Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-297

Proposal Title: Increasing Fish Habitat and Water Quality in Lakes

Project Manager Information

Name: James Cotner

Organization: U of MN - College of Biological Sciences

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Project Basic Information

Project Summary: Many lakes and ponds in Minnesota are increasingly lacking dissolved oxygen which leads to water quality and fish habitat problems. We will examine the effectiveness of a commercial mitigation system.

ENRTF Funds Requested: $616,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Water (B)

Project Location

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

Statewide

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

Statewide

When will the work impact occur?

During the Project

Narrative

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

Lakes and ponds are experiencing increased depletion of dissolved oxygen (DO). There are many causes, including how humans alter the landscape and how a warmer climate and a longer growing season impacts lakes.. Eutrophication is an important cause of DO loss particularly in agricultural and urban settings. Excess nutrients fuel growth of plants and algae which deplete DO when they decompose. Climate change also contributes to DO loss because it causes lakes and ponds to stratify for longer periods of time, cutting deeper waters off from oxygen that is in the atmosphere. Decreasing DO in deep, cold regions of lakes is particularly problematic for some of our most treasured fish species, such as cisco and lake trout, because they need cold water habitat with high DO levels. Furthermore, both eutrophication and longer stratification lead to increased methane production and our research has shown that methane oxidation consumes significant quantities of DO. Therefore, methane accentuates the DO problem in shallow and deep lakes. Furthermore, methane is an important greenhouse gas that is 80 times more effective than carbon dioxide at warming our planet. If we could develop tools to remove methane and add DO, we could essentially solve

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

Here, we will examine the effectiveness of a lake deployable system that will remove methane and add oxygen. The Reduction of Aquatic Methane (RAM) system developed by Floating Island International can cost-effectively remove methane while adding DO using a rapid pumping system that enables aeration of deep water without warming it up. Deep water is brought to the surface where turbulence enables the exchange of gases between the water and the atmosphere, removing methane while adding DO. While this process allows some methane release into the atmosphere, by delivering DO to bottom waters it enables the proliferation of methanotrophic bacteria that consume methane and convert it to carbon dioxide. While carbon dioxide is also a greenhouse gas, as mentioned previously, it is much less effective at warming the atmosphere, leading to a reduction of the impact of aquatic systems in terms of warming our planet. Through this process, we will also increase habitat for cold water fish species. In the work proposed here, we will examine the effectiveness of RAM in two intensively studied Minnesota lakes, one shallow and the other one a deep lake with great fish diversity. Both lakes are extensively instrumented which will enable effective evaluation RAM.

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?

Loss of DO is increasingly problematic in many of our lakes and we need tools to address this problem. This project will evaluate a tool that is relatively inexpensive for both aerating bottom waters and decreasing methane both within the lakes and that released to the atmosphere. If effective, this technology could be used in water management districts across the state. In addition, we will evaluate the potential utility of this system in shallow lakes and ponds including stormwater systems which are incredibly abundant in the state with well over 30,000 of them.

Activities and Milestones

Activity 1: Evaluate the capacity of a methane mitigation system to add oxygen and increase fish habitat in shallow lakes

Activity Budget: $400,000

Activity Description:
Our objective is to determine the extent to which the RAM system can minimize both methane production and DO losses in lakes. The tasks involved with this activity include a) evaluating methane production and DO losses due to methane oxidation prior to and after deploying the RAM system in a shallow lake and b) a deep lake; and c) quantifying the relative abundance of both methanogenic bacteria, which are the primary producers of methane, and methanotrophic bacteria, which are the primary consumers of methane. We will quantify the accumulation of methane and DO loss by measuring the concentrations of these gases seasonally both before and after deployment of the RAM system. Most methane is produced at the bottom of lakes where there is no DO, and most of DO comes from the atmosphere and the surface of lakes where photosynthesis, which produces DO, is highest. The loss of DO with depth in the water column is due to aerobic respiration and methanotrophy and we will quantify both of these processes. We will quantify changes in the relative abundance of both methanogens (which produce methane) and methanotrophs (which consume methane) using quantitative PCR methods.

