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

Project Title: **ENRTF ID: 054-AH**

Best Management Practices for Minnesota Coldwater Lakes

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

Sub-Category: A. Foundational Natural Resource Data and Information

Total Project Budget: $ 199,653

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

Summary:

Remedial measures are needed to conserve fish in Minnesotas coldwater lakes. We will identify the causes of fish habitat loss and compile a set of management recommendations for salvageable lakes.

Name: Euan Reavie

Sponsoring Organization: U of MN - Duluth

Job Title: Dr.

Department: Natural Resources Research Institute

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Web Address: https://www.nrri.umn.edu/about-nrri/Euan-Reavie

Location:

Region: Statewide

County Name: Statewide

City / Township: Paynesville, Laporte, Benedict, Grand Marais

Alternate Text for Visual:

Coldwater fish are declining in Minnesota. Historical measurements will inform on causes. Outcomes will be future fish habitat quality and best management recommendations for lakes that can be saved.

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

PROJECT TITLE: Best management practices for Minnesota coldwater lakes

I. PROJECT STATEMENT

We will use a novel combination of lake sediment cores and water quality data to describe the 200-year history of coldwater fish habitat. Then, based on modern trajectories **we will predict future persistence of coldwater fish habitat** in these lakes so that best management practices are appropriately targeted. This effort is needed to ensure stable recreational fishing in Minnesota, which annually comprises $9 billion in salaries, wages, earnings, retail spending, tax revenues and economic impacts in the forms of gas, lodging and resort services.

Unfortunately, **coldwater fish** populations **have been declining in Minnesota lakes** since the 1970s. This alarming trend has been attributed to:

- more algae due to nutrient inputs (which reduces oxygen concentrations in the bottom waters of lakes);
- higher water temperatures (which heat surface waters beyond what fish can tolerate);
- longer ice-free seasons (which also reduces oxygen in deep waters);
- the combined effects of nutrients, algae and warming, which collectively "squeeze" fish between habitats that are too warm and those with too little oxygen.

To combat loss of fish habitat we need to focus remedial measures on lakes where best management practices will be most beneficial. **We will identify the causes and timing of coldwater fish habitat loss in three important Minnesota lakes** as it relates to cisco (a forage fish) and the game fish that feed on cisco (lake trout, walleye, pike). These lakes will range from good (stable fish population) to poor (declining water quality and fish). We will determine how nutrients and other stressors have affected lake temperature and oxygen levels over the last two centuries. The Sentinel Lakes Program (funded through ENRTF) provided some valuable data, but **the deepwater oxygen histories of Minnesota lakes are unknown**, so we do not know the trajectory of coldwater fish habitat. The major outcomes will be (1) a set of urgently needed management recommendations for lake water quality and (2) a confirmed method to characterize fish refuge lakes throughout the state.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Determine past water quality conditions for three representative coldwater lakes
Description: The three coldwater lakes selected range from low-nutrient with healthy coldwater fish populations (Greenwood Lake) to a high-nutrient lake whose coldwater fish are in decline (Lake Koronis). Kabekona Lake is intermediate in its condition. Fish habitat will be reconstructed from lake bottom sediment cores using the fossil remains of algae (indicators of past nutrient stress) and midges (aquatic insects that can indicate deep-water oxygen levels), allowing us to reconstruct historic nutrient and oxygen levels.
ENRTF BUDGET: $130,600

Outcomes	Completion Date
1. Collect 6 sediment cores from 3 coldwater lakes; date sediment profiles; analyze fossil remains; total 450 sample analyses.	January 2021
2. Reconstruct historic nutrients and environmental conditions using algae fossils.	December 2021
3. Reconstruct historic lake temperatures & oxygen levels using aquatic insect fossils.	December 2021

Activity 2: Establish relationships between stress (nutrients and warming) and coldwater fish habitat
Description: Past lake nutrient concentrations and deep-water dissolved oxygen levels reconstructed in Activity 1 will be related to historic air temperatures and land use.
ENRTF BUDGET: $31,000

