Environment and Natural Resources Trust Fund

2022 Request for Proposal

General Information

Proposal ID: 2022-117

Proposal Title: How do lakes influence Minnesota's carbon budget?

Project Manager Information

Name: James Cotner

Organization: U of MN - College of Biological Sciences

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Project Basic Information

Project Summary: Minnesota has inventoried the major sources of greenhouse gases but lakes have not been included. We will fill that gap by measuring the release of three greenhouse gases from them.

Funds Requested: $499,000

Proposed Project Completion: June 30 2025

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 and In the Future

Narrative

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

Minnesota lakes are impacted by warming temperatures and longer ice-free conditions which impacts exchanges 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. Lakes and wetlands are important sources of greenhouse gases, therefore, they not only respond to ongoing changes in the climate, but they play an important role in determining our future climate. Their responses could either make things worse or better--we just don't know at this point because we do not have high temporal resolution data that would enable understanding lake responses to specific climate phenomena such as storms, droughts and warming events. Either way, these feedbacks have important policy and management implications. We have limited knowledge of the effects of climate change on either the direction (increase or decrease) or magnitude of greenhouse gas production of lakes and we know even less about Minnesota lakes. Importantly, our results will provide the Minnesota PCA and others the critical data they need in their state carbon accounting efforts.

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

The solution to every problem begins with understanding and we currently do not understand how lakes are responding to a changing climate. There are efforts in Minnesota to quantify the carbon budgets of agricultural systems, peatlands, and fossil fuels, but not lakes. If we know how they are responding we should be able to adaptively manage them. 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 take advantage of high temporal resolution instrumentation recently purchased via a federal grant to study three Minnesota lakes to determine how they are responding at daily, annual and inter-annual time scales. We will quantify the production of carbon dioxide and methane in the lakes and the exchange of these gases with the atmosphere. The lakes are at Cedar Creek Ecosystem Science Reserve and in Itasca State Park. We have instruments for measuring physical, chemical and biological parameters along with methane, carbon dioxide and nitrous oxide (the third most important greenhouse gas) fluxes in the lakes and other tools on the surface for measuring the exchange of these greenhouse gases in lakes throughout the state.

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 not trivial, equivalent to that required to heat our homes. But the information that the PCA is using to estimate greenhouse gas fluxes is based on published data that was not collected from Minnesota lakes. The work proposed here will quantify greenhouse gas fluxes to and from Minnesota lakes and enable a full accounting allowing 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 Minnesota lakes respond to episodic weather events and climate drivers

Activity Budget: $166,000

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
Determine how the three lakes are responding to large rain events	June 30 2023
Determine the amount of greenhouse gases released after winter ice out occurs	June 30 2024
Determine the amount of greenhouse gases released after summer stratification breaks down	June 30 2025
Determine how greenhouse gas production responds to drought	June 30 2025

Activity 2: Quantify greenhouse gas fluxes from a diverse set of freshwater lakes

Activity Budget: $150,000

Activity Description:
We also have technology that will enable us to survey in-lake concentrations of carbon dioxide, methane and nitrous oxide in a wide variety of lakes across the state and to quantify the fluxes of these gases into 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 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
Quantify fluxes in lakes in the Itasca region	June 30 2023
Quantify fluxes in lakes in the Twin Cities region	June 30 2024
Quantify fluxes in lakes in the southwest part of the state	June 30 2025

Activity 3: Model the release of greenhouse gases from lakes to inform the PCA and natural system management

Activity Budget: $183,000

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 changing stratification patterns in lakes such as increased duration of summer stratification, decreased ice cover in the winter along with more precipitation in winter as rain rather than snow, and lastly, the importance of droughts and 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 these systems in the Minnesota carbon budget. The Minnesota Pollution Control Agency has expressed interest in our work and will provide a letter of support. We will work closely with them to insure 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
Model the effects of episodic events on greenhouse gas fluxes	June 30 2023
Model the effects of different winter scenarios on greenhouse fluxes in spring	June 30 2024
Model the effects of summer stratification duration on greenhouse gas fluxes	June 30 2025

