

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

Project Title:

ENRTF ID: 012-A

Conserving Lake Trout in Minnesota

Category: A. Foundational Natural Resource Data and Information

Sub-Category:

Total Project Budget: \$ 782,549

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

Summary:

Determine long-term causes of fish loss and develop management recommendations for rehabilitation of coldwater fisheries in hundreds of lakes. A collaboration with the MNDNR to enhance the sentinel lakes program.

Name: Euan Reavie

Sponsoring Organization: U of MN - Duluth

Title: Senior Research Associate

Department: Natural Resources Research Institute

Address: 5013 Miller Trunk Hwy
Duluth MN 55811-1442

Telephone Number: (218) 788-2692

Email ereavie@d.umn.edu

Web Address www.nrri.umn.edu

Location

Region: Central, Northwest, Northeast

County Name: Aitkin, Beltrami, Benton, Carlton, Cass, Clearwater, Cook, Crow Wing, Hubbard, Itasca, Kanabec, Koochiching, Lake, Lake of the Woods, Mille Lacs, Morrison, Roseau, St. Louis, Wadena

City / Township:

Alternate Text for Visual:

Coldwater fish are declining in Minnesota. Historical measurements will inform on nutrients and oxygen. Outcomes will be future fish habitat quality and best management recommendations.

<input type="checkbox"/>	Funding Priorities	<input type="checkbox"/>	Multiple Benefits	<input type="checkbox"/>	Outcomes	<input type="checkbox"/>	Knowledge Base	
<input type="checkbox"/>	Extent of Impact	<input type="checkbox"/>	Innovation	<input type="checkbox"/>	Scientific/Tech Basis	<input type="checkbox"/>	Urgency	
<input type="checkbox"/>	Capacity Readiness	<input type="checkbox"/>	Leverage	<input type="checkbox"/>		TOTAL	<input type="checkbox"/>	%
<input type="checkbox"/> If under \$200,000, waive presentation?								



PROJECT TITLE: Conserving Lake Trout in Minnesota

I. PROJECT STATEMENT

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 nutrient stress and warming, which collectively “squeeze” fish between habitats that are too warm and those with too little oxygen.

We will **identify the causes and timing of coldwater fish habitat loss** in Minnesota lakes as they relate to **cisco** (a forage fish) and the game fish that rely on it (**lake trout, walleye, pike**). We will determine how nutrients and other stressors affected lake temperature and oxygen levels over the last two centuries. Though the Sentinel Lakes Program (funded through ENRTF) includes fish monitoring and historic reconstructions, the important deepwater oxygen histories are unknown. We will take the Sentinel effort several steps further using a novel combination of sediment cores and water quality data to quantify a 200-year history of coldwater fish habitat. Then, **we will predict future persistence of coldwater fish habitat in lakes based on environmental conditions**. The major outcome will be a set of **urgently needed management recommendations for water quality**. Further, we will **identify specific lakes where management will have the greatest likelihood to sustain fish populations**.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Determine past water quality conditions for 10 coldwater lakes. **ENRTF Budget: \$254,701**

Ten coldwater lakes will be selected as surrogates for lake types throughout northern Minnesota. They will range from oligotrophic (very low nutrient) with healthy coldwater fish populations to higher nutrient lakes whose coldwater fish are in decline or have been lost. Fish habitat will be reconstructed using the fossil remains of algae (indicators of past nutrient stress) and midges (aquatic insects that can indicate deep-water oxygen levels) from lake bottom sediment cores. These data will allow us to reconstruct historic nutrient and oxygen levels since pre-European settlement.

Outcome: Understand past water quality in lakes important for coldwater fish	Completion Date
1. Collect 20 sediment cores from 10 coldwater lakes; analyze fossil remains; total 2,200 sample analyses.	February 2020
2. Use algae remains to reconstruct historic nutrients and environmental conditions.	February 2021
3. Use aquatic insect remains to reconstruct historic lake temperatures & oxygen levels.	February 2021

Activity 2: Establish relationships between stress (nutrients and warming) and coldwater fish habitat. **ENRTF Budget: \$271,154**

Past lake nutrient concentrations and deep-water dissolved oxygen levels reconstructed in Activity 1 will be related to historic air temperatures and land use. Relationships between temperature and dissolved oxygen with respect to coldwater fish habitat will be derived based on historic records from the study lakes. These relationships will reconstruct lake temperature and deep-water oxygen levels through time in study lakes and will be used to extrapolate future fish habitat in a larger set of 750 coldwater lakes.

