Environment and Natural Resources Trust Fund

2023 Request for Proposal

General Information

Proposal ID: 2023-190

Proposal Title: Managing Lakes for Our Future

Project Manager Information

Name: James Cotner

Organization: U of MN - College of Biological Sciences

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Project Basic Information

Project Summary: Minnesota Lakes are a major source of greenhouse gases, but the amounts of these gases coming from them is unknown. We will fill this gap and determine the causes.

Funds Requested: $545,000

Proposed Project Completion: June 30, 2026

LCCMR Funding Category: Air Quality, Climate Change, and Renewable Energy (E)

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.

Aquatic ecosystems are one of the largest natural sources of greenhouse gases (primarily carbon dioxide and methane) to our atmosphere. In fact, freshwater lakes and wetlands release over 30% of all methane released to the atmosphere each year and over half of all natural methane sources. Methane is particularly important because it is 28 times more effective at warming the atmosphere than carbon dioxide. A third greenhouse gas, nitrous oxide, is also released from lakes and it is 300 times stronger than carbon dioxide in terms of its warming potential.

While the gases released from freshwaters are important to our changing climate, they are, somewhat paradoxically, also affected by the climate that they are changing. Warming temperatures, increased intensity of flooding, increased drought duration and intensity and longer ice-free conditions all will affect the production and exchange of greenhouse gases with the atmosphere. Increased losses of carbon dioxide and methane will enhance regional climate warming and impact the water quality and carbon balance of these lakes.

But this challenge is also an opportunity. Importantly, our results will provide the Minnesota PCA and the data they need to make predictions about these changes.

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.

To fix problems, we need the right tools. In the case of climate change, we need to know where most of the greenhouse gases are coming from so that we manage them for reductions. There are efforts in Minnesota to quantify the amount of greenhouse gases released from agricultural systems, peatlands, and fossil fuels, but not lakes. The main goal of this project is to provide a tool for managers to adaptively manage lakes to minimize greenhouse gases. For instance, we know that increased nutrients can lead to more methane production in most lakes, but if we knew how much we could make better choices about how much of those nutrients should be used in the watershed. Similarly, if we knew the effects of floods and droughts on greenhouse gases, we might be able to mitigate their impact.

We need to understand what climate processes have the most important impacts on greenhouse gas fluxes from lakes and wetlands and how much. We will study greenhouse gas exchange with the atmosphere at daily, annual and interannual time scales and build a model that will allow us to predict the effects of the changing climate on lake-greenhouse gas exchange.

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?

The Minnesota PCA recently added lakes to their accounting of statewide greenhouse gas emissions and the amounts are substantial, equivalent to that required to heat our homes. But the tools that the PCA is using to estimate greenhouse gas exchange are based on data from other parts of the world and not Minnesota. We will provide a model that can be used for better policy and management decisions. We have discussed this issue with scientists from the PCA and they enthusiastically endorse the work we are proposing.

Activities and Milestones

Activity 1: Determine how greenhouse gases in lakes respond to floods, droughts, warming and other events

Activity Budget: $173,500

Activity Description:
We have lake monitoring systems in three different Minnesota aquatic systems that will be used to examine how they respond to changes in weather and climate. Each of the lakes is equipped to monitor physical, chemical and biological conditions both in the lakes and in the atmosphere above the lakes at high frequencies. This will make it possible to determine how in-lake processes are affecting the amount of carbon dioxide, methane and nitrous oxide that is released to the atmosphere. The parameters measured in the lakes include temperature, pH, dissolved oxygen, conductivity, dissolved organic matter, algal biomass (chlorophyll), and dissolved carbon dioxide concentrations. In addition, we have state-of-the-art instrumentation that enables us to quantify the fluxes of carbon dioxide and methane using eddy covariance instrumentation. Lastly, we have other tools that can measure the release of these gases at very small scales so that we can, for instance, determine if certain kinds of plants, such as water lilies or bullrush might be important sources of these gases. Alternatively, during or after episodic events, such as snow melt or large rain events, we would be able to determine how much influence plumes of incoming water affect greenhouse gas fluxes.

