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

Project Title: **ENRTF ID: 086-B**

Double Trouble: Blooms, Invasive Mussels and Lake Health

Category: B. Water Resources

Sub-Category:

Total Project Budget: $ 576,279

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

Summary:

This study will compare microbiomes in healthy MN lakes to those impacted by HABs and invasive mussels to inform management strategies to mitigate the compounding effects of HABs and mussels.

Name: Trinity Hamilton

Sponsoring Organization: U of MN

Title: Assistant Professor

Department: Plant and Microbial Biology

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St. Paul MN 55108

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Healthy lakes will be compared to those impacted by HABs and invasive mussels. Sentinel Lakes will be included to leverage ongoing studies, with new information from water and sediment sampling.

_____ 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: DOUBLE TROUBLE: BLOOMS, INVASIVE MUSSELS AND LAKE HEALTH

I. PROJECT STATEMENT

Increased nutrient inputs drive the proliferation of invasive cyanobacteria and algae, resulting in harmful algal blooms (HABs) that negatively impact the health of Minnesota lakes. HABs reduce water quality, can be toxic, and cause fish kills. Several of these toxic, bloom-forming, cyanobacteria are regularly observed in MN lakes. Invasive species of mussels (Zebra and Quagga mussels) further compound the proliferation of HABs through selective feeding by consuming beneficial algae and rejecting cyanobacteria, releasing them back into the water. **The combined impacts of increased nutrient input and mussels on the composition and severity of HABs is not known and the impact of mussels on the susceptibility of lakes to form blooms is not well understood. These outstanding questions are the focus of this proposal.**

We will collaborate with researchers at the St. Croix Watershed Research Station (SCWRS) to leverage data collected for previous ENRTF projects on the Minnesota Sentinel Lakes. Our project will be complementary to ongoing HAB research in MN while adding a significant missing component: **HAB composition analyzed by high resolution DNA sequencing connected to water chemistry.** These studies will require new samples (both water column and sediment) beyond those already being collected through ENRTF-funded projects because DNA sequencing requires careful preservation of samples, and we will target additional lakes impacted by both HABs and mussels that were not included in other studies. Our study will:

1. **Determine the impact of HABs on the lake microbiome to inform management strategies;**
2. **Provide a comprehensive analysis of HAB composition, historically and seasonally, before and after invasive mussels;**
3. **Measure the severity (toxin production and biomass load) in lakes impacted by HABs alone and invasive mussels + HABs; and**
4. **Evaluate whether the same management strategies will be effective in lakes impacted by both HABs and mussels.**

II. PROJECT ACTIVITIES AND OUTCOMES

1. How does the microbial composition of a healthy lake compare to a HAB-impacted or a HAB + mussel-impacted lake?

Activity 1: Determine bloom composition in the water column and sediment core samples from healthy lakes, lakes impacted by HABs and lakes impacted by HABs + invasive mussels. We will use high resolution DNA sequencing to determine the microbiome composition in impacted and healthy lakes seasonally (water column) and historically (sediment cores).

Outcome	Completion Date
1. Set a healthy lake microbiome baseline for managers.	October 2020
2. Identification of microbial community members in lakes with HABs and lakes with HABs + mussels to compare to healthy lakes.	December 2020
3. Determine the impacts of nutrient enrichment and mussels on HAB composition, both seasonally and historically	January 2021

2. How do HABs + mussels effect nutrient retention and cycling compared to healthy lakes?

Activity 2: Determine connections between microbiome composition in healthy versus impacted lakes with nutrient retention and loss in the water and sediments from the same lakes targeted in Activity 1. Specifically, we will measure nutrients (C, N, P) in sediment and water samples collected as part of Activity 1.

Outcome	Completion Date
1. Determine the susceptibility of lakes to HABS and their continued impact, and how mussels effect/perpetuate HABs.	February 2021
2. Quantify the amount of nutrients retained in the sediments which can fuel blooms vs. external delivery.	June 2021

3. How do mussels impact HAB composition and severity over a seasonal bloom?

Activity 3: Monitor HAB composition and toxicity throughout bloom formation and collapse compared to normal cycling in healthy lakes. 1 healthy, 1 HAB impacted, 1 HAB + mussels lake will be selected from **Activity 1** to determine the timing of events in the water column: HAB formation, HAB composition throughout the bloom, and HAB severity, and HAB collapse compared to healthy lake dynamics.