Activity Milestones:

Description	Approximate Completion Date
Quantify DO consumption via methane oxidation in deep and shallow lakes before RAM deployment	June 30, 2027
Quantify methanogen abundance in the deep and shallow lake prior to RAM deployment	June 30, 2027
Quantify methanotroph abundance in the deep and shallow lake before RAM deployment	December 31, 2027
Quantify DO consumption via methane oxidation in deep and shallow lakes after RAM deployment	June 30, 2029
Quantify methanogen abundance in the deep and shallow lake after RAM deployment	June 30, 2029
Quantify methanotroph abundance in the deep and shallow lake after RAM deployment	June 30, 2029

Activity 2: Determine how effective the RAM system is in decreasing methane losses to the atmosphere

Activity Budget: $191,000

Activity Description:
Our objective is to determine if the RAM system is able to mitigate losses of methane to the atmosphere. The tasks involve measuring the fluxes of methane from the lake to the atmosphere in both shallow and deep lakes before and after deployment of the RAM system. We will measure fluxes via two mechanisms. In both the proposed shallow lake and the deep lake, we will use a method whereby we determine how much methane concentrations increase in a closed chamber that is deployed over the water surface when we sample the lakes. The advantage of this method is that it allows us to determine fluxes over short time intervals and in specific habitats, i.e., over plants, in deep vs. shallow regions, etc. The disadvantage is that it does not tell us what is happening when we are not there, such as in the nighttime. In both of our study lakes, we also have capabilities to deploy an eddy covariance system which measures the fluxes of methane from the lake over longer time spans and therefore gives us a more integrative perspective of when and how much methane is lost from the lake.

Activity Milestones:

Description	Approximate Completion Date

Quantify atmospheric methane fluxes during seasonal sampling prior to deployment of the RAM system	June 30, 2027
Quantify shallow lake methane fluxes to the atmosphere continuously using an eddy covariance system	June 30, 2028
Quantify deep lake methane fluxes to the atmosphere continuously using an eddy covariance system	June 30, 2029

Activity 3: Sustained community engagement for testing site selection and result dissemination

Activity Budget: $25,000

Activity Description:

Ultimately adoption of new technologies requires buy-in from technology users, which can be supported through early engagement during the design, development, and evaluation phases. To this end, an important part of this project will be creating bi-directional communication pathways with Minnesota communities to engage with individuals as the team prepares to test the RAM systems, gather questions and concerns from the community members, and share information about the RAM systems from a process and outcomes perspective, including dissemination of project results throughout the process. To achieve these efforts, the research team will work with Freshwater, a Minnesota non-profit with a mission to inspire and empower people to protect and preserve Minnesota's waters. Freshwater has over 50 years of experience connecting Minnesota communities with cutting-edge aquatic science research in Minnesota and is a trusted voice within public agencies, local units of government, and many Minnesota communities. Freshwater will lead the efforts of developing community engagement materials for the project, facilitating conversations with important parties (such as regulatory bodies, lake associations, and shoreline landowners), and disseminating project results.

Activity Milestones:

Description	Approximate Completion Date
Develop community engagement materials to communicate about project to potential technology users	June 30, 2027
Support research team in permitting process with appropriate regulatory groups as needed	June 30, 2027
Disseminate project findings back to community audiences to empower data-based decisions making on technology adoption	June 30, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Timothy Griffis	University of Minnesota-Twin Cities	Co investigator. Griffis will be responsible for measuring the concentrations and fluxes of both carbon dioxide and methane from the lakes in our study. He will also be responsible for developing and implementing the model for quantifying these fluxes at a statewide level.	Yes
Trinity Hamilton	University of Minnesota-Twin Cities	Co investigator. Hamilton will be responsible for quantification of methanogens and methanotrophs and the genomics components of the research.	Yes

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 work be funded?

The infrastructure for this project comes from two National Science Foundation grants (approximately $500,000 for one and the other is ongoing $100,000 per year). We have purchased most of the equipment but we will build the RAM system in this project (approximately $25,000) that will be used in both of our study lakes. If successful, this infrastructure can used throughout the state, particularly on lakes, ponds and wetlands that have considerable anoxia (low to no oxygen conditions).

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Climate Change and Management Effects on Methane Cycling in Lakes	M.L. 2024, , Chp. 83, Art. , Sec. 2, Subd. 04c	$540,000
Supporting Minnesota Teachers to Implement Culturally Sustaining Environmental Education	M.L. 2024, , Chp. 83, Art. , Sec. 2, Subd. 05c	$295,000

Project Manager and Organization Qualifications

Project Manager Name: James Cotner

Job Title: Professor

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

Cotner has forty years of experience studying freshwater ecosystems and conducting research on the organisms and chemistry in those systems. He has trained students at all levels from undergraduates to PhDs and post-doctoral fellows. His lab is uniquely qualified to do both the field work and the laboratory work that is proposed for this project. Furthermore, for this project we will take advantage of two National Science Foundation funded projects that has equipped three of our field station lakes and multiple Twin Cities lakes with state-of-the-art instrumentation for quantifying greenhouse gas fluxes from lakes, with a focus on carbon dioxide, methane, and nitrous oxide.