Activity Milestones:

Description	Completion Date
Deployment of eddy covariance and in-lake monitoring equipment	May 31, 2024
Water column monthly sampling	February 28, 2026
Quantification of fluxes using eddy covariance system	June 30, 2026

Activity 2: Survey diverse lakes across the state for greenhouse gas exchange with the atmosphere

Activity Budget: $157,500

Activity Description:
We also have technology that will enable us to survey in-lake concentrations of carbon dioxide, methane and nitrous oxide in a variety of lakes across the state and to quantify exchange of these gases with the atmosphere. We can measure the release of those gases in the field using a Fourier-transform mass spectrometer (FTIR) that quantifies greenhouse gas absorbance in the infrared range of the electromagnetic spectrum. In addition, we have a drone that will be deployed over the lakes to collect air samples and measure the concentrations of these gases above the lakes. Lastly, we will measure the concentrations of all three gases in the lake water itself. By coupling these three types of measurements, we will be able to determine both how much gas is produced in the lakes and how much is being released into the atmosphere. We plan to make these measurements in three different regions of the state and in a minimum of ten lakes in each region, in northern forests, in the Twin Cities Metropolitan region and in the southern agriculturally-dominated part of Minnesota. Over the three years of our study, we will make these measurements in all seasons, spring, summer, fall and winter.

Activity Milestones:

Description	Completion Date
Sample and measure exchange in central lakes region	December 31, 2023
Sample and measure exchange in northern lakes region	December 31, 2024
Sample and measure exchange in southern lakes region	June 30, 2026

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

Activity Budget: $214,000

Activity Description:

We will develop a model focused on freshwater systems to simulate greenhouse gas emissions from lakes and wetlands. 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 droughts, floods, warming temperatures, decreased ice cover in the winter along with more precipitation in winter as rain rather than snow, and lastly, the importance extreme precipitation events to methane, carbon dioxide and nitrous oxide release from Minnesota's aquatic systems. We will scale results up so that we can quantitatively estimate the role of lakes in the Minnesota carbon budget. The Minnesota Pollution Control Agency has expressed interest in our work and has provided a letter of support. We will work closely with them to ensure that the work we do matches their needs for a state-wide carbon 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	Completion Date
Quantify CO2, and CH4 fluxes at statewide scale under current conditions	May 31, 2024
Determine the effects of a warming environment on greenhouse gas fluxes for 2050	May 31, 2025
Develop land-surface model that includes lakes	May 31, 2026
Determine the effects of extreme climate such as drought and floods on statewide greenhouse gases	June 30, 2026

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 a grant from the National Science Foundation (approximately $500,000). We have purchased all of the equipment and built and deployed monitoring buoys in the three focal lakes discussed above. 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 the other 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 from multiple funding agencies.

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 a National Science Foundation funded project that has equipped two of our field stations 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:

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								
Professor James Cotner		Project director			11%	0.12		$23,300
C0-investigator Tim Griffis		Measurement and quantification of greenhouse gas fluxes			11%	0.12		$27,200
Post-doctoral fellow		Model development and testing			17%	36		$215,100
Graduate student/Academic year		Sample collection and analyses			53%	1.11		$75,300
Graduate student/summer		Field sample collection and analyses			14%	0.75		$27,600
Undergraduate research assistant		Field and lab assistance			0%	0.6		$15,600
Lab/Field technician		Maintenance of eddy covariance system and data management			22%	0.6		$43,400
							Sub Total	**$427,500**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Equipment	Field methane sensors	To measure CH4 in the lakes					$16,000
	Tools and Supplies	Lab and field supplies	For water analyses and field needs					$56,200
	Tools and Supplies	Equipment repair	To replace damaged field equipment					$25,000
							Sub Total	**$97,200**
Capital Expenditures								
							Sub Total	**-**

Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	4 trips per year, 500 miles per trip, 2 persons, $0.55 per mile	trips to Itasca Biological Station and other field sites					$16,000
							Sub Total	**$16,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Fees for publication	Open access and publishing costs					$4,300
							Sub Total	**$4,300**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$545,000**

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				
			Non State Sub Total	**-**
			Funds Total	**-**

Attachments

Required Attachments

Visual Component

File: 597cf330-162.pdf

Alternate Text for Visual Component

We show pictures of instrumentation that will be used (both in water and in the atmosphere) along with data from the in-water instrumentation. Those data show that CO2 concentrations in Elk Lake were low in the surface water and high in the deep water through summer....

Optional Attachments

Support Letter or Other

Title	File
PCA letter	df3c9ac5-3f1.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?