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Tim Griffis	University of Minnesota-Twin Cities	He will oversee the portion of the project where we will quantify the fluxes of CO2 and CH4 from the lakes and wetland to the atmosphere.	Yes
Lesley Knoll	University of Minnesota-Twin Cities	She will coordinate research efforts at Itasca Biological Station	No

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 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 the other two 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.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Assessing Effectiveness of Wetland Restorations for Improved Water Quality	M.L. 2016, Chp. 186, Sec. 2, Subd. 04u	$420,000

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 in those systems, particularly the microbes. He has trained students at all levels from undergraduates to PhDs and post-doctoral fellows. His lab is uniquely qualified to do this project because our lab group combines field studies along with studies of microbes that are responsible ecosystem processes. This particular project we will take advantage of a National Science Foundation funded project of nearly $500,000 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 they are so numerous and they have 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. We are particularly interested in how variation in microbial metabolism can affect ecosystem dynamics. We have examined microbial and

ecosystem processes in pelagic and benthic habitats, freshwater and marine systems, rivers and lakes and natural and human-dominated systems.

Organization: U of MN - College of Biological Sciences

Organization Description:
University of Minnesota-College of Biological Sciences; Department of Ecology, Evolution and Behavior. Our college is part of a comprehensive university that conducts research, and teaches and trains students. In the College of Biological Sciences, we teach and conduct research on the fundamentals of biology as well as in the area of environmental sciences.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
James Cotner		PI			27%	0.24		$26,000
Tim Griffis		Co-PI			27%	0.24		$30,000
Post Doc tbd		Post Doctoral Associate			20%	2.88		$183,000
Grad Student TBD		Graduate Student			40%	1.5		$88,000
Lab Technician TBD		Lab Technician			24%	3		$45,000
Undergrad Student TBD		Undergraduate Student			0%	0.24		$15,000
							Sub Total	**$387,000**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Tools and Supplies	Lab supplies including filters, chemicals, standards, reagents, and calibration gases	Lab and field supplies					$56,000
	Equipment	2 methane sensors	Used to observe and quantify methane concentrations in two of the lakes (Cedar Bog Lake and Elk Lake). Concentrations in Itasca will have to be measured manually because they are lower.					$16,000
							Sub Total	**$72,000**
Capital Expenditures								
							Sub Total	**-**

Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Seasonal (winter, spring, summer and fall) trips to Itasca and SW Minnesota for 2 people, at 500 miles per round trip, and $0.55 per mile) and 20 nights per year lodging per year (@$30/night at Itasca and $75/night in SW MN).	Sample collection and instrument calibration					$15,000
							Sub Total	**$15,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		Repairs and maintenance	Equipment repair and part replacement. Buoys will need annual maintenance and the multi-probe sondes require servicing at the factory annually. Parts that degrade or break in service will need to be repaired.					$25,000
							Sub Total	**$25,000**
							Grand Total	**$499,000**

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				
In-Kind	Indirect costs associated with this proposal at 55% MTDC.	Indirect costs cover both facilities costs and administrative costs that are incurred by the University of Minnesota when conducting sponsored research, instruction, and public service projects.	Secured	$252,239
			State Sub Total	**$252,239**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**$252,239**

Attachments

Required Attachments

Visual Component

File: 1769ec61-c79.pdf

Alternate Text for Visual Component

Diagram showing the design of buoy (measuring in water parameters) and the eddy flux system for quantifying the exchange of greenhouse gases with the atmosphere and an example of data collected....

Optional Attachments

Support Letter or Other

Title	File
Letter of support from MPCA	93cc0934-850.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

How do lakes influence Minnesota's carbon budget?