Outcome	Completion Date
1. Determine onset of blooms and identify HAB species throughout bloom formation and collapse and compare to healthy lake seasonal dynamics.	March 2022
2. Quantification of the severity of the bloom (toxin production, biomass, and longevity) and impact on nutrient cycling with and without mussels compared to a healthy lake.	April 2022

4. Will current mitigation strategies combat the compounded effects of mussels on HABs?

Activity 4: Integrate data to determine the impacts of invasive mussels on the severity of HABs and disseminate findings.

Outcome	Completion Date
1. Generate and disseminate scientific reports to inform managers and stake holders (including the general public) about the compounded effects of mussel on HABs.	March 2022
2. Publish data in scientific journals and publicize the results through media releases, social media, and University of Minnesota Extension HABs outreach.	June 2022

III. PROJECT PARTNERS:

A. Partners receiving ENRTF funding	Title	Affiliation	Role
Trinity Hamilton	Assistant Professor	UMN-TC	Project Lead
Jeff Havig	Assistant Professor	UMN-TC	Co-PI
B. Partners NOT receiving ENRTF funding	**Contact**	**Role**	
St. Croix Watershed Research Station	Adam Heathcote	Scientific collaborator	

IV. LONG-TERM-IMPLEMENTATION AND FUNDING:

This study will be the first to characterize the compounding effects of mussels and HABs in MN lakes. Our study will provide new data on the role of mussels in HAB composition, timing, and severity. These data will inform management strategies for HAB-impacted lakes vs. lakes impacted by HABs and mussels, will help better focus management to return a healthy microbiome to impacted lakes, and will help cement Minnesota as a national leader in combating HABs. We will share our data with other research groups studying HABs including the SCWRS and disseminate the results broadly to inform the long-term strategies necessary for management and mitigation of HABs.

V. TIME LINE REQUIREMENTS:

The proposed project will be completed in 3 years (July 2019-June 2022). Fieldwork will be completed in years 1 and 2 but the project will generate significant amounts of data that will take an additional year to analyze, interpret and generate and disseminate results. We will submit a final report to LCCMR by the end of the funding period.

