Environment and Natural Resources Trust Fund
2020 Request for Proposals (RFP)

Project Title: **ENRTF ID: 090-B**

Climate Impacts on Nitrogen Gas Release from Lakes

Category: B. Water Resources

Sub-Category:

Total Project Budget: $ 452,000

Proposed Project Time Period for the Funding Requested: June 30, 2023 (3 yrs)

Summary:

Nitrogen pollution enters lakes and microbes convert some of it to a nitrogen-based greenhouse gas. We will estimate nitrogen emissions in lakes statewide and guide management to enhance nitrogen removal.

Name: Nicole Hayes

Sponsoring Organization: U of MN

Job Title:

Department: Ecology, Evolution, and Behavior

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Location:

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Nitrogen pollution enters lakes and microbes convert some of it to gas. Climate change may affect how much nitrogen gas is made. How much gas is a greenhouse gas?

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Climate impacts on nitrogen gas release from lakes

I. PROJECT STATEMENT

Microbes in lakes, streams, and wetlands (henceforth, water bodies) naturally remove nitrogen (N) pollution by converting dissolved N to gaseous forms (N_2 and N_2O) that are released into the atmosphere. This "exhalation" can permanently remove much of the N that enters wetlands and lakes leading to improved water quality. However, if N_2O gas is produced, there is a negative impact for our climate. **Here we propose to determine how much N gas (N_2 and N_2O) is being produced by a diverse set of Minnesota waterbodies and how much is N_2 vs. N_2O**. N_2O (but not N_2) is a potent greenhouse gas and the amount of N_2O produced relative to N_2 depends on the dominant microbial process and lake conditions such as, nutrient pollution levels, water temperature, and the duration of lake stratification. *Ultimately, we will provide management guidance for enhanced N removal while maintaining low N_2O production in lakes*.

Despite watershed nutrient management, N loads are predicted to increase in the future as a result of a wetter climate and larger storm events. Additionally, climate change may affect the efficacy of microbial N removal by altering lake conditions. For example, water temperature controls the reaction rates of microbial communities and warming temperatures due to climate change could lead to increased microbial reaction rates and therefore increased N gas production. Alternatively, longer growing seasons may prolong stratification, limiting the availability of essential reactants and decrease N gas production. **Our second goal is to assess how climate change will affect N gas production** since it is unclear if larger nutrient loads, longer growing seasons, and warmer summers will enhance or suppress N removal.

This project will provide data about the magnitude of N removal by Minnesota's lakes and wetlands and help predict how N_2O emissions will be affected by a changing climate. With this information we can **update N_2O emissions estimates for Minnesota's waterbodies** and develop a statistical model to predict how it will change with changing land use and climate conditions.

Our project will produce:

1. Management recommendations for low N_2O production and high N removal in lakes responding to a changing climate;
2. Greenhouse gas budgets for N_2O in waterbodies statewide.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Measure N gas emissions (both N_2 and N_2O) from waterbodies.

Emissions of N_2 and N_2O in deep lakes, shallow lakes, and wetlands will likely have variable responses to climate change. **We will measure fluxes of N_2 and N_2O from 40 deep lakes, shallow lakes, and wetlands that are part of the Minnesota Department of Natural Resources (MDNR) Sentinel Lakes program or were restored by the United States Fish and Wildlife Service**. There is historical nutrient data on these sites and the MDNR Sentinel Lakes Program takes high frequency measurements of temperature and stratification. We will sample the lakes during late summer when the deep lakes are likely to be strongly stratified and the shallow lakes and wetlands are warmest. Five sites in each system (e.g. Sentinel Lakes and wetlands) will be sampled seasonally to identify temporal patterns in N gas emissions. We will develop a predictive model of N gas emissions that considers a broad suite of variables, but we will focus on the effects of temperature and stratification to better understand the effects of climate change.

ENRTF BUDGET: $165,100

Outcome	Completion Date
1. Measure N_2O and N_2 gas concentrations in 40 waterbodies throughout Minnesota.	*Fall 2022*
2. A statistical model that relates stratification and water temperature to N gas production.	*Summer 2023*

Activity 2: Measure rates of microbial processes that produce N gas and quantify the effects of water temperature and stratification.