Outcome: Understand factors creating good coldwater fish habitat	Completion Date
1. Quantify relationships between air temperature, water quality, and fish habitat for coldwater lakes in Minnesota; validate for 10 study lakes.	July 2021
2. Extrapolate to coldwater fish habitat in 750 coldwater lakes.	December 2021
3. Quantify historical impacts of human stressors on coldwater fish habitat.	December 2021

Activity 3: Predict extent of coldwater fish habitat in the future, identify savable lakes, and recommend on-the-ground conservation measures.

ENRTF Budget: \$256,694

Based on the causes of fish loss and temperature/oxygen projections from Activity 2, we will make projections of future coldwater fish habitat in lakes across northern and central Minnesota. Warming will likely continue, but we can manage nutrients and therefore lake oxygen. Future management scenarios (e.g., land conservation; nutrient management) will be simulated to predict their long-term benefits. The outcome will be a set of management actions that are suited to different lake types to promote the persistence or recovery of coldwater fish communities.

Outcome: Management recommendations and implementation to preserve coldwater fish habitat	Completion Date
1. Refine future stressor – fish habitat scenarios.	January 2022
2. Map future lake conditions in 750 lakes under varying land management scenarios. Identify a subset of “refuge” lakes that are likely to respond to conservation efforts.	February 2022
3. Tailor management recommendations for different lake types (range: oligotrophic lakes with coldwater fish to mesotrophic lakes where coldwater fish have declined).	June 2022

III. PROJECT PARTNERS:

A. Partners receiving ENRTF funding

Name	Title	Affiliation	Role
Daniel Engstrom & Mark Edlund	Sediment dating specialists	St. Croix Watershed Research Station	Isotopic analyses; assist with data exchange from previous ENRTF projects

B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
Peter Jacobson	Fisheries Habitat Research Supervisor	MNDNR	Advice on lake selection, temperature, and fish data; help develop the management recommendations, including linkages to the Sentinel Lakes program (previously funded through ENRTF)
Local user sectors	e.g., angling groups, lake associations	Public	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.

With clear linkages among air temperature, nutrient stress, low oxygen, and fish declines, we will create management recommendations for improving water quality in northern lakes that we have identified as salvageable. The data and results produced by this project **will guide coldwater lake conservation efforts** on many iconic Minnesota lakes such as Sea Gull Lake on the Gunflint Trail, Burntside Lake near Ely, Trout Lake near Grand Rapids, and Big Trout Lake near Pine River. On-the-ground management practices will continue well after completion of this project. 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.

V. TIMELINE REQUIREMENTS: Three years, starting July 1, 2019 and ending June 30, 2022.

2019 Proposal Budget Spreadsheet

Project Title: Conserving Lake Trout in Minnesota

IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel:	\$ 730,925
Euan Reavie, Principal Investigator: \$54,399 (fringe rate 33.5%); 15% FTE in Y1, 10% FTE in Y2 & Y3	
Valerie Brady, Co-Investigator: \$37,882 (fringe rate 33.5%); 10% FTE in Y1 & Y2, 15% FTE in Y3	
Bill Herb, Co-Investigator: \$108,232 (fringe rate 33.5%); 10% FTE in Y1, 40% FTE in Y2, 50% FTE in Y3	
Lucinda Johnson, Co-Investigator: \$37,223 (fringe rate 33.5%); 4% FTE in Y1 & Y2, 8% FTE in Y3	
Andy Bramburger, Co-Investigator: \$58,039 (fringe rate 33.5%); 20% FTE in Y1 & Y2, 15% FTE in Y3	
Kris Johnson, GIS Mapping: \$38,548 (fringe rate 27.2%); 10% FTE in Y1, 15% FTE in Y2, 20% FTE in Y3	
Katya Kovalenko, Statistical Analysis: \$31,944 (fringe rate 33.5%); 1% FTE in Y1, 15% FTE in Y2, 20% FTE in Y3	
Taxonomy Lab Staff (2): \$80,923 (fringe rate 27.2%); 50% FTE in Y1 & Y2, 25% FTE in Y3	
Lab and Field Technicians (4): \$160,457 (fringe rate 27.2% for 3, 33.5% for 1); cumulative 95% FTE in Y1, 145% FTE in Y2, 70% FTE in Y3	
Graduate Research Assistant: \$123,278 (fringe rate 15% and tuition reimbursement); Y1: 50% AY, 30% SUM; Y2: 50% AY, 100% SUM; Y3 100% SUM	
Professional/Technical/Service Contracts:	\$ 30,000
St. Croix Watershed Research Station, sediment isotope dating, 10 cores*\$3,000 per core	
Equipment/Tools/Supplies:	\$ 9,600
Computer lab supplies and software (\$1,800): Computer and mapping-software/license \$500 (statistical package updates, website annual fees, Google Analytics license), hardware \$1,000 (server)	
Lab/field supplies (\$4,000): sediment containers \$600, reagents \$1,500, crucibles \$100, slides and prep material for \$1,200, disposables \$600	
Invertebrate lab supplies (\$3,800): ultrasonic cleaner \$500, slides 2,500 @ \$0.15 ea = \$375, cover slips 20,000 @ \$0.07 ea = \$1,400, mounting media + vials, sieves, forceps, preservative, gloves \$1,320, 4 Bogorov counting troughs \$200	
Acquisition (Fee Title or Permanent Easements):	\$ -
Travel:	\$ 11,424
Project personnel travel between Duluth and Twin Cities to confer with project collaborators and with personnel in agencies that may have water quality data (\$2,244): 4 trips per year 325 mi RT x \$0.545=\$177 + \$10 vehicle rent fee x 4 trips = \$748 * 3 yrs	
Field work for two people (\$5,993): coring excursions yrs 1-2, \$1,315 vehicle (2,000 mi*\$0.545=\$1,090 + \$225 truck & trailer rent fee(\$15/day*15 days)): \$1,530 per diem (\$51/day fed rate meals*15days*2), \$2548 lodging (\$91/night fed rate*14 night*2), snowmobile support incl fuel \$600 (\$40/day*15)	
Water Resources Conference, MSP (\$3,187): Conference attendance to present research. yr 3, 3 days for 4 ppl-lodg: \$145 fed rate*2 night* 4 rooms = \$1,160, meals \$64 full day+\$48 for 2 partial days*4 people=\$640, transp 325 mi RT*\$0.545=\$177+\$10 vehicle rent fee=\$187, registration \$300 ea*4 people=\$1,200.	
Additional Budget Items:	\$ 600
FedEx-expedited mailing (\$600) rapid mail of subsamples for analysis	
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND \$ REQUEST =	\$ 782,549