In our research group, we try to understand how bacteria, cyanaobacteria and dissolved organic matter affect biogeochemical processes in aquatic systems. Microbes are incredibly important to ecosystem processes because of the great magnitude of their biomass and their diverse modes of metabolism (aerobic, anaerobic, sulfate reduction, methanogenesis, iron reduction, sulfide oxidation, metal oxidation, photosynthesis). Because of this diversity of function, bacteria have significant impacts on the geochemistry and nutrient composition of lakes, rivers and oceans. Where these processes are particularly relevant to the work we are proposing here is that many of these microbes

compete with each other for the organic carbon provided by algae and other aquatic plants growing in lakes as well as the carbon coming from terrestrial systems. Some of the microbes convert organic carbon to carbon dioxide when they metabolize it and others produce methane. Which process is dominant clearly is important because methane has 25-40 times the global warming potential of carbon dioxide.

Organization: U of MN - College of Biological Sciences

Organization Description:
University of Minnesota-College of Biological Sciences; Department of Ecology, Evolution and Behavior. Prepares students for work and training in the biological and environmental sciences. The College of Biological Sciences is one of the only colleges dedicated to the biological sciences in the country. Research in the college spans the breadth of the discipline from ecology to biophysics to microbiology. The mission of the College of Biological Sciences is to deliver cutting-edge, internationally recognized research and teaching at all levels of biological organization from molecules to ecosystems. While preparing today's students to create the biology of tomorrow, CBS promotes collaborative research within and beyond the University to advance knowledge and find solutions that improve human health and the environment locally, nationally, and globally.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Cotner/Professor		Lead the project			37%	0.06		$32,000
Griffis/Professor		Co-Investigator			37%	0.06		$38,000
Hamilton/Professor		Co-Investigator			37%	0.06		$31,000
To be determined/Post-doctoral investigator		Oversee field operations and data collection			25.9%	2		$211,000
Graduate student/academic year		Collect and process samples, analyze data			98.6%	0.76		$52,000
Graduate student/summer		Collect samples, analyze samples, analyze data			23.2%	0.26		$32,000
Undergraduate/Summer and academic year		Assist with sample collection and processing			0%	0.3		$19,000
Milliren/Technician		Maintain sensors and equipment for in lake and atmospheric measurements			36.6%	0.12		$14,000
							Sub Total	**$429,000**
Contracts and Services								
Freshwater	Service Contract	They will oversee outreach and permitting processes				0.4		$25,000
University of Minnesota Genomic Center	Internal services or fees (uncommon)	Sequencing related to quantifying methanogens and methanotrophs in study systems.				0.3		$16,000
							Sub Total	**$41,000**
Equipment, Tools, and Supplies								
	Tools and Supplies	Filters, reagents, field supplies (bottles, sampling devices)	These supplies will enable us to collect samples and analyze them for nutrients and gases					$48,000
							Sub Total	**$48,000**
Capital Expenditures								
		In lake aeration system for mitigating methane	This system will be deployed in our two study lakes to determine	X				$70,000

			their effectiveness in alleviating low oxygen conditions					
							Sub Total	**$70,000**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	9 trips to northern MN (ca 545 miles each trip), two people and $65/night for 11 nights)	field work at Itasca Biological Station and surrounding areas					$15,000
							Sub Total	**$15,000**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Two conference trips per year ($500 per flight, $800 registration, 6 days per diem $1050)	Present results of project					$7,000
							Sub Total	**$7,000**
Printing and Publication								
	Publication	Page charges	Publishing results from project					$6,000
							Sub Total	**$6,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$616,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Expenditures		In lake aeration system for mitigating methane	This equipment is required since we are testing its capability to mitigate methane accumulation. **Additional Explanation :** This system can be deployed in other lakes once the project is completed.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	University of Minnesota-Twin Cities	Indirect costs associated with the requested funds in this proposal	Secured	$284,000
			Non State Sub Total	**$284,000**
			Funds Total	**$284,000**

Total Project Cost: $900,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 187ef41a-496.pdf

Alternate Text for Visual Component

Diagram showing how RAM (Reduced Aquatic Methane) functions. Cold, deep water is brought to the surface, aerated and returned to the bottom of the lake without significant heating of the water. High dissolved oxygen inhibits methane production....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Authorization to submit from Sponsored Projects	db5e4689-153.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

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

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?

Yes, Sponsored Projects Administration

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

Launa Shun, College of Biological Sciences

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

Yes, I understand