We will measure rates of two microbial processes that produce N_2O, denitrification and nitrification. Denitrification produces N_2 and both nitrification and denitrification produce N_2O. These processes vary in the amount of gas they produce and the environmental conditions they are favored in/inhibited by. *In order to manage waterbodies to increase N removal but not N_2O production, it is necessary to understand when each process is favored and how to control them.* Lab based measurements of nitrification and denitrification are time and labor intensive, so we will focus on sampling a few sites multiple times over a two year period. We will pair these findings with N_2O and N_2 emissions data, and environmental data from the Sentinel Lake program and a previously funded LCCMR project in restored wetlands (J. Finlay, Univ. of Minn.).

ENRTF BUDGET: $195,900

Outcome	Completion Date
1. Dataset of rates of nitrification and denitrification in nine waterbodies seasonally.	*Fall 2022*
2. Management guidance for enhanced N removal while maintaining low N_2O production in lakes.	*Spring 2023*

Activity 3: Model N_2O emissions from lakes across Minnesota.

Using tools developed from previous LCCMR funded projects, specifically state-level estimates of lake bathymetry (J. Nieber, Univ. of Minn.) and water quality (J. Finlay, Univ. of Minn.), **we will develop models to estimate statewide N_2O concentrations in lakes**. Current models only use watershed fertilizer application rates to estimate N_2O and we will improve estimates by incorporating lake specific variables.

ENRTF BUDGET: $ 91,000

Outcome	Completion Date
1. Statewide N_2O emission estimates for waterbodies across Minnesota.	*Summer 2023*

III. PROJECT PARTNERS AND COLLABORATORS:

Project Partners Receiving Funds: Dr. Nicole M. Hayes (Project Manager, University of Minnesota), Dr. James Cotner (Collaborator, University of Minnesota), Dr. Jacques Finlay (Collaborator, University of Minnesota), Sarah G. Winikoff, M. Sc. (Collaborator, University of Minnesota), Brianna Loeks-Johnson, M. Sc. (Collaborator, University of Minnesota), Erin Mittag (Collaborator, University of Minnesota)

IV. LONG-TERM IMPLEMENTATION AND FUNDING:

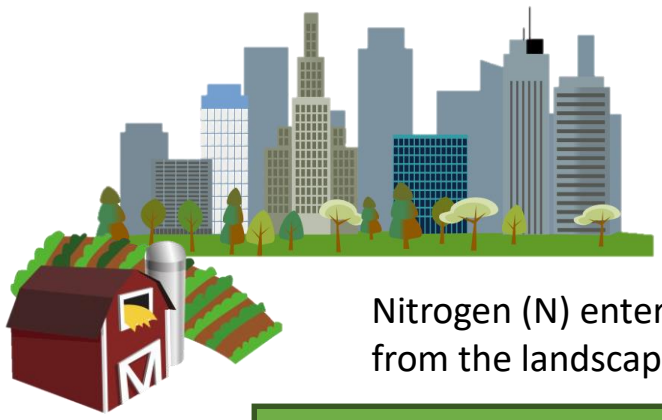
This research will inform water quality management decisions by providing valuable data about the magnitude of current N removal by water bodies and help identify how climate change will affect removal rates and N gas production. Our findings can be used to make management recommendations to enhance N removal while minimizing greenhouse gas production. We will also generate emission estimates to describe N_2O produced in water bodies currently. Ultimately, these N_2O values can be added to statewide greenhouse gas budgets.