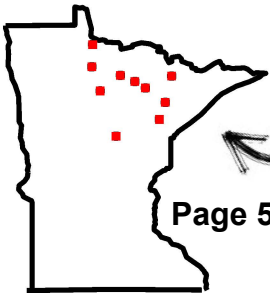
V. OTHER FUNDS

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:	\$ -	N/A
MN Department of Natural Resources: MN DNR Fisheries Research Supervisor Peter Jacobson will provide 100 hours of in-kind support of this project each year for 3 years (\$55/hr; \$5,500 annually; \$16,500 total). Mr. Jacobson will provide advice on lake selection and existing temperature and fish data, and will also participate in model development and developing management recommendations to protect coldwater fish habitat.	\$ 16,500	Secured
NRRI unrecovered indirect: 54% on modified total direct costs (\$752,115 base; excludes grad student tuition reimbursement)	\$ 406,142	Secured
Past and Current ENRTF Appropriation:	\$ -	N/A
Other Funding History:	\$ -	N/A

CONSERVING LAKE TROUT IN MINNESOTA



The problem: environmental stress is causing a loss of coldwater fish



Through this project we will:
...determine which lakes can be saved through watershed management

...enact management practices to conserve oxygen and fish (e.g. focused nutrient reduction)

PROJECT TITLE: Conserving Lake Trout in Minnesota

LCCMR 2019 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; Dr. Bill Herb, an expert in aquatic habitat modeling and forecasting; 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.B. Edlund, N.A. Andresen, D.R. Engstrom, P.R. Leavitt, S. Schottler, M. Cai. 2018.

Paleolimnology of the Lake of the Woods southern basin: continued water quality degradation despite lower nutrient influx. *Lake and Reservoir Management* (in press).

Reavie, E.D., G.V. Sgro, L.R. Estep, A.J. Bramburger, R.W. Pillsbury, V.L. Shaw Chraïbi, M. Cai, C.A. Stow, A. Dove. 2017. Climate warming and changes in *Cyclotella sensu lato* in the Laurentian Great Lakes. *Limnology and Oceanography* 62: 768-783.

Alexson, E.E., E.D. Reavie, R.P. Axler, S.V. Yemets, M.B. Edlund, R.W. Pillsbury, D. Desotelle. 2018.

Paleolimnology of a freshwater estuary to inform Area of Concern nutrient delisting efforts. *Journal of Paleolimnology* 59: 373-395.

Reavie, E.D., M. Cai, M.R. Twiss, H.J. Carrick, T.W. Davis, T.H. Johengen, D. Gossiaux, D.E. Smith, D.

Palladino, A. Burtner, G.V. Sgro. 2016. Winter-spring diatom production in Lake Erie is an important driver of summer hypoxia. *Journal of Great Lakes Research* 42: 608-618.

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*. NRRRI scientists have extensive experience in managing large, interdisciplinary projects. Major objectives include the development of tools for environmental assessment and resource management. NRRRI'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.