# Environment and Natural Resources Trust Fund

2022 Request for Proposal

## General Information

**Proposal ID:** 2022-264

**Proposal Title:** Unprecedented Change Threatens Minnesota's Pristine Lakes

## Project Manager Information

**Name:** Mark Edlund

**Organization:** Science Museum of Minnesota - St. Croix Watershed Research Station

**Office Telephone:** (612) 965-6946

**Email:** medlund@smm.org

## Project Basic Information

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

**Funds Requested:** $850,000

**Proposed Project Completion:** June 30 2025

**LCCMR Funding Category:** Water Resources (B)

## Project Location

**What is the best scale for describing where your work will take place?**

Region(s): Central, NE, NW,

**What is the best scale to describe the area impacted by your work?**

Statewide

**When will the work impact occur?**

During the Project and In the Future

## Narrative

**Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.**

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. Based on our work, we predict that climate change is working in concert with atmospheric deposition 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.

**What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.**

We will determine why Minnesota's nicest lakes are unexpectedly turning green using:
1) first of their kind in-lake and atmospheric monitoring systems
2) sediment analysis showing how, when, and why pristine lakes are changing
3) lake simulations determining which lakes are most at risk
4) communication with managers and lake users on how and why nice lakes are changing.

Climate, weather, and atmospheric deposition change everything. Sediment cores from wilderness lakes show two causes of unprecedented noxious algae growth. Climate change results in longer ice-free seasons, stronger stratification, increased tannins, and correlates with alarming increased frequency of noxious algae blooms. In lakes with no watershed runoff we find large increases in mineral matter and greater growth of algae. If that mineral matter and its nutrients did not come from the watershed, it must be coming from dustfall or precipitation.

Nutrients in lakes have many sources—local, regional, global. Climate affects lakes by changing how nutrients are cycled in lakes and watersheds. Elsewhere, long-distance dustfall is linked to dramatic changes in remote lakes. We need to know if our lakes are imperiled by climate and dust-borne nutrients, rule out other causes of wilderness lake change, and not waste management dollars.

**What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?**

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 and landuse changes well beyond Minnesota may be working in concert to change our pristine lakes. By linking modern and historical lake ecology, air deposition, and lake simulations, we will solve the unprecedented change question, and determine how to preserve and protect water quality in our pristine lakes. This project will fundamentally change lake management strategies everywhere in Minnesota.

## Activities and Milestones

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

**Activity Budget:** $348,973

**Activity 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 National Atmospheric Deposition Program (NADP) to measure and map dustfall patterns and nutrient delivery.

**Activity Milestones:**

| Description | Completion Date |
|---|---|
| Establish state-of-the-art dustfall monitoring network in north and central Minnesota | December 31 2024 |
| Measure nutrients and algae for two years from 16 remote and wilderness lakes | December 31 2024 |

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

**Activity Budget:** $406,817

**Activity Description:**
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 climate and dust-borne nutrients through time on each lake to understand why they changed, when they changed, and which lakes are most imperiled.

**Activity Milestones:**

| Description | Completion Date |
|---|---|
| Compare climate and dustfall records from cores with monitoring to determine why lakes are changing | January 31 2025 |
| Collect, date, and analyze sediment cores from 16 remote lakes | January 31 2025 |

### Activity 3: Use lake simulations to determine which lakes are most at risk and how to protect them

**Activity Budget:** $94,210

**Activity 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.

We will spread our findings to help Minnesotans understand what threatens our favorite lakes and how to protect them.

**Activity Milestones:**

| Description | Completion Date |
|---|---|
| Develop a framework for predicting which protected lakes are at risk | January 31 2025 |

| | |
|---|---|
| Create a MINLAKE model for 16 study lakes to measure historical changes in lake function | January 31 2025 |
| Develop reports, factsheets, and outreach to inform managers and Minnesotans on protecting their threatened lakes | June 30 2025 |

## Project Partners and Collaborators

| Name | Organization | Role | Receiving Funds |
|---|---|---|---|
| Minnesota Pollution Control Agency | Minnesota Pollution Control Agency | 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. | No |

## Long-Term Implementation and Funding

**Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this be funded?**

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. Through reporting, presentations, and outreach, we will spread our findings to help Minnesotans understand what really threatens our favorite lakes and fisheries.

## Other ENRTF Appropriations Awarded in the Last Six Years

| Name | Appropriation | Amount Awarded |
|---|---|---|
| Tracking and Preventing Harmful Algal Blooms | M.L. 2016, Chp. 186, Sec. 2, Subd. 04a | $500,000 |
| Determining Risk of a Toxic Alga in Minnesota Lakes | M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 06f | $200,000 |

## Project Manager and Organization Qualifications

**Project Manager Name:** Mark Edlund

**Job Title:** Senior Scientist

**Provide description of the project manager's qualifications to manage the proposed project.**

Dr. Mark Edlund has been a Senior Scientist at the St. Croix Watershed Research Station of the Science Museum of Minnesota since 2007. He has also held the position of adjunct Professor of Water Resources Science/Earth Sciences at the University of Minnesota since 2004. Dr. Edlund has a 20-year record of federal, state, and local project management in his areas of expertise: aquatic biology, limnology, paleolimnology, and phycology; environmental drivers of ecological change; lake sediment records to understand short- and long-term environmental change; and has authored or co-authored more than 100 publications on the subjects. Dr. Edlund's current research focuses on biomonitoring of lakes in Great Lakes Region National Parks; water quality in Lake of the Woods; and understanding and predicting harmful algal blooms (HABS).

**Organization:** Science Museum of Minnesota - St. Croix Watershed Research Station

**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 is the environmental research center of the SMM with the mission "we do the science that helps make our rivers and lakes clean" through research and outreach. 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.

## Budget Summary

| Category / Name | Subcategory or Type | Description | Purpose | Gen. Ineligible | % Benefits | # FTE | Classified Staff? | $ Amount |
|---|---|---|---|---|---|---|---|---|
| **Personnel** | | | | | | | | |
| Mark Edlund, Senior Scientist | | Project coordination, Sediment Analysis, Reporting | | | 43.7% | 1.5 | | $171,798 |
| Adam Heathcote, Senior Scientist | | Project Coordination, Fieldwork, Water and Air Quality, DNA, Reporting | | | 43.7% | 1.5 | | $154,392 |
| Assistant Scientist | | Lake Modeling | | | 43.7% | 0.99 | | $90,210 |
| 2 Field and Laboratory Technicians | | Fieldwork and Laboratory Analysis | | | 43.7% | 0.66 | | $58,884 |
| Science Communication Specialist | | Outreach, Communication, and Social Media | | | 0% | 0.24 | | $12,000 |
| | | | | | | | **Sub Total** | **$487,284** |
| **Contracts and Services** | | | | | | | | |
| TBD | Professional or Technical Service Contract | Lab Analysis of Dust Samples: Dust chemistry (mass, P frac, N): 120 samples @ $100 ($12,000; Utah State University or competitive bid) | | | | - | | $12,000 |
| TBD | Professional or Technical Service Contract | Lab Analysis of Pigments Samples: Algal pigment analysis: 240 samples @ $124 ($30,000; University of Regina or competitive bid) | | | | - | | $30,000 |
| TBD | Professional or Technical Service Contract | Lab Analysis of Cyano DNA: 16S sediment DNA sequencing: 16 cores @ $1,500 ($24,000; University of Minnesota or competitive bid) | | | | - | | $24,000 |
| | | | | | | | **Sub Total** | **$66,000** |
| **Equipment, Tools, and Supplies** | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Tools and Supplies | Lab / Field Supplies | Bottles, reagents, preservatives, consumables | | | | | $10,000 |
| | Equipment | Dust Monitoring, ADS/NTN Atmospheric Deposition Samplers (Qty: 5) | Dust monitoring, ADS/NTN atmospheric deposition sampling | | | | | $25,000 |
| | Tools and Supplies | Monitoring Buoy Supplies (Qty: 16) | Component sensors for constructing and installing monitoring buoys on lakes | | | | | $51,200 |
| | | | | | | | **Sub Total** | **$86,200** |
| **Capital Expenditures** | | | | | | | | |
| | | Water Quality Sonde, YSI EXO2 (Qty: 1) | Advanced water quality monitoring platform | | | | | $20,000 |
| | | | | | | | **Sub Total** | **$20,000** |
| **Acquisitions and Stewardship** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Travel In Minnesota** | | | | | | | | |
| | Miles/ Meals/ Lodging | Atmospheric Monitoring and Network Setup ($2,500), 1 trip, 2 scientists, 6 days, 1,000 miles to north central Minnesota | Atmospheric monitoring and network setup | | | | | $2,500 |
| | Miles/ Meals/ Lodging | Sediment Core Collection ($6,000), 2 coring trips, 2-3 field crew, 10 days and 850 miles/trip to northern Minnesota | Sediment core collection | | | | | $6,000 |
| | Miles/ Meals/ Lodging | Water Quality Monitoring ($20,000), 6 water quality trips, 2-3 field crew, 10 days and 850 miles/trip to northern Minnesota | Water quality monitoring | | | | | $20,000 |
| | | | | | | | **Sub Total** | **$28,500** |
| **Travel Outside Minnesota** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Printing and Publication** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Other Expenses** | | | | | | | | |
| | | Lab Analysis of Water Samples | Lab analysis of water samples: TN/TP, DIN/SRP, DOC, DIC: 144 samples at $116.22 per sample ($16,736) (unit prices for analysis at SCWRS) | | | | | $16,736 |
| | | Lab Analysis of Sediment Samples | 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) | | | | | $145,280 |
| | | | | | | | **Sub Total** | **$162,016** |
| | | | | | | | **Grand Total** | **$850,000** |

## Classified Staff or Generally Ineligible Expenses

| Category/Name | Subcategory or Type | Description | Justification Ineligible Expense or Classified Staff Request |
|---|---|---|---|

## Non ENRTF Funds

| Category | Specific Source | Use | Status | Amount |
|---|---|---|---|---|
| **State** | | | | |
| | | | **State Sub Total** | **-** |
| **Non-State** | | | | |
| In-Kind | All indirect project costs are provided in-kind by the Science Museum of Minnesota (federally negotiated indirect rate of 40.09% on all direct costs = $340,765) | In-kind contribution of indirect costs | Pending | $340,765 |
| | | | **Non State Sub Total** | **$340,765** |
| | | | **Funds Total** | **$340,765** |

# Attachments

## Required Attachments

*Visual Component*

File: 1e3fa238-db8.pdf

*Alternate Text for Visual Component*

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

## Optional Attachments

*Support Letter or Other*

| Title | File |
|---|---|
| Letter of Support, Science Museum of MN | 022e0c11-75f.pdf |

# Administrative Use

**Does your project include restoration or acquisition of land rights?**

No

**Does your project have potential for royalties, copyrights, patents, or sale of products and assets?**

No

**Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?**

N/A

**Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?**

N/A

**Does your project include original, hypothesis-driven research?**

Yes

**Does the organization have a fiscal agent for this project?**

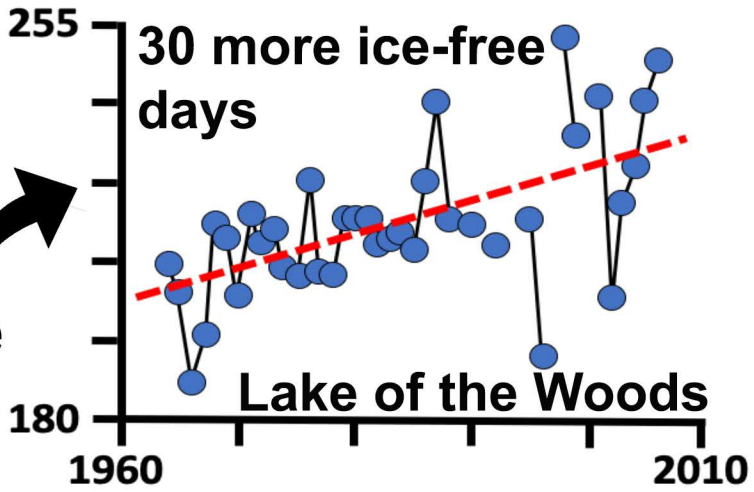
No

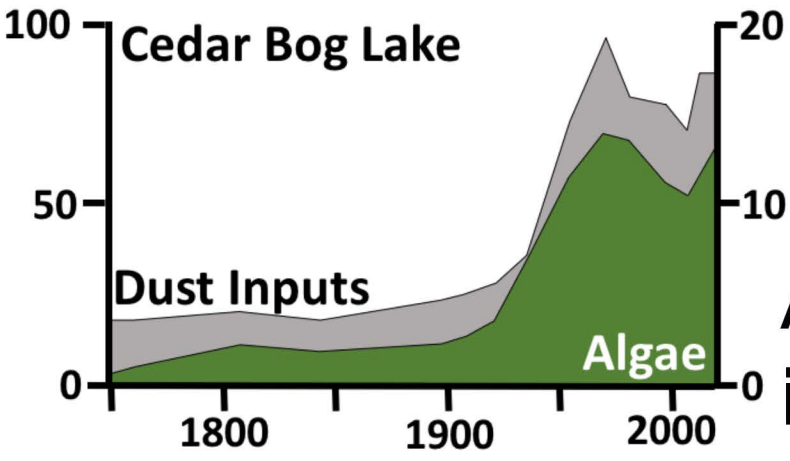
# *Unprecedented change threatens Minnesota's pristine lakes*


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?