2019 Proposal Budget Spreadsheet

Project Title: DOUBLE TROUBLE: BLOOMS, INVASIVE MUSSELS AND LAKE HEALTH

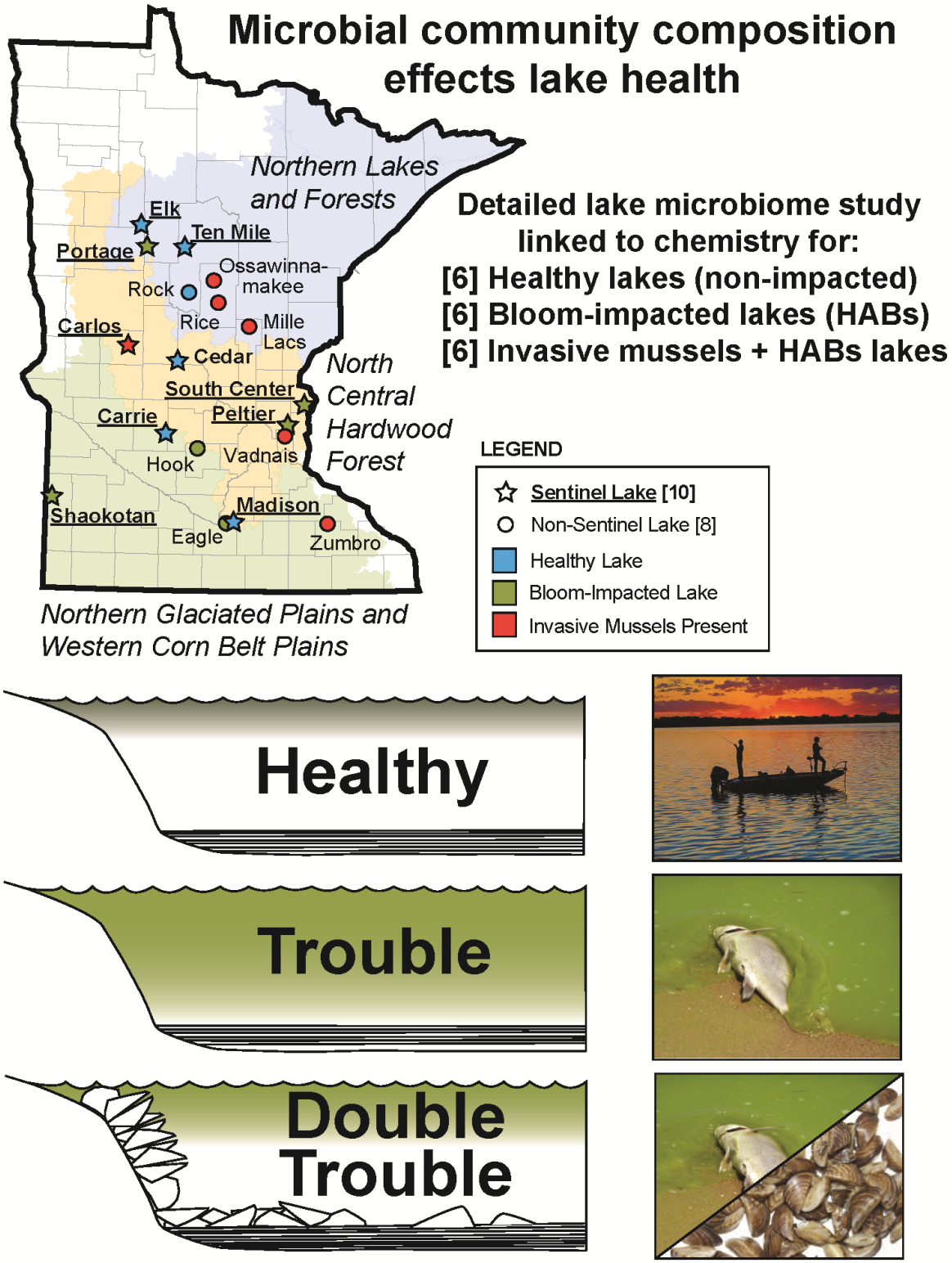
IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel: **Dr. Trinity Hamilton, Lead PI,** Professor, UMN-TC, Dept of Plant and Microbial Biology, 4% FTE (2 summer weeks in years 1-3), 68% salary, 32% benefits. Lead Activity 1, 2 and 4, advise graduate students and co-advise post doc and undergraduate students. **$18,892** **Dr. Jeff Havig, co-PI,** Professor, UMN-TC, Dept of Earth Sciences, 4% FTE (2 summer weeks in years 1-3), 75% salary, 25% benefits. Lead Activity 2, co-advise post doc and students. **$16,607** **Post doc,** Field lead, sediment core analyses, data integration for Activities 1-4. 100% FTE for years 1-3. 79% salary, 21% benefits. **$179,916** **Graduate student,** Microbial analyses lead for Activity 1 and 3. 50% FTE for years 1-3, 42% salary, 58% benefits (includes tuition). **$136,136.** **Undergrad technicians,** Field sampling, sample processing, 38% FTE for years 1-3. **$21,000**	$372,551
Professional/Technical/Service Contracts: Carbon analyses for solid samples – **$15,255** (90 core samples @ $30, 297 seston samples @ $15, 540 biomass samples at $15) Nutrient analyses (i.e. N, P, C, Fe) – **$47,592** (297 water column samples @ $136, 90 pore water samples @ $80) Community composition – **$8,475** (DNA Sequencing (387 x 2, 16S and 18S rRNA) @ $10.95) LacCore Lake Coring – **$26,748** (18 lakes @ $1,486/lake) and 210-Pb Analyses: $20,000 (8 non-	$118,070
Equipment/Tools/Supplies: Multi-parameter sonde (field meter) and sensors for water-column measurements – **$20,000** Field equipment and field and laboratory supplies including bottles, reagents, calibration reagents, DNA extraction kits and supplies, filters, analytical standards – **$30,000** Cyanotaxin ELISA kits – **$4,752** (297 @ $16 (microcystin and cylindrospermopsin))	$54,752
Acquisition (Fee Title or Permanent Easements):	N/A
Travel: Field travel for year 1 – **$9,098** (4 people visit 18 lakes, target 3 lakes/trip, 3 nights, 4 days/trip) – UMN suburban rental, $50/day, $0.37/mile. GSA Per diem, ($91/person/day lodging and $51/person/day meals). Based on average roundtrip mileage of 450 miles. 6 trips total. Field travel for year 2 – **$19,808** (2 people, monitoring at 3 lakes, 3 nights, 4 days/trip) – UMN suburban rental, $50/day, $0.37/mile. GSA Per diem, ($91/person/day lodging and $51/person/day meals). Based on average roundtrip mileage of 450 miles. 15 trips total.	$28,906
Additional Budget Items: Publication costs.	$2,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 576,279

