoring of water quality for 2 years on 16 state and national forest and park lakes. We will simultaneously establish a state-of-the-art dustfall network with 5-7 sites in north and central Minnesota in partnership with NADP to measure and map dustfall patterns and nutrient delivery.

ENRTF BUDGET: $348,365

Outcome	Completion Date

1. Measure nutrients and algae for two years from 16 study lakes	*October 2022*
2. Establish state-of-the-art dustfall monitoring network in north and central Minnesota	*October 2022*

Activity 2: Use sediment cores to determine if our best lakes are imperiled
Description: Every lake accumulates sediments that record its history. We will collect sediment cores from the 16 study lakes and determine when and how much they have changed—their biology, nutrient levels, dust inputs—using analysis of multiple biological and geochemical measures. We will reconstruct the influence of climate and dust-borne nutrients through time on each lake to understand why they changed, when they changed, and which lakes are most imperiled.
ENRTF BUDGET: $406,817

Outcome	Completion Date
1. Collect, date, and analyze sediment cores from 16 study lakes	*January 2023*
2. Compare historical climate and dustfall records from sediment cores with modern monitoring to determine when and why lakes are changing	*January 2023*

Activity 3: Use lake simulations to determine which lakes are most at risk and how to protect them
Description: Computer simulations allow us to understand how lakes have changed in the past and how they might change in the future. MINLAKE is a simulation program that estimates lake thermal and oxygen dynamics. Importantly, input variables in the program let us test interactive effects of other forces that may be affecting our protected lakes such as changing weather patterns and ice-on/off. Model results will be paired with monitoring and sediment core histories to predict which protected lakes are most at risk.
ENRTF BUDGET: $94,210

Outcome	Completion Date
1. Create a MINLAKE model for 16 study lakes to measure historical changes in lake function	*January 2023*
2. Develop a framework for predicting which protected lakes are at risk	*January 2023*
3. Develop scientific reports, informational factsheets, and engage social media to inform managers and lay-persons on the state and fate of Minnesota's most protected lakes	*June 2023*

III. PROJECT PARTNERS AND COLLABORATORS:
This project will be led by the St. Croix Watershed Research Station (Dr. Mark Edlund, Dr. Adam Heathcote, and a lake modeler). MPCA-Air Quality will advise on our air quality monitoring network, and Jesse Anderson, MPCA-Water Quality, will advise on lake choice and sampling sites.

IV. LONG-TERM IMPLEMENTATION AND FUNDING:
This project establishes a new air monitoring network, provides the first baseline data on dustfall in northern Minnesota, its effect on our best lakes, and determines which lakes are at risk. This project leverages collaborations with other research groups on dustfall and previous ENRTF and NPS funding on wilderness lakes across northern Minnesota, including the DNR Sentinel Lakes and the NPS Inventory & Monitoring programs.

V. SEE ADDITIONAL PROPOSAL COMPONENTS:

A. Proposal Budget Spreadsheet
B. Visual Component or Map
F. Project Manager Qualifications and Organization Description
G. Letter or Resolution

