Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-255

Proposal Title: Restoring Lakes and Mitigating Our Changing Climate

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: $565,000

Proposed Project Completion: June 30, 2030

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, especially eutrophication and a warming climate which increases respiration rates that consume DO but also increases stratification duration, cutting off the bottom portion of lakes off from the atmosphere, a critical important source of oxygen. 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 because the microbes that produce methane are inhibited by DO. Also, our research has shown that methane oxidation consumes significant quantities of DO. Therefore, methane both responds to and accentuates the DO problem in shallow and deep lakes. Methane also accentuates climate change because it is the second most important greenhouse gas, behind carbon dioxide in warming the planet. It actually warms the Earth 80 times more effectively than carbon dioxide. If we could develop tools to remove methane and add DO, we could essentially solve two problems simultaneously.

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 both 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. As mentioned, carbon dioxide is also a greenhouse gas but not as strong as methane, leading to a reduction of the impact of aquatic systems in terms of warming our planet. It also does not consume DO. This process will increase habitat for cold water fish species by adding DO to bottom waters..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.

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 increasing water quality and recreational value through fisheries production. This tool has great potential utility in shallow lakes and ponds including stormwater systems with well over 30,000 of them in our state alone.

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: $270,000

Activity Description:
Our objective is to determine the extent to which the RAM system can increase DO in lakes and ponds. The tasks involved with this activity include a) evaluating DO levels after deploying the RAM system in a shallow lake and b) a deep lake; and c) quantifying DO demand particularly in the deeper regions of lakes and ponds. We will measure DO loss in the lakes by measuring the DO concentration at high frequency before and after deployment of the RAM system. In addition, we will collect water samples to determine how DO demand changes with and without RAM deployment. We anticipate that DO concentrations in deep regions of the lakes will increase due to a) delivery of DO by RAM and b) decreased DO demand. Decreased DO demand is driven by two factors: decreased organic matter (DOM) content and b) decreased methane concentrations. The impact of these results will be to increase the tools available to lake managers for increasing the water quality in lake and pond systems. Outcomes will be evaluated based on the capacity of the RAM system to increase and maintain high DO levels throughout the stratified period in the summer.

Activity Milestones:

Description	Approximate Completion Date
Quantify DO consumption in deep and shallow lakes before and after RAM deployment	June 30, 2029
Quantify dissolved organic matter (DOM) content of lakes before and after RAM deployment	June 30, 2029
Quantify DO concentration in deep and shallow lakes before and after RAM deployment	June 30, 2030

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

Activity Budget: $270,000

Activity Description:
Our objective is to determine how much RAM system is able to decrease methane production and decomposition. Our previous work has demonstrated that methane is an important component of DO demand in lakes where it is abundant. We anticipate that RAM will both decrease methane production because DO inhibits methanogens, and increase methane consumption (oxidation) because oxygen is an ideal oxidant. The tasks involve measuring methane concentrations before and after deployment of the RAM system, quantifying the abundance of microbes that both produce and consume methane and lastly, quantify the amount of methane that escapes the lakes to the atmosphere.. Methane will be measured with mass spectrometry, molecular tools will be used to quantify methane producers and consumers and flux chambers will be used to examined atmospheric exchange. We will evaluate whether the RAM system can a) decrease methane production and accumulation in deep regions of lakes and ponds and b) decrease the release of methane from the lakes to the atmosphere. By comparing observations in this activity with activity 1, we will also be able to determine how much of the oxygen demand in lakes comes from methane.

Activity Milestones:

Description	Approximate Completion Date
Quantify methane concentrations and fluxes before and after RAM deployment in shallow lake	June 30, 2029
Quantify methane producing microbe abundance (methanogens) before and after RAM deployment in shallow lake	June 30, 2029

Quantify methane consuming microbe abundance (methanotrophs) before and after RAM deployment in shallow lake	June 30, 2029
Quantify flux of methane to the atmosphere before and after RAM deployment in shallow lake	June 30, 2029
Quantify methane concentrations and fluxes before and after RAM deployment in deep lake	June 30, 2030
Quantify methane consuming microbe abundance (methanotrophs) before and after deployment in deep lake	June 30, 2030
Quantify flux of methane to the atmosphere before and after RAM deployment in deep lake	June 30, 2030

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, 2029
Support research team in permitting process with appropriate regulatory groups as needed	June 30, 2029
Disseminate project findings back to community audiences to empower data-based decisions making on technology adoption	June 30, 2030

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
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
Jacques Finlay	University of Minnesota-Twin Cities	Assist in site selection and provide background data on potential lakes and ponds to study	Yes

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
Scientific results will be published in scientific journals such as Water Research, Limnology and Oceanography and Ecology. We will also present results at national/international conferences. Data will be published in a permanent repository (University of Minnesota/DRUM). We are also working with Freshwater to lead community engagement and communication efforts to support the successful testing and evaluation of the RAM water treatment systems in Minnesota. Because adoption of new water technologies depends on trust, transparency, and user input, Freshwater will create structured opportunities for bi-directional communication between the research team and Minnesota communities. Lastly, we will work with the MN DNR and the Minnesota Cities Stormwater Coalition to make them aware of our results.

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 examined will be available commercially in several years so that if successful, it will be available for lake management programs to purchase it and use it for water quality remediation. The system is much less expensive to operate than an aeration system, minimizing costs of operation. We have been in contact with individuals at the Minnesota Coalition of Lake Associations about this work and we plan to update them with information about this project during and after the funding has been spent.

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%	0.12		$32,552
Hamilton/Professor		Co-Investigator			37%	0.12		$32,296
Moller/Post-doctoral investigator		Oversee field operations and data collection			25.9%	2		$204,630
Graduate student/academic year		Collect and process samples, analyze data			98.6%	0.76		$83,396
Graduate student/summer		Collect samples, analyze samples, analyze data			23.2%	0.26		$22,565
Undergraduate/Summer and academic year		Assist with sample collection and processing			0%	0.3		$12,240
Milliren/Technician		Maintain sensors and equipment for in lake and atmospheric measurements			36.6%	0.12		$15,065
Finlay/Professor		Site selection/field operations			37%	0.12		$34,902
							Sub Total	**$437,646**
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		$46,824
							Sub Total	**$71,824**
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					$37,030
							Sub Total	**$37,030**
Capital Equipment								
							Sub Total	**-**

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					$9,000
							Sub Total	**$9,000**
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					$3,500
							Sub Total	**$3,500**
Printing and Publication								
	Publication	Page charges	Publishing results from project					$6,000
							Sub Total	**$6,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$565,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

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	Potential	$288,000
Cash	Floating Islands International, Inc.	FII will supply a RAM system to the Cotner Lab for use in this project.	Pending	$75,000
			Non State Sub Total	**$363,000**
			Funds Total	**$363,000**

Total Project Cost: $928,000

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
LCCMR Proposal Approval Letter	75cc28db-35c.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:

Trinity Hamilton, University of Minnesota-Twin Cities, Jacques Finlay, University of Minnesota-Twin Cities

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