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:	$ -	*N/A*
Other State $ To Be Applied To Project During Project Period:	$ -	*N/A*
In-kind Services To Be Applied To Project During Project Period: In-kind from UMN-TC, Indirect costs not paid by ENRTF requested funds (54%).	$311,239	*Secured*
Past and Current ENRTF Appropriation:	$ -	N/A
Other Funding History:	$ -	*N/A*

B. Visual Component



F. Project Manager Qualifications and Organization Description

Trinity L. Hamilton

Education

B.Sc.	Montana State University	2003	Cell Biology
B.Sc.	Montana State University	2006	Chemistry & Biochemistry
Ph.D.	Montana State University	2012	Chemistry & Biochemistry

2. Positions

2017-present	University of Minnesota-TC, Assistant Professor, Plant and Microbial Biology
2015-2017	University of Cincinnati, Assistant Professor, Biological Sciences
2012-2014	Pennsylvania State University, Postdoctoral Fellow, Geosciences

3. Research Expertise

The Hamilton lab has extensive experience in the extraction of high quality DNA from samples collected from environmental samples. In addition, the lab is well-versed in DNA sequence analyses and quantitative PCR as well as other molecular techniques. The lab routinely collects and analyzes 100s of samples each year from a range of natural systems. The Hamilton lab houses and maintains all the necessary equipment to perform the analyses described unless otherwise noted.

Jeff Havig, co-PI, Assistant Professor, Department of Earth Sciences (UMN-TC)

Dr. Havig is the director of the Modern and Deep-time Environmental Geochemistry and Geobiology Laboratory in the Dept. of Earth Sciences and brings extensive expertise in aqueous geochemistry and water quality sampling and analysis.

4. Recent Publications

- Hamilton, T.L. Havig, J.R. (2018) Inorganic carbon stimulates snow algae primary productivity. *The ISME Journal. In press.* (doi: 0.1038/s41396-018-0048-6)
- Hamilton, T.L., Klatt, J., de Beer, D., Macalady J.L. (2018) Cyanobacterial photosynthesis under sulfidic conditions - Insights from the isolate *Leptolyngbya* sp. strain hensonii. *The ISME Journal* 12, 568–584.
- Schuler C., Havig, J.R., Hamilton, T.L. (2017) Carbon fixation across geochemical gradients in the Greater Obsidian Pool Area. *Frontiers in Earth Science*. 5:97.
- Colman, D.R., Poudel, S., Hamilton T.L., Havig, J.R., Selensky, M., Shock, E.L., Boyd, E.S. (2017) Geobiological feedbacks and the evolution of thermoacidophiles. *The ISME Journal*. 12: 225-236.
- Hamilton, T.L., Welander, P., Albrecht, H.L., Fulton, J.M., Schaperdoth, I., Bird, L., Summons, R., Freeman, K.H., Macalady, J.L. (2017) Microbial communities and organic biomarkers in a Proterozoic-analog sinkhole environment. Geobiology. 15: 784-797.
- Havig, J.R., Hamilton, T.L., McCormick, M.L., McClure, B., Sowers, T., Wegter, B., Kump, L.R. (2017). Water column and sediment carbon isotope geochemistry of permanently redox-stratified Fayetteville Green Lake, New York, USA: Carbon cycling and implications for the Paleoproterozoic ocean. *In press. Limnology and Oceanography.*
- Havig, J.R., Hamilton, T.L., Bachan, A., Kump, L.R. (2017) Sulfur and carbon isotopic evidence for metabolic pathway evolution and a four-stepped Earth system progression across the Archean and Paleoproterozoic. *Earth-Science Reviews*. 174: 1-21.

5. Organization Description

The Department of Plant and Microbial Biology and the University of Minnesota are dedicated to supporting biological research across scales spanning molecular biology to genomics and ecosystem science. The Department is collaborative and interdisciplinary resulting in cutting edge research at the forefront of plant and microbial biology.