Outcomes	Completion Date

1. Quantify relationships between air temperature, water quality, and fish habitat for three coldwater lakes in Minnesota.	April 2022
2. Determine historic impacts of human stressors on coldwater fish habitat.	April 2022

Activity 3: Predict extent of coldwater fish habitat in the future; identify savable lakes and recommend on-the-ground conservation measures; derive a plan to expand findings to all coldwater lakes in Minnesota.
Description: We will determine which lake management practices are likely to be successful. Based on the causes of fish loss (from Activity 2) we will make projections of future coldwater fish habitat in our study lakes. Warming will likely continue, but we can manage nutrients to preserve deepwater oxygen. The outcome will be a set of management actions to promote the persistence or recovery of coldwater fish communities. Outcomes may range among the following scenarios: Worst case: lake is no longer a coldwater refuge; warming has been impacting fish for decades; management unlikely to be successful; low action priority. Best case: natural coldwater fish refuge; lake is unimpacted by nutrients and warming; existing or minimal management recommended. Action case: potential fish refuge; lake is little impacted by warming but is nutrient-enriched; catchment management recommended for restoration.
ENRTF BUDGET: $38,053

Outcomes	Completion Date
1. Describe future fish habitat in the three lakes based on management scenarios.	June 2022
2. Tailor management recommendations for different lake types (range: low nutrient lakes with coldwater fish to productive lakes where coldwater fish have declined). Work directly with MNDNR personnel to ensure recommendations are considered.	June 2022
3. Develop a plan to extend this application to hundreds of threatened coldwater lakes throughout the state.	December 2022

III. PROJECT PARTNERS AND COLLABORATORS:

- Daniel Engstrom & Mark Edlund (funded), sediment dating specialists, St. Croix Watershed Research Station; will perform isotopic analyses; assist with data exchange from previous ENRTF projects
- Peter Jacobson & MNDNR (unfunded), Fisheries Habitat Research Supervisor, MNDNR; will provide temperature and fish data; help develop the management recommendations, including linkages to the Sentinel Lakes program (previously funded through ENRTF)
- Local user sectors (unfunded), e.g. angling groups, lake associations; will contribute to management recommendations

IV. LONG-TERM IMPLEMENTATION AND FUNDING:

Minnesota is losing coldwater fish habitat and populations, a trend that will have long-term impacts on angling and tourism. However, loss can be minimized or reversed with appropriate management options. Using clear linkages among air temperature, nutrient stress, low oxygen and fish declines in the three selected lakes we will create management recommendations for improving water quality in lakes that can be saved. The data and results produced by this project **will guide coldwater lake conservation efforts**. Most importantly, we will confirm the utility of this method as a tool to reconstruct lake sensitivity and trajectory, which could then be used for similar assessments across the state. Future work representing more lake conditions in the state would allow us to make recommendations for hundreds of coldwater systems. Major long-term benefits will include **improved water quality, well-oxygenated fish habitat and greater stability in angling and tourism sectors**. We secured additional in-kind funding to provide training for young scientists and a student in the techniques used to complete this work.