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Nicole M. Hayes
Project Title: Climate impacts on nitrogen gas release from lakes
Organization: University of Minnesota
Project Budget: $452,000
Project Length and Completion Date: 3 years, 2020-06-01 through 2023-05-31
Today's Date: 4/15/2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 379,000	$ -	$ 379,000
Nicole M Hayes: Postdoctoral Associate. Project manager and lead on sampling, data collation and data management, and modeling. (81% salary, 19% benefits) 50% FTE year 1, 100% FTE years 2 and 3. $178,000			
Sarah Winikoff: Postdoctoral Associate. Expertise on denitrification assays and chemical analysis. (81% salary, 1% fringe) 50% FTE years 1 and 2; $69,000			
Graduate Research Assistants (Loeks-Johnson and Mittag): Field sampling, N gas analyses, and laboratory analyses. (53% salary, 47% benefits during the academic year and 86% salary, 14% benefits during the summer), 1 person= 30% FTE for year 1 and 13% FTE in year 2 and 1 person = 13% FTE in year 1, 19% FTE in year 2, and 13% FTE in year 3; $76,000			
Undergraduate Assistant. Assist with field and lab work. (100% salary, 0% benefits) 44% FTE years 1-2; $22,000			
Laboratory Manager. Organize field equipment, ordering, and lab logistics.(74% salary, 26% benefits) 20% FTE for years 1 and 2; $34,000			
Equipment/Tools/Supplies	$ 40,000	$ -	$ 40,000
Gas chromatographs and mass spectrometer use for analyzing 1,000 each nitrous oxide and dinitrogen gas samples. Samples will be run by the graudate assistant and postdoctoral associate. $4,615			
Field/Lab supplies - Supplies to collect and store samples for sample processing (chemicals, filters, bottles, bags, etc.). $32,885			
Freezer to store sample $2,500			
Printing	$ 1,000	$ -	$ 1,000
Poster printing (@ approx. $70 per poster) for disseminating results at state-level meetings.			
Travel expenses in Minnesota	$ 20,000	$ -	$ 20,000
Boat and truck rental (from UMN LACCORE and UMN Fleet Services, respectively) for trips to MN field locations to collect lake samples. $18,600			
Conference fees for Hayes and graduate research assistant to attend conferences within the state of Minnesota to present project results. $1,400			
Other	$ 12,000	$ -	$ 12,000
Lab Services - Sample processing for nutrients (dissolved, totals, and particulates), suspendid solids, total algal biomass, and DNA. For shallow lakes we will analyze about 225 samples each, in deep lakes about 200 samples each. $12,000			
COLUMN TOTAL	$ 452,000	$ -	$ 452,000

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status	Amount	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Indirect costs associated with this proposal @ 54% MTDC	Secured	$ 235,000	$ -	$ 235,000
Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	**Amount legally obligated but not yet spent**	**Budget**	**Spent**	**Balance**
	$ -	$ -	$ -	$ -

Climate impacts on nitrogen gas release from lakes



Nitrogen (N) enters from the landscape

N_2 and N_2O gases are released and no longer contribute to nutrient enrichment

How much N_2O is released?

Warming will change how lakes respond to N, but how?

Field measurements of N gas & laboratory experiments to assess how warming and prolonged periods of stratification will impact N_2 and N_2O.

Microbes consume and remove nitrogen by converting it to N_2 and N_2O gas.

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Higher temperature may **INCREASE** N removal by stimulating microbial activity.

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Longer stratification may **DECREASE** N removal by reducing watershed N inputs

Outputs

Management guidance to enhance N removal and maintain low N_2O production.

Statewide N_2O emission estimates.

Project manager qualifications: Dr. Nicole Hayes

Dr. Nicole Hayes will serve as project manager, overseeing all project activities. Dr. Hayes is currently a postdoctoral scientist at the University of Minnesota where she works with Dr. James Cotner. She previously served as a postdoctoral scientist at the University of Regina where she managed the long-term ecological research program, including hiring undergraduate assistants, organizing sampling activities and laboratory analyses, and provided quality assurance/quality control on the long-term dataset. Dr. Hayes is currently a co-principle investigator on a National Geographic Explorer grant to examine the effects of climate change on methane emissions from Icelandic lakes. She has traveled internationally with undergraduate students to collect data and mentored them on independent projects related to their time in Iceland. Finally, she leads a synthesis group of early career scientists using the U.S. Environmental Protection Agency's National Lake Assessment data to study continental scale patterns in water quality. Dr. Hayes has published in leading journals.

Project manager's organization and description: University of Minnesota, Department of Ecology, Evolution, and Behavior

The University of Minnesota's mission is to advance learning and knowledge and to enrich the state and global community with that knowledge. The College of Biological Sciences has the equipment and expertise to support the proposed research.