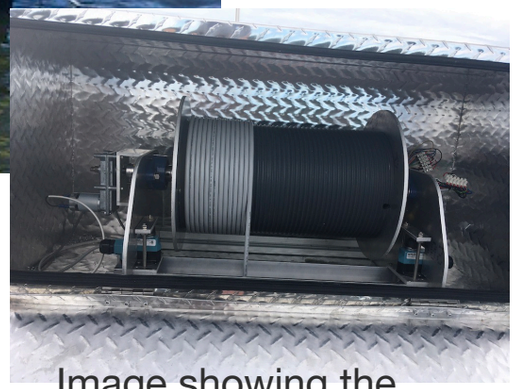


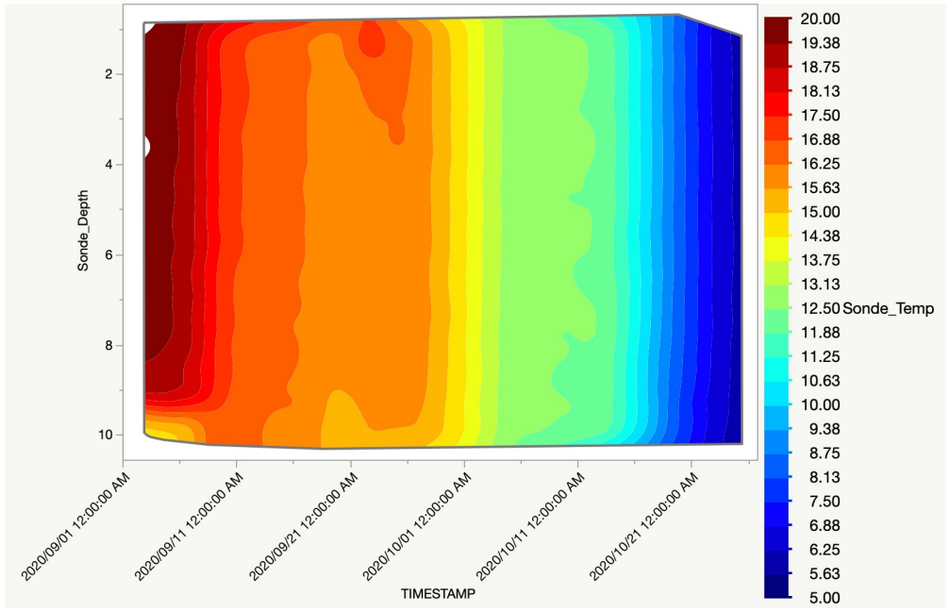
Image showing the motorized cable with communication with the buoy system sensors

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

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 (algae), colored organic matter, and pCO_2 (carbon dioxide)

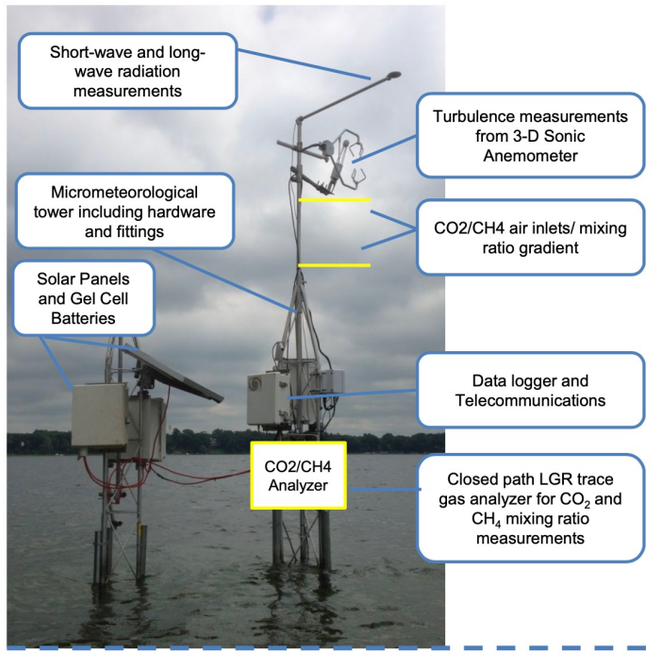
Example of water temperature data collected



Itasca temperature

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.