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

Project Title: **ENRTF ID: 168-DH**

Invasive Rock Snot Threatens North Shore Streams

Category: H. Proposals seeking $200,000 or less in funding

Sub-Category: D. Aquatic and Terrestrial Invasive Species

Total Project Budget: $ 197,896

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

Summary:

We examine the recent spread, origin, cause, and economic and ecological threat of nuisance rock snot formation in North Shore streams and Lake Superior to inform management and outreach.

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

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Web Address:

Location:

Region: Northeast

County Name: Cook, St. Louis

City / Township:

Alternate Text for Visual:

We examine the recent spread, origin, cause, and economic and ecological threat of nuisance rock snot formation in North Shore streams and Lake Superior to inform management and outreach.

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

PROJECT TITLE: Invasive Rock Snot Threatens North Shore Streams

I. PROJECT STATEMENT: A North Shore stream was invaded by rock snot and the time to stop it is now!
In 2018, the first nuisance growth of rock snot (aka *Didymospenia geminata* or, more simply "didymo") developed in the North Shore's Poplar River and we don't know why. Didymo is a freshwater diatom (a type of algae) that can form nuisance mats of goo in coldwater streams worldwide, both in its native range and where it is invasive. Formation of didymo mats in streams has aesthetic, economic, and recreational impacts, including impacting angling and recreation. Economic impacts to tourism have exceeded $20 million per year following invasions elsewhere, **a serious threat to the North Shore's $250 million summer economy**. Didymo mats disrupt community structure and ecosystem function in streams, alter habitat and food web dynamics, impact fish and invertebrate abundance and diversity, and result in major shifts in natural bacterial composition.

Summary: With LCCMR support we will understand:
1) the distribution, dynamics, and effect of *Didymosphenia geminata* in North Shore streams
2) why did rock snot form in the Poplar River and what other streams are at risk?
3) the source of didymo in North Shore streams
4) share information and work with with resource managers, citizen groups, and resource users to stop rock snot invasion of North Shore streams.

Two hypotheses may explain rock snot: The **aggressive colonization hypothesis** maintains that an aggressive strain of *Didymosphenia geminata* is being introduced and invading coldwater streams. The **changing environmental conditions hypothesis** states that environmental conditions (e.g., nitrogen to phosphorus ratios or timing of nutrient delivery) have become favorable to the formation of didymo mats. *Understanding which of these models is supported by data is vital to management response*.

While didymo has been documented in the near shore algal community of Lake Superior with increasing frequency since the 1960s, the Poplar River, near Lutsen, MN, is the first stream that has been colonized. Didymo is unique because it only blooms in oligotrophic (low nutrient) waters and recently, mats have been observed more frequently in streams similar to those on the North Shore around the world, including New Zealand, South America, Canada, and the US. Research shows thicker didymo mats have formed along the Superior shoreline annually for over a decade; however, it was only in 2018 that didymo was first observed colonizing North Shore streams in either single cells or mat form. It is unclear why the mat formed in the Poplar River and whether didymo is already invading other North Shore streams.

We can solve rock snot: If the populations in North Shore streams and Lake Superior are not each-other's closest relatives (i.e., the stream didymo came from elsewhere), efforts for prevention of didymo mat formation will be focused on preventing movement of the alga among streams, paralleling practices that prevent the spread of other microbes in freshwater systems. Alternatively, if the stream didymo originated from Lake Superior populations, management practices should focus on understanding the specifics that promote mat formation. In both cases, we will fully understand the source and cause of mat formation and broadly communicate the threat, implications, and management response to didymo mat formation in North Shore streams.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Understand didymo mat formation and distribution in North Shore streams and Lake Superior
Description: We will monitor the Poplar River and Lake Superior shoreline near the mouth of the Poplar to determine if a didymo mat reforms in the next two years and monitor the timing and environmental conditions associated with mat formation in the stream and lake. We will similarly sample 3-4 other stream-lakeshore pairs along the North Shore to document changes in the algal community and associated environmental conditions. Sampling will be monthly from April-November and will include sampling of the

algal community and chemical (e.g., nutrients, dissolved organic carbon) and physical characteristics of the stream. Temperature, water depth, and flow will be measured continuously throughout the project. During peak didymo growth (late Aug-Sept 2019) a single survey each year will target 20 major North Shore stream-lakeshore pairs to fully assess current didymo presence and susceptibility of North Shore resources. All sampling will adhere to MNDNR protocols for preventing spread of aquatic invasive species.
ENRTF BUDGET: $140,596

Outcome	Completion Date
1. Describe the algal communities and environmental conditions in 4-5 paired Lake Superior shoreline and North Shore tributary sites	*January 2022*
2. Survey all major North Shore streams for presence of Didymo and invasion susceptibility during peak growth	*December 2021*
3. Communicate findings with natural resource managers, citizens, and scientists through presentations, signage, fact sheets, social media, and peer-reviewed publications.	*June 2022*

Activity 2: Genetic variability in MN didymo populations and the associated bacterial community.
Description: We will collect genetic information on North Shore tributary and Lake Superior coastal didymo populations to determine if the populations in the Poplar River and other North Shore streams are most closely related to didymo populations in Lake Superior or to other didymo populations in North America. We will apply reduced representation genomic sequencing on each population from the Lake Superior region and analyze the new data in the context of preexisting genomic data for didymo populations across the continental US. We will characterize the bacterial communities using 16S rRNA gene sequencing from total DNA extracted from the periphyton mat samples to predict broader ecological consequences of didymo and learn how nuisance blooms are triggered in ultra-clean waters.
ENRTF BUDGET: $57,300

