Environment and Natural Resources Trust Fund

2024 Request for Proposal

General Information

Proposal ID: 2024-061

Proposal Title: Climate Change and Management Effects on Lake Methane

Project Manager Information

Name: James Cotner

Organization: U of MN - College of Biological Sciences

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Project Basic Information

Project Summary: Rising temperatures and increased precipitation contribute to decreased oxygen and increased methane in Minnesota lakes and wetlands. We will identify impacts on water quality and methane emissions, providing management guidance.

Funds Requested: $599,000

Proposed Project Completion: June 30, 2027

LCCMR Funding Category: Water Resources (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.

Minnesota's freshwaters are our largest natural source of greenhouse gases (GHGs) to the atmosphere with the largest impact coming from methane produced in the smallest lakes and ponds. Most of the methane produced in these systems is converted to less harmful carbon dioxide (CO_2) before escaping to the atmosphere. Methane warms the atmosphere 25-80 times more than CO_2 and methane conversion to CO_2 requires oxygen. Thus, oxygen is not only critical to the health of ecosystems and our iconic fish species, but also to minimizing GHG production by reducing methane.

Eutrophication is an important cause of low oxygen, but climate change is making freshwaters warmer, and warmer water holds less oxygen than cooler water. Climate change is also increasing the delivery of nutrients and organic matter to lakes via increased precipitation, a phenomenon called 'browning'. Browning increases eutrophication, oxygen depletion, and methane production. Thus, not only will there be less habitat for cold-water fish but contributions of freshwaters to GHGs may rise steeply with both warming and increased precipitation. Efforts to manage Minnesota's greenhouse gases require fundamental information about current rates of production in freshwaters and how they will respond to both climate and human impacts, including lake management.

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.

We seek funding to inform management of lakes under a warmer climate. First, we will gather information to understand how increasing methane impacts water quality in deep lakes that provide a climate refuge for coldwater fish. Deep, colder conditions allow more methane to be converted to CO_2. Due to climate warming, many deep lakes that provide important refuge for cold-water fish species are stratifying longer which means more oxygen is consumed with less available for fish. We will determine which lakes are most vulnerable to decreased oxygen from methane consumption and determine how climate change (warming, longer stratification and increased precipitation) is likely to affect this process in the future.

Second, we provide information on how lake management can be used to reduce methane production. Small lakes and ponds have a disproportionately large effect on methane release to the atmosphere. They are under intensive management in both agricultural and urbanized areas to control nutrients and improve water clarity. These management efforts are likely to reduce methane, providing a large, yet unmeasured, benefit from water quality management investments. As the state seeks ways to reduce its total GHG emissions, information on effects of lake management on methane will be essential.

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?

We will determine how climate change induced phenomena, browning, lake stratification and warming are affecting methane concentrations and, in turn, how methane concentrations are affecting water quality, i.e., oxygen concentrations. Increases in oxygen demand due to high methane concentrations will have further negative impacts on water quality by mobilizing phosphorus and nitrogen in sediments which should increase nutrient availability and algal blooms, an amplification effect. Lastly, we will model the release of methane from ponds and lakes in Minnesota, an important, but presently unquantified flux needed to inform better policy and management decisions for both eutrophication and climate change.

Activities and Milestones

Activity 1: Determine how increasing duration of stratification is affecting methane production, oxygen demand and methane release from Minnesota lakes

Activity Budget: $227,000

Activity Description:
We will answer these questions: 1) Are Minnesota lakes stratifying for longer periods of time due to climate change? 2) If so, does that mean that there is less dissolved oxygen, especially in the bottom waters of these lakes due to methane? And 3) What proportion of the oxygen that is consumed in bottom waters of lakes is due to methane oxidation? We have lake monitoring systems in three different Minnesota lakes that will be used to quantify stratification duration, methane and dissolved oxygen concentrations and fluxes. Each of the lakes is equipped to monitor physical, chemical and biological conditions in the lakes and the atmosphere above the lakes at high frequencies. Also, we will work with a set of lakes monitored by the Minnesota DNR (Sentinel Lakes) and another set of over 100 diverse ponds and lakes monitored via the Twin Cities LTER (NSF) to measure these similar parameters but at lower frequencies. We will incorporate methane oxidation into a pond assessment tool, developed for evaluating risk of low oxygen and excess phosphorus, a key control over eutrophication and methane production, to predict the occurrence of anoxia in ponds and small lakes to better manage phosphorus release from sediments.

Activity Milestones:

Description	Approximate Completion Date
Determine how length of stratification is changing in Minnesota lakes and ponds	June 30, 2026
Determine how oxygen levels are changing in Minnesota lakes and ponds especially in bottom waters	June 30, 2026
Determine the proportion oxygen that is being consumed by methane oxidation in Minnesota lakes	June 30, 2027

Activity 2: Determine how browning and light levels affect methane production, oxygen demand and methane release from Minnesota lakes

Activity Budget: $165,000

Activity Description:
Browning is due to the movement of colored dissolved organic compounds from the land to lakes. A lot of it makes water look like tea or coffee. Increasing concentrations of these compounds in freshwaters is occurring globally and is thought to be amplified by climate change via increased precipitation and increased terrestrial plant production. These processes lead to more organic matter in soils and more of it transported to freshwaters. Unfortunately, colored compounds absorb light, essentially 'stealing' it from photosynthetic plants and algae. Light is particularly important in deeper, stratified lakes because, through photosynthesis, it can generate oxygen in deep regions that do not have contact with the atmosphere. Using lakes in Activity 1, we will answer these questions: 1) Is lake browning leading to decreased light in our lakes? 2) Do lower light levels lead to decreased dissolved oxygen and increased methane in lakes? And 3) what proportion of the oxygen consumed in the deep-water region of stratified lakes comes from photosynthesis? We will measure light levels and model photosynthesis in stratified systems. Using lake morphometry, photosynthesis and methane oxidation data, we will determine how important photosynthesis is to methane oxidation and identify Minnesota lakes most vulnerable to browning.