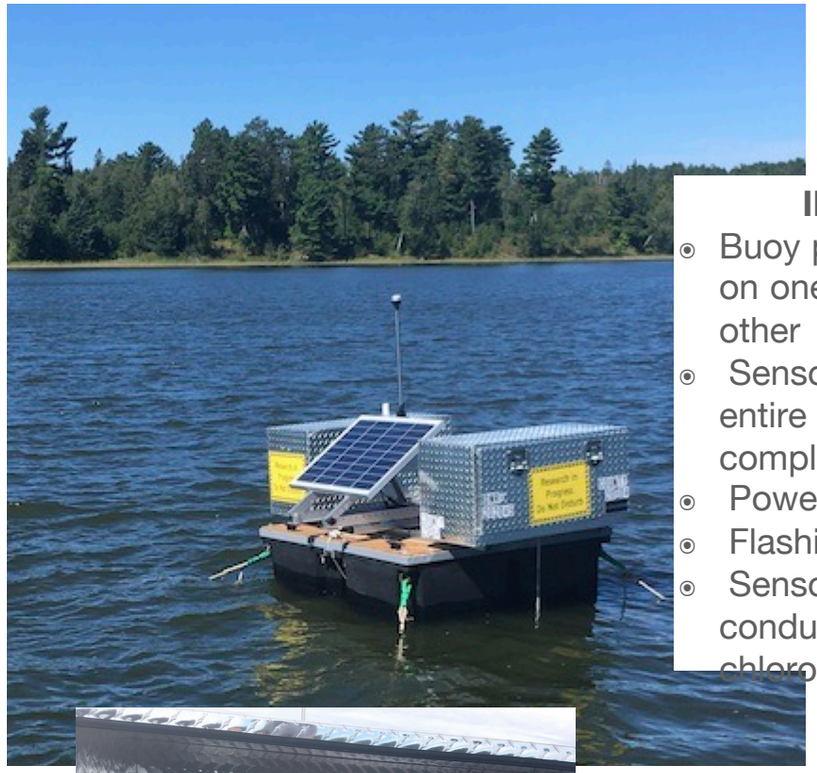
N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No



IN WATER BUOY SYSTEM

- Buoy platform is 4’x4’ with a power case on one side and a reel with motor on the other
- Sensors move up and down through the entire water column providing a complete picture of parameters
- Powered by solar panels
- Flashing lights for safety
- Sensors measure: temperature, pH, conductivity, depth, dissolved oxygen, chlorophyll, CDOM and pCO_2

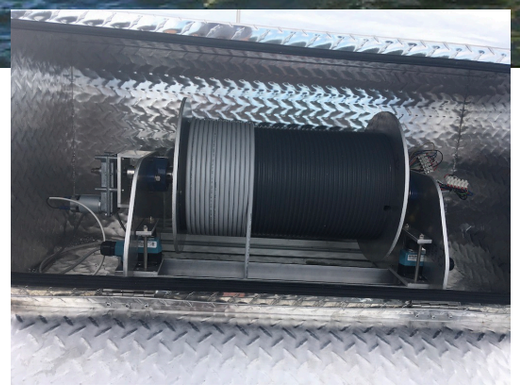
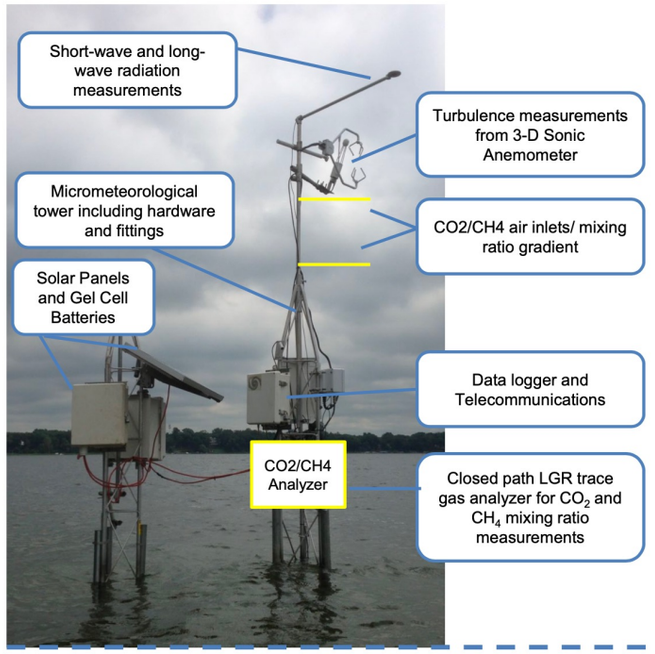


Image showing the motorized cable with communication with the sensors

The FTIR system for measuring CO_2, CH_4 and N_2O. This portable instrument consists of a chamber that floats on the water and the FTIR instrument (yellow instrument in black box).

Flux system

Micrometeorological System for Energy, CO_2, and CH_4 Flux Measurements above Lakes



We will have lights at night for safety.

Note that our ideal location will be on land for Lake Itasca and in shallow water in Elk Lake.

Example of data collected: It shows that carbon dioxide accumulated through the summer