Outcome	Completion Date
1. Sequence genetics of North Shore didymo populations to determine source of rock snot	*January 2022*
2. Determine genetic structure of the microbial mat community among lake and stream pairs and how changes in these communities alter ecological function and nutrient pathways in these systems.	*December 2021*
3. Communicate results with natural resource managers (MNDNR, state parks, watershed groups, MPCA) to inform management through meetings, signage, and presentations.	*June 2022*

III. PROJECT PARTNERS AND COLLABORATORS:

This project will be led by the St. Croix Watershed Research Station (Dr. Mark Edlund) and the MNDNR (Dr. Heidi Rantala). Other collaborators include Dr. Robert Pillsbury (UW-Oshkosh) and Dr. Teofil Nakov (University of Arkansas) who provide specialized sole source molecular analyses to the project.

IV. LONG-TERM IMPLEMENTATION AND FUNDING:

The MNDNR, as well as local watershed groups, will use data from this study to understand what causes nuisance didymo mats in North Shore streams. Understanding why mats form (aggressive colonizer or changing environment) is critical to managing didymo in streams, as management activities differ depending on the cause of mat formation. After understanding conditions that favor didymo mat formation in North Shore streams, documenting the impacts on stream invertebrate, fish, and algal communities will be our next steps.

V. SEE ADDITIONAL PROPOSAL COMPONENTS:

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Mark Edlund
Project Title: Invasive Rock Snot Threatens North Shore Streams
Organization: Science Museum of Minnesota
Project Budget: $197,896
Project Length and Completion Date: 2 yrs, 30 Jun 2022
Today's Date: 15 Apr 2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ -	$ -	$ -
Dr. Mark Edlund, Periphyton analyst at Science Museum of Minnesota, FY20, 25% of time (520 hr), salary $37.50/hr, Fringe $10.58/hr; FY21 32% of time (666 hr), salary $37.50/hr, Fringe $10.58/hr. Salary for diatom identification, $57,000 over 2 yrs; this is a grant-funded position	$ 57,000	$ -	$ 57,000
Salary for 2 part time interns at Science Museum of Minnesota, 800 hours total (400 hr FY20, 400 hr FY21) @ $15/hr salary (FY20), $1.80/hr fringe (FY20), $15.45/hr salary (FY21), $1.85/hr fringe (FY21). Salary for field work, lab tech. $6000 for FY20 and $6180 for FY21; total $13,642; this is a grant-funded position	$ 13,642	$ -	$ 13,642
Communication Specialist, Science Museum of Minnesota, 40 hours @$50/hour, 0 hours in FY20, 40 hours in FY21. Salary for outreach and social media. Total FY21 $2,000	$ 2,000	$ -	$ 2,000
Professional/Technical/Service Contracts			
Water chemistry analyses, St Croix Watershed Research Station, $198/sample (for suite of 10 analyses), 110 samples in FY20 and 110 samples in FY21, total $43,560.	$ 43,560	$ -	$ 43,560
Bacterial genetic analysis, sole source at UW-Oshkosh, 200 samples @ $130.80/sample, total $26,160	$ 26,160		$ 26,160
Didymo genetic analyses, sole source at University of Arkansas, 200 samples @ $149.10/sample, Total $29,820	$ 29,820	$ -	$ 29,820
Equipment/Tools/Supplies			
Stream gaging equipment, five 13-foot water levels @ $495.00 each, software $75, and communication cable $249	$ 2,799	$ -	$ 2,799
Consumable supplies: $4000 field supplies, $1320 microbial DNA extraction kits	$ 5,320	$ -	$ 5,320
Travel expenses in Minnesota			
Round Trip from St. Croix Watershed Research Station to Grand Marais, 2 employees, 18 days ea	$ 16,000	$ -	$ 16,000
Other			
Cost of open access publication, PLOS ONE ($1595)	$ 1,595	$ -	$ 1,595
COLUMN TOTAL	**$ 197,896**	**$ -**	**$ 197,896**

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
In kind:		$ -	$ -	$ -
Rantala Salary, in kind, FY20, 10% of time (208 hr), salary $36.32/hr, Fringe $8.99/hr; FY21 10% of time (208 hr), salary $37.63/hr, Fringe $9.39/hr, secured (Total $19,205 over 2 years)	$ 19,205	$ -	$ -	$ -
All indirect project costs are provided in-kind by the Science Museum of Minnesota (federal indirect rate 45.13% on all direct costs = $89,310, secured)	$ 89,310			
Waived genetic laboratory fees, secured by Pillsbury ($1744 total over 2 years)	$ 1,744	$ -	$ -	$ -
Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	**Amount legally obligated but not yet spent**	**Budget**	**Spent**	**Balance**
1) "Determining Risk of Toxic Alga in Minnesota Lakes" M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 06f: $200,000, Jul 2018-Jun 2021	$ 141,867	$ 593,000	$ 451,133	$ 141,867

Invasive Rock Snot
Threatens North Shore Streams

An Ecological and Economic Disaster for the North Shore?

Why did the Poplar River go from this...

Changing environmental conditions? Aggressive algae strain?

to this in 2018?

that's ROCK SNOT!

Where did rock snot come from? Is it in other streams?
How is it impacting stream function?
LET'S STOP IT NOW!

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.