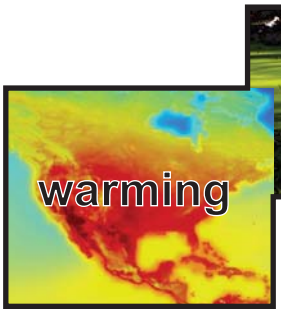
Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Euan Reavie
Project Title: Best management practices for Minnesota coldwater lakes
Organization: University of Minnesota - Duluth
Project Budget: $199,653
Project Length and Completion Date: 2.5 years (completed 12/31/2022)
Today's Date: 04/04/2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 184,825	$ -	$ 184,825
Euan Reavie (NRRI, Project Manager); $21,002 (74% salary, 26% benefits), 5% FTE for project year (PY) 1 & 2, 6% effort for PY 3			
Valerie Brady (NRRI, Co-investigator); $13,900 (74% salary, 26% benefits), 5% FTE each PY			
Lucinda Johnson (NRRI, Co-investigator); $4,736 (74% salary, 26% benefits), 1% FTE PY1 & 2, 0% FTE PY3			
Elizabeth Alexson (NRRI, Aquatic Scientist responsible for field work, data collection and interpretation, report writing and mentoring grad student); $6,118 (77% salary, 23% benefits), 5% FTE for PY1 & 2, 0% FTE in PY3			
Robert Hell (NRRI, Invertebrate Taxonomist responsible for); $20,203 (77% salary, 23% benefits), 15% FTE in PY1 & 2, 0%FTE in PY3. *Note: NRRI research staff salaries are largely sponsored by external funders.			
Josh Dumke (NRRI, Project Coordinator responsible for supervision of lab staff, data analysis and reporting); $6,576 (74% salary, 26% benefits), 3% FTE PY1, 2 & 3.			
Kari Hansen (NRRI, Technician responsible for lab sample preparation); $19,734 (77% salary, 23% benefits), 20% FTE in PY1 & 2, 0% FTE in PY3. *Note: NRRI research staff salaries are largely sponsored by external funders.			
Kitty Kennedy (NRRI, Technician responsible for paleo sample processing); $12,592 (77% salary, 23% benefits), 15% FTE in PY1, 5% FTE in PY2, 0% FTE in PY3. *Note: NRRI research staff salaries are largely sponsored by external funders.			
Graduate Research Assistant (NRRI, Academic Year and Summer Research Assistant responsible for performing diatom analysis); $79,964 (52% salary, 48% benefits inc. tuition), 50% FTE in PY1 &2, 0% FTE in PY3. *Note this effort is committed by a non-salaried graduate student employee.			
Professional/Technical/Service Contracts			
	$ -	$ -	$ -
Equipment/Tools/Supplies			
Sediment lab supplies: sample containers ($400); reagents ($1,000); crucibles ($100); slides ($200)	$ 2,500		$ 2,500
Invertebrate lab suplies: Ultrasonic cleaner ($500); slides ($113); cover slips ($280); CMC-10 mounting media ($45)	$ 2,080	$ -	$ 2,080
Capital Expenditures Over $5,000			
Fee Title Acquisition			
Easement Acquisition			
Professional Services for Acquisition			
Printing			
	$ -	$ -	$ -
Travel expenses in Minnesota			
Field travel for core sampling: 6 days, 3 people	$ 2,748		$ 2,748
lodging: 5 nights, $94/night, 3 people. Total = $1410			
Meal per diem: $55, 3 people, 6 days. Toal = $990			
Mileage: 600 miles, $0.58/mile. Total = $348			
Other			
Sediment isotope dating: St. Croix Watershed Research Station - 3 cores @ $2,400/core	$ 7,200		$ 7,200
Postage/shipping: Rapid-mail subsamples for isotope analysis	$ 300	$ -	$ 300
COLUMN TOTAL	$ 199,653	$ -	$ 199,653

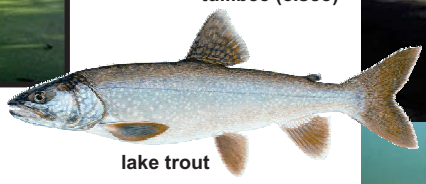
SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Unrecovered F&A @ 54% MTDC		$ 90,543	$ -	$ 90,543

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
		$ -	$ -	$ -

BEST MANAGEMENT PRACTICES FOR MINNESOTA COLDWATER



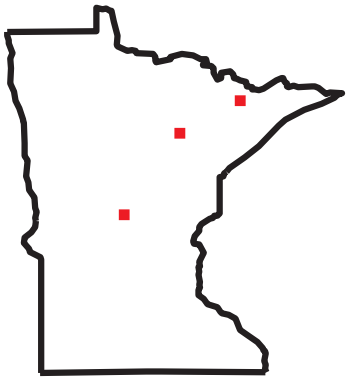

tullibee (cisco)


lake trout


walleye


pike

<u>The problem</u>: environmental stress is causing a loss of coldwater fish



<u>Through this project we will</u>:

