Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-177

Proposal Title: Glyphosate, Phosphorus and Harmful Algal Blooms

Project Manager Information

Name: James Cotner

Organization: U of MN - College of Biological Sciences

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Project Basic Information

Project Summary: We will determine whether, when, and how much glyphosate (Roundup) is in our lakes. We will also determine if glyphosate increases the frequency of harmful algal blooms.

Funds Requested: $506,000

Proposed Project Completion: 2024-06-30

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?

In the Future

Narrative

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

Glyphosate is the most widely used herbicide on our planet. And its most extensive use is in the upper Midwest, including Minnesota, where it is used at higher rates than anywhere else in the world. It has been extremely beneficial, particularly for the production of corn and soybeans in the southern and western parts of our state. One of the important selling points for glyphosate to farmers and to the general public is the fact that it breaks down quickly in soils and waters. While this may be true, the phosphorus in glyphosate does not go away and there is evidence suggesting that certain microbes, such as cyanobacteria or blue-green algae may be better able to use the partially degraded glyphosate than other algae. This means that glyphosate use may be one of the factors contributing to an increased prevalence of blue-green algae in many of our rivers and lakes where glyphosate is used, degrading water quality, making habitat less suitable for wildlife and fisheries. However, we do not know the extent of this problem and how much it might be influencing Minnesota lakes and rivers.

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.

In order to provide solutions to problems, we first must know the extent of the problem. Second, we need to know the factors causing the problem. Third and finally, we need to decide if the harm is worth the cost of fixing the problem. The work we are proposing here addresses the first two components in solving problems. We already know that harmful algal blooms (HABs) are increasing in frequency in the US and Minnesota and it is clear that there are multiple causative factors, including climate change, excess nutrient use and land use changes. But we need to know if the herbicides we are using to grow our food may also be compromising water quality. Compromised water quality means the water we drink may cost more because we need to remove contaminants or it could mean that we cannot use certain water sources. It can also mean that we cannot catch fish the way we once did from certain water bodies or that wildlife will be less abundant. Whether or not we are willing to make policy decisions to minimize glyphosate use in our state and country must first begin by understanding the full extent of harm it causes.

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 protect our lakes by identifying a potential source of contaminants. Although glyphosate is used as a herbicide, it is also a compound that includes phosphorus in the form of a phosphonate. There is some evidence in the scientific literature that phosphonate is more readily consumed by cyanobacteria relative to other types of algae. We will conserve and enhance the state's freshