Environment and Natural Resources Trust Fund
2019 Request for Proposals (RFP)

Project Title: **ENRTF ID: 174-E**

When the Dust Settles: Pristine Lakes are Changing

Category: E. Air Quality, Climate Change, and Renewable Energy

Sub-Category:

Total Project Budget: $ 696,667

Proposed Project Time Period for the Funding Requested: June 30, 2022 (3 yrs)

Summary:

Minnesota's most protected lakes are changing without an obvious source of pollution. We need to know if windblown dust is carrying the nutrients that turn these once pristine lakes green.

Name: Mark Edlund

Sponsoring Organization: Science Museum of Minnesota

Title: Senior Scientist

Department: St. Croix Watershed Research Station

Address: 16910 152nd St N

Marine on St. Croix MN 55047

Telephone Number: (651) 433-5953

Email medlund@smm.org

Web Address https://www.smm.org/scwrs

Location

Region: Northeast

County Name: St. Louis

City / Township:

Alternate Text for Visual:

Why are Minnesota's most protected lakes turning green? Are our most pristine Minnesota lakes imperiled by wind-blown dust? We show that dust can fuel increased algae growth in protected lakes.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%
____ If under $200,000, waive presentation?			

PROJECT TITLE: When the dust settles: pristine lakes are changing

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 cyanobacteria. 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. *So what is the source? If, as we suspect, dust-borne nutrients are the culprit changing our pristine lakes, this project will fundamentally change lake management strategies everywhere in Minnesota*.

An unexpected source of nutrients: *windblown dust*. Several factors may be causing unprecedented changes in our protected lakes, but our work suggests windblown dust may be the culprit. We used sediment cores to reconstruct the history of perched lakes that receive no watershed runoff and found large increases in mineral matter and greater growth of algae (see visual). If that mineral matter did not come from the watershed, it must be coming from dustfall or precipitation. We already measure wet deposition with a network of sites across Minnesota—the National Atmospheric Deposition Program (NADP)—which shows little recent change in nutrient deposition. So the finger points at dustfall. We will establish Minnesota's first dry deposition air quality network to measure dustfall and its impact on protected lakes across northern Minnesota.

Dustfall on lakes can originate from many sources—local, regional, and global. Lakes selected for this study will be entirely within northern Minnesota's protected areas, so we can rule out watershed inputs. Regional and global landuse changes well beyond Minnesota may be to blame for changing our pristine lakes. 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 dust-borne nutrients and where the dust is from.

Dust changes everything. Using a 16-lake study set paired with Minnesota's first dry deposition air quality network, we will test the effects of dust on deep vs shallow lakes, across watershed size, and along an E-W transect. This project provides the first assessment of dustfall across the state, its historical effect on lakes, a two-year assessment of water quality on iconic and poorly studied wilderness lakes, and develops new lake models to determine which lakes are at most risk and rule out other potential causes of wilderness lake change.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Use air quality monitoring to link dustfall to changing water quality in our "pristine" lakes*
Air quality monitoring in Minnesota does not measure dustfall and water quality in remote lakes is rarely monitored. We will 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. We will simultaneously do high resolution monitoring of water quality for 2 years on 16 nearby Sentinel, state and national forest and park lakes.
ENRTF BUDGET: $290,073

Outcome	Completion Date
1. Establish state-of-the-art dustfall monitoring network in north and central Minnesota	*October 2021*
2. Measure nutrients and algae for two years from 16 remote and wilderness lakes	*October 2021*

Activity 2: ***Use sediment cores to determine if our best lakes are imperiled***

Every lake accumulates sediments that record its history. We will collect sediment cores from 16 remote and protected 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 dust-borne nutrients through time on each lake to understand why they changed, when they changed, and which lakes are most imperiled.

ENRTF BUDGET: $338,525

Outcome	Completion Date
1. Collect, date, and analyze sediment cores from 16 remote lakes	*January 2022*
2. Compare historical dustfall records from sediment cores with modern patterns of dustfall to determine when and why lakes and dustfall are changing	*January 2022*

Activity 3: ***Use lake simulations to determine which protected lakes are most at risk***

Computer simulations allow us 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 of dust-borne nutrients to predict which protected lakes are most at risk.

ENRTF BUDGET: $68,069

Outcome	Completion Date
1. Create a MINLAKE model for 16 study lakes to measure historical changes in lake function	*January 2022*
2. Develop a framework for predicting which protected lakes are at risk	*January 2022*
3. Develop scientific reports, informational factsheets, and engage social media to inform managers and lay-persons on the state and fate of protected lakes in Minnesota	*June 2022*

III. PROJECT PARTNERS

A. Partners receiving ENRTF funding

This project will be led by St. Croix Watershed Research Station scientists: Mark Edlund and Adam Heathcote. Staffing for computer simulation work is TBD.