Activity Milestones:

Description	Approximate Completion Date
Determine whether light levels contribute significant oxygen to the deep region of Minnesota lakes	June 30, 2026

Determine effects of browning on light levels in Minnesota lakes and ponds	June 30, 2027
Determine whether decreased light levels lead to decreased dissolved oxygen in deep regions of lakes	June 30, 2027

Activity 3: Model the release of greenhouse gases from Minnesota lakes to inform the MPCA

Activity Budget: $207,000

Activity Description:

To better apply the results from the above activities, we will develop a model to simulate methane production and emission from lakes and wetlands. This tool does not currently exist and would be extremely valuable to managers and policy makers. The model will be calibrated with data collected in this study. Key aspects of the model that we will develop are to better understand how aquatic systems are responding to a changing climate. Specifically, we will focus on the importance of browning, floods, warming temperatures, decreased ice cover in the winter along with more precipitation in winter as rain rather than snow. Lastly, the importance of extreme precipitation events to methane production, oxidation and release from Minnesota's aquatic systems will be examined. We will scale results up so that we can quantitatively estimate the role of lakes in the Minnesota carbon dioxide and methane budgets. The Minnesota Pollution Control Agency has expressed interest in this and we will work closely with them to match their needs for a state-wide methane budget. Their current estimates indicate that inland waters are second only to crop and animal agriculture in terms of emissions in the Agriculture, Forestry and Land use sector.

Activity Milestones:

Description	Approximate Completion Date
Use data to model how Minnesota lakes and ponds are responding to browning and warming	June 30, 2026
Determine how Minnesota lakes are responding to increased precipitation and longer stratification	June 30, 2026
Scale model results of methane fluxes up to the entire state of Minnesota	June 30, 2027

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
Jacques Finlay	University of Minnesota-Twin Cities	Co investigator. Finlay will be responsible for making field measurements on the physical and chemical characteristics of the lakes and ponds that are part of the Twin Cities LTER-NSF funded project. He will insure that the parameters for this study are adequately sampled and measured.	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 $1,000,000 per year). We have purchased all equipment and built and deployed monitoring buoys in the three focal lakes. One of the eddy covariance systems for quantifying the carbon dioxide and methane fluxes from these systems is in place at Cedar Bog Lake and Lake Itasca and another one will be deployed this spring/early summer. We anticipate operating these systems well into the future and are in the process of securing funding to do so.

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			27%	0.06		$15,000
Griffis/Professor		Co-Investigator			27%	0.06		$17,000
Finlay/Professor		Co-Investigator			27%	0.06		$15,000
Yuan/Post-doctoral investigator		Development of lake methane model			20%	2		$146,000
Graduate student/academic year		Collect and process samples, analyze data			51%	0.57		$71,000
Graduate student/summer		Collect samples, analyze samples, analyze data			20%	0.39		$29,000
Undergraduate/Summer and academic year		Assist with sample collection and processing			0%	0.3		$11,000
Civil service/2 technicians		Maintain sensors and equipment for in lake and atmospheric measurements			24%	1.17		$110,000
Research associate		Field supervisor and technician			27%	0.81		$83,000
							Sub Total	**$497,000**
Contracts and Services								
University of Minnesota Agriculture Research Services	Internal services or fees (uncommon)	Nutrient and carbon analyses				0		$16,000
							Sub Total	**$16,000**
Equipment, Tools, and Supplies								
	Equipment	In lake methane sensors	These will enable quantifying methane in our study lakes					$18,000
	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					$39,000
							Sub Total	**$57,000**
Capital Expenditures								
							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 $30/night for 11 nights)	field work at Itasca Biological Station and surrounding areas					$13,000
							Sub Total	**$13,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		Instrument repair	Instruments need recalibration and occasional repair due to wear and tear in the environment					$16,000
							Sub Total	**$16,000**
							Grand Total	**$599,000**

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	Secured	$304,000
			Non State Sub Total	**$304,000**
			Funds Total	**$304,000**

Attachments

Required Attachments

Visual Component

File: d6a77f35-c7c.pdf

Alternate Text for Visual Component

We show that methane can consume a lot of oxygen in lakes and ponds. In lakes where there is little to no oxygen, more of the methane escapes to the atmosphere. Therefore, it is important to manage lakes and ponds to have lots of oxygen....

Optional Attachments

Support Letter, Photos, Media, Other

Title	File
SPA letter	30251a76-b85.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

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 design, construction, or renovation of a building, trail, campground, or other capital asset costing $10,000 or more?

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?

No