►select 3 lakes ranging from "poor" to "excellent" fish condition

►determine which lakes can be saved through watershed management

►recommend lake-specific management practices to conserve oxygen and fish (e.g. focused nutrient reduction)

WE WILL CONFIRM THE POWER OF THE APPROACH AND PROPOSE EXTENSION TO HUNDREDS OF THREATENED COLDWATER LAKES

LCCMR 2020 Project Manager Qualifications and Organization Description
Euan D. Reavie, Natural Resources Research Institute, University of Minnesota Duluth

Key Qualifications

Dr. Reavie is a Senior Research Associate with specialties in the aquatic sciences at the Natural Resources Research Institute. He is an aquatic ecologist with particular expertise in paleoecology, describing the environmental histories of lakes to help define management and remedial protocols. His research focuses on the use of modern and historical biological indicators that inform on the effects of stressors such as nutrient loads, harmful algal blooms and atmospheric warming. Reavie will be supported by Dr. Lucinda Johnson, an expert in forecasting fish habitat conditions due to stressors; Dr. Valerie Brady, an expert in the use of aquatic insects to indicate aquatic habitat condition; and Mr. Peter Jacobson, MN DNR Fisheries Research, who has worked extensively with coldwater fish and stressor impacts in Minnesota.

Reavie Education

Dec. 1998 – Oct. 2000: Postdoctoral (Geology), University of Toronto
Nov. 1994 – Oct. 1997: PhD (Biology), Queen's University

Reavie Selected Grants as Principal Investigator

USEPA Great Lakes National Program Office, $2,500,000, 2016-21, Great Lakes monitoring: phytoplankton

MPCA + MN Sea Grant (two grants supporting a project), $404,983, 2014-16, Paleolimnology and delisting of the St. Louis River Area of Concern

Northeast-Midwest Institute, NOAA and others, $1,300,000 (to date), 2006-17, Development of ballast water treatment technologies

Reavie Selected Recent Publications:

Reavie, E.D., M. Cai, T.N. Brown 2018. Historical watershed stressors for the Laurentian Great Lakes. *Geoscience Data Journal*, doi.org/10.1002/gdj3.53.

Reavie, E.D., M.B. Edlund, N.A. Andresen, et al. 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.

Reavie, E.D., G.V. Sgro, L.R. Estepp, et al. 2017. Climate warming and changes in *Cyclotella sensu lato* in the Laurentian Great Lakes. *Limnology and Oceanography* 62: 768-783.

Reavie, E.D., M. Cai, M.R. Twiss, et al. 2016. Winter-spring diatom production in Lake Erie is an important driver of summer hypoxia. *Journal of Great Lakes Research* 42: 608-618.

Alexson, E.E., E.D. Reavie, R.P. Axler, et al. 2018. Paleolimnology of a freshwater estuary to inform Area of Concern nutrient delisting efforts. *Journal of Paleolimnology* 59: 373-395.

Sgro, G.V., E.D. Reavie 2018. Lake Erie's ecological history reconstructed from the sedimentary record. *Journal of Great Lakes Research* 44: 54-69.

The Natural Resources Research Institute is a part of the University of Minnesota Duluth. Its mission is *to deliver research solutions to balance our economy, resources and environment for resilient communities*. NRRI scientists have extensive experience in managing large, interdisciplinary projects. Major objectives include the development of tools for environmental assessment and resource management. NRRI's role is as a non-partial, science-based resource that develops and translates knowledge by characterizing and defining value-resource opportunities, minimizing waste and environmental impact, maximizing value from natural resource utilization and maintaining/restoring ecosystem function. Major outcomes include informing environmental management and policy and assisting industry and communities in defining and maintaining the social license to operate in natural systems.