B. Partners NOT receiving ENRTF funding

Rick Strassman, Research Scientist with 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 Sentinel Lakes and the NPS Inventory & Monitoring programs.

V. TIME LINE REQUIREMENTS:

The project will require three years to complete, including two summer field seasons (2020-2021) of air and water quality monitoring and one winter field season (2019/2020) to collect sediment cores. The remainder of the time will be spent on the laboratory components of water quality analysis, sediment core processing, and modeling. Results will be summarized in a final report to be submitted to LCCMR by June 30, 2022.

2019 Proposal Budget Spreadsheet

Project Title: When the dust settles: Pristine lakes are changing

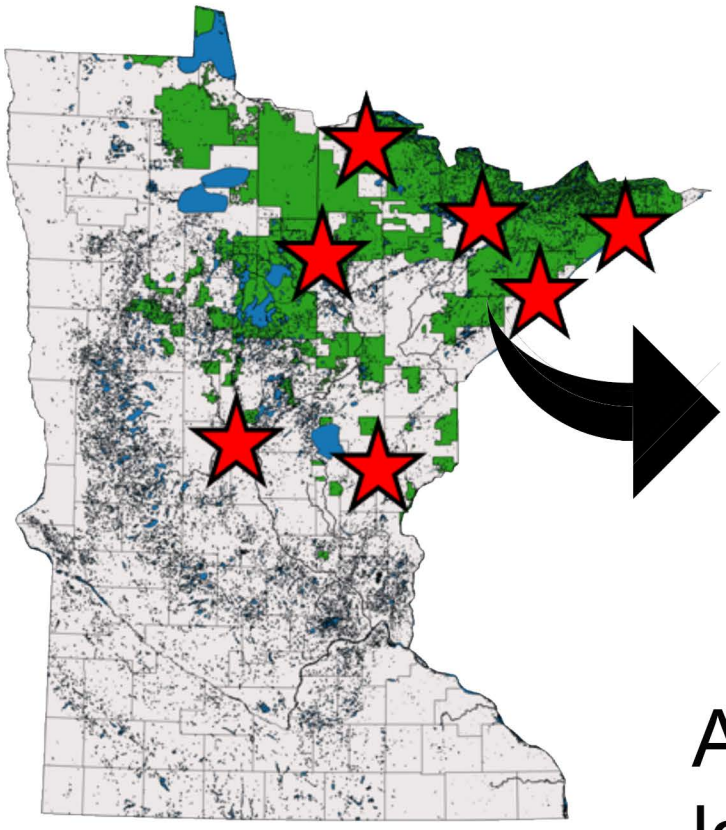
IV. TOTAL ENRTF REQUEST BUDGET *3* **years**

BUDGET ITEM (See "Guidance on Allowable Expenses")	**AMOUNT**
Personnel:	$ 334,559
Edlund, Senior Scientist: Sediment Analysis; 40% FTE for 3 yrs; Salary=53.3%, Benefits=46.7% ($131,856 over 3 years); this is a grant-funded position	
Heathcote, Associate Scientist: Water Quality, DNA; 40% FTE for 3 yrs; Salary=53.3%, Benefits=46.7% ($110,178 over 3 years); this is a grant-funded position	
TBD, Assistant Scientist: Lake Modeling; 40% FTE for 2 yrs; Salary=53.3%, Benefits=46.7% ($68,069 over 2 years); this is a grant-funded position	
Field and Laboratory Technician: Field work and lab analyses; 25% FTE for 2 yr; Salary=53.3%, Benefits=46.7% ($24,456 over 2 years); this is a temporary position	
Professional/Technical/Service Contracts:	$ -
Equipment/Tools/Supplies:	$ 106,200
Lab/Field supplies (bottles, reagents, preservatives, consumables - $10,000) Water Quality Sonde, YSI EXO2, ($20,000) Dust Monitoring, ADS/NTN Atmospheric Deposition Samplers, 5 @ $5000 ($25,000) Monitoring buoy supplies, 16@$3200 ($51,200)	
Acquisition (Fee Title or Permanent Easements):	$ -
Travel:	$ 28,500
Sediment core collection ($6000), 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	
Dust Monitoring and Network setup ($2500) 1 trip, 2 scientists, 6 days, 1000 miles to north central Minnesota	
Additional Budget Items: Lab analysis of water samples: TN/TP, DIN/SRP, DOC, DIC: 144 samples @ $112 ($16128) (unit prices for analysis at SCWRS) 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, pigments, diatoms, BSi): 16 cores @ $7655 ($122,480) (unit prices for analysis at SCWRS, pigment analysis at Univ Regina) Cyano DNA: 16 cores @ $1500 ($24,000) (via University of Minnesota or competitive bid) Lab analysis of dust samples: Dust chemistry (mass, P frac, N): 120 samples @ $100 ($12,000) (via Utah State University or competitive bid)	$ 227,408
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 696,667

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

SOURCE OF FUNDS	**AMOUNT**	**Status**
Other Non-State $ To Be Applied To Project During Project Period: All indirect project costs are provide in-kind by the Science Museum of Minnesota (federal indirect rate 43.10% on all direct costs = $300,263)	$ 300,263	*in-kind*
Other State $ To Be Applied To Project During Project Period:	$ -	*N/A*
In-kind Services To Be Applied To Project During Project Period:	$ -	*N/A*
Past and Current ENRTF Appropriation: **1) "Determining Risk of Toxic Alga in Minnesota Lakes" M.L. 2018, Chp. xx, Sec. xx, Subd. 6f: $200,000, Recommended for funding** **2) "Tracking and Preventing Harmful Algal Blooms" M.L. 2016-186-2-04a: $500,000, Jul 2016-Jun 2019**	$ 700,000	Current and pending
Other Funding History:	$ -	*N/A*

When the dust settles: pristine lakes are changing

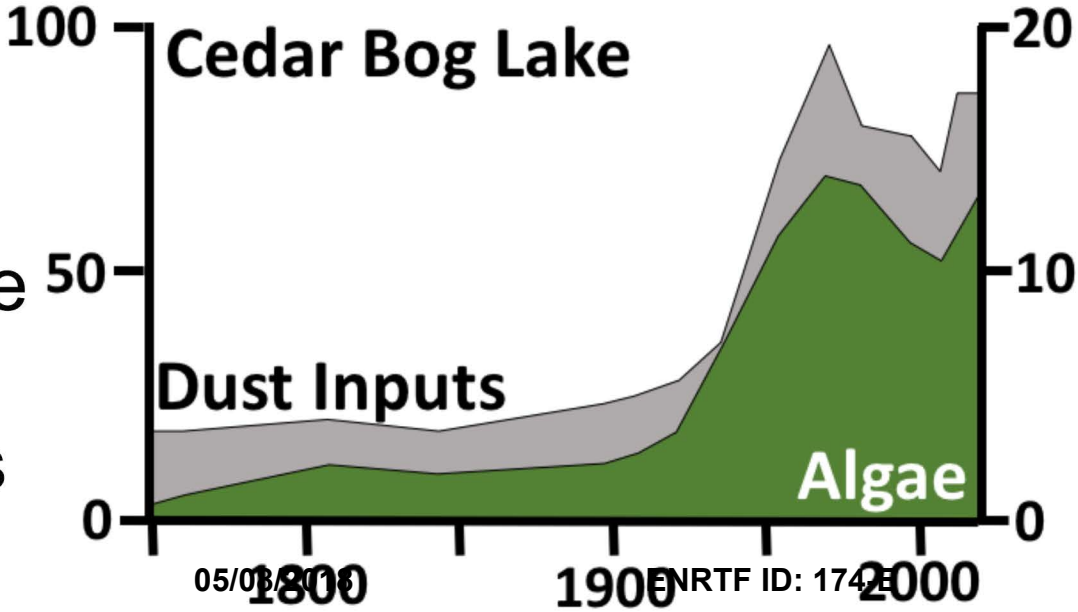


Are our most ***pristine*** lakes imperiled by dust?

Wilderness areas

Dust monitoring sites

Dust can fuel increased algae growth in protected lakes



PROJECT MANAGER QUALIFICATIONS

MARK B. EDLUND, PH.D.

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.
2004-	Adjunct Professor, Water Resources Science/Earth Sciences, University of Minnesota
2000-02	Ass't Scientist, St. Croix Watershed Research Station, Science Museum of Minn.

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

- 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 95)

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.

Ramstack Hobbs, J., Hobbs, W.O., **Edlund, M.B.**, Zimmer, K.D., Theissen, K.M., Hoidal, N., Domine, L.M., Hanson, M.A., Herwig, B.R., Cotner, J.B. 2016. The legacy of large regime shifts in shallow lakes. *Ecological Applications* doi:10.1002/eap.1382

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. Its mission is to inspire learners, inform policy, and improve lives through science. The ***St. Croix Watershed Research Station*** (SCWRS) 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.