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Mark Edlund
Project Title: Unprecedented change threatens Minnesota's pristine lakes
Organization: St. Croix Watershed Research Station, Science Museum of Minnesota
Project Budget: $849,392
Project Length and Completion Date: 3 years; June 30, 2023
Today's Date: 4/15/2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 487,284	$ -	$ 487,284
Edlund, Senior Scientist: Sediment Analysis; 50% FTE for 3 yrs; Salary=54.5%, Benefits=45.5% ($171,798 over 3 years); this is a grant-funded position			
Heathcote, Senior Scientist: Water/Air Quality, DNA; 50% FTE for 3 yrs; Salary=54.5%, Benefits=45.5% ($154,392 over 3 years); this is a grant-funded position			
TBD, Assistant Scientist: Lake Modeling; 50% FTE for 2 yrs; Salary=71%, Benefits=45.5% ($90,210 over 2 years); this is a grant-funded position			
Field and Laboratory Technicians:2 temporary field and laboratory technicians; 33% FTE for 2 yrs; Salary=54.5%, Benefits=45.5% ($58,884 over 2 years); these are temporary grant-funded position			
Science Communication Specialist: Outreach and social media; 5.8% FTE for 2 yrs; Salary=100%, Benefits=0% ($12,000 over 2 yrs); this is a grant-funded position			
Professional/Technical/Service Contracts			
Lab analysis of dust samples: Dust chemistry (mass, P frac, N): 120 samples @ $100 ($12,000; Utah State University or competitive	$ 66,000	$ -	$ 66,000
Lab analysis of pigments samples: Algal pigment analysis: 240 samples @ $124 ($30,000; University of Regina or competitive bid)			
Lab analysis of Cyano DNA: 16S sediment DNA sequencing: 16 cores @ $1500 ($24,000; University of Minnesota or competitive			
Equipment/Tools/Supplies			
Lab/Field supplies (bottles, reagents, preservatives, consumables - $10,000) Dust Monitoring, ADS/NTN Atmospheric Deposition Samplers, 5 @ $5000 ($25,000) Monitoring buoy supplies, 16@$3200 ($51,200)	$ 86,200	$ -	$ 86,200
Capital Expenditures Over $5,000			
Water Quality Sonde, YSI EXO2 ($20,000)	$ 20,000	$ -	$ 20,000
Fee Title Acquisition			
	$ -	$ -	$ -
Easement Acquisition			
	$ -	$ -	$ -
Professional Services for Acquisition			
	$ -	$ -	$ -
Printing			
	$ -	$ -	$ -
Travel expenses in Minnesota			
Atmospheric Monitoring and Network setup ($2,500) 1 trip, 2 scientists, 6 days, 1000 miles to north central Minnesota	$ 28,500	$ -	$ 28,500
Sediment core collection ($6,000), 2 coring trips, 2-3 field crew, 10 days and 850 miles/trip to northern Minnesota			
Water Quality monitoring ($20,000), 6 water quality trips, 2-3 field crew, 10 days and 850 miles/trip to northern Minnesota			
Other			
Lab analysis of water samples: TN/TP, DIN/SRP, DOC, DIC: 144 samples @ $112 ($16,128) (unit prices for analysis at SCWRS)	$ 161,408	$ -	$ 161,408
Lab analysis of sediment samples: 210-Pb (dating): 16 cores @ $2,500 ($40,000) (unit price for analysis at SCWRS) loss-on-ignition: 16 cores @ $800 ($12,800) (unit price for analysis at SCWRS) biogeochemistry (Sed P, diatoms, BSi): 16 cores @ $5,780 ($92,480) (unit prices for analysis at SCWRS)			
COLUMN TOTAL	$ 849,392	$ -	$ 849,392

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ 394,269	$ -	$ 394,269
All indirect project costs are provide in-kind by the Science Museum of Minnesota (federal indirect rate 45.13% on all direct costs = $383,331)				
State:		$ -	$ -	$ -
In kind:		$ -	$ -	$ -

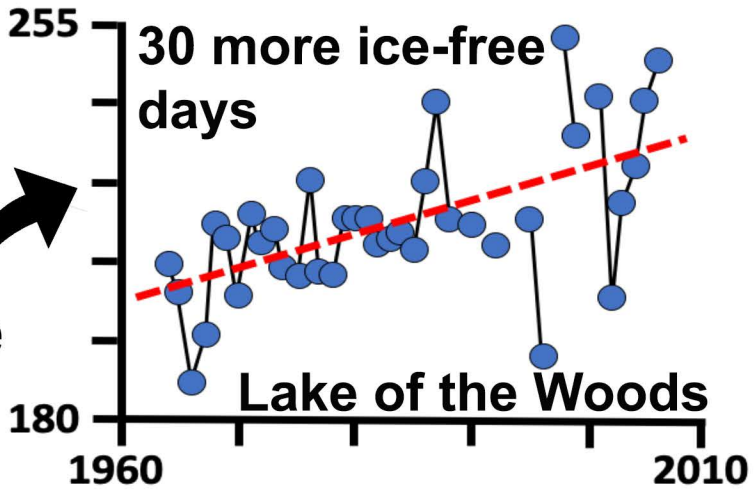
Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Tracking and Preventing Harmful Algal Blooms M.L. 2016-186-2-04a: $593,000, Jul 2016-Jun 2019	$ 141,867	$ 593,000	$ 451,133	$ 141,867

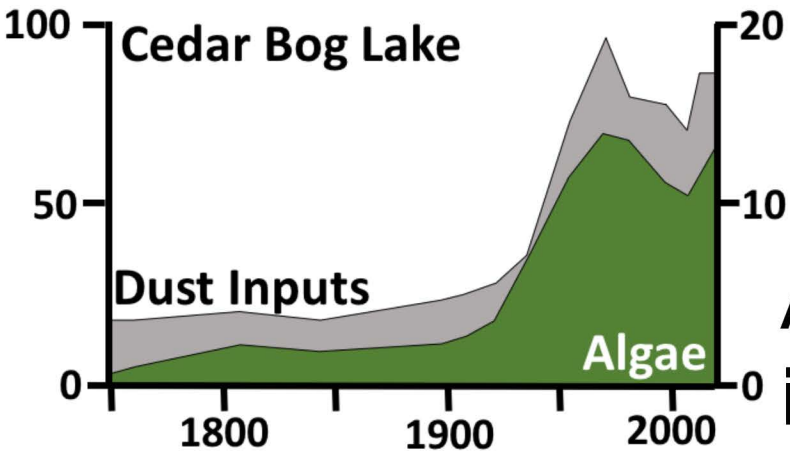
Unprecedented change threatens Minnesota's pristine lakes

Why are our ***pristine*** lakes turning green?

Possible Factors

Longer growing season with warmer temperature





Increased atmospheric inputs

Are some lakes more **imperiled** than others?

Project Manager Qualifications

MARK B. EDLUND

1. Education

Ph.D.	1999	University of Michigan, (Natural Resources & Environment)
M.S.	1992	University of Michigan, (Natural Resources)
B.A.	1971	University of Minnesota (Biochemistry)

2. Positions

2007-	Sr. Scientist, St. Croix Watershed Research Station, Science Museum of Minn.
2002-07	Assoc. Scientist, St. Croix Watershed Research Station, Science Museum of Minn.
2000-02	Ass't. Scientist, St. Croix Watershed Research Station, Science Museum of Minn.
2004-	Adjunct Professor, Water Resources Science/Earth Sciences, University of Minnesota
1987-99	Research Ass't I, Center for Great Lakes and Aquatic Sciences, University of Michigan

3. Research Expertise

Aquatic biology, limnology, paleolimnology, and phycology; environmental drivers of ecological change; use of lake sediment records to understand short- and long-term environmental change
Current Research:

- Biomonitoring of lakes in Great Lakes region National Parks
- Paleolimnology of Upper and Lower Red Lake
- Understanding and predicting harmful algal blooms (HABs)

4. Recent Publications (of more than 100)

Edlund, M.B., Schottler, S.P., Reavie, E.D., Engstrom, D.R., Baratono, N.G., Leavitt, P.R., Heathcote, A.J., Wilson, B. and Paterson, A.M. 2017. Historical phosphorus dynamics in Lake of the Woods (USA-Canada) – Does legacy phosphorus still affect the southern basin? *Lake and Reservoir Management* 33: 386-402.

Reavie, E.D., **Edlund, M.B.**, Andresen, N.A., Engstrom, D.R., Leavitt, P.R., Schottler, S., Cai, M. 2017. Paleolimnology of the Lake of the Woods southern basin: Continued water quality degradation despite lower nutrient influx. *Lake and Reservoir Management* 33:369-385.

Edlund, M.B., Almendinger, J.E., Fang, X., Ramstack Hobbs, J., VanderMeulen, D.D., Key, R.L. and Engstrom, D.E. 2017. Effects of climate change on lake thermal structure and biotic response in northern wilderness lakes. *Water* 9(9), 678, 1-34.

Spaulding, S.A., Kilroy, C. and **Edlund, M.B.** 2010. Diatoms as nonnative species. In Smol, J.P. and Stoermer, E.F. (Eds) *The Diatoms: Applications for the Environmental and Earth Sciences*. Cambridge University Press. pp 560-569.

Organization Description

The Science Museum of Minnesota (SMM) is a private, non-profit 501(c)3 institution dedicated to encouraging public understanding of science through research and education. The St. Croix Watershed Research Station the environmental research center of the SMM with the mission to foster, through research and outreach, "a better understanding of the ecological systems of the St. Croix River basin and watersheds worldwide." The SCWRS supports an active year-round program in environmental research and graduate-student training, guided by a dedicated in-house research staff with direct ties to area universities and colleges. It collaborates closely with federal, state, and local agencies with responsibility for managing the St. Croix and upper Mississippi rivers and is a full partner with the National Park Service for resource management in parks of the western Great Lakes region. Its research has played a central role in setting management policy for the St. Croix and Mississippi rivers, for establishing water-quality standards for Minnesota lakes and for developing long-term monitoring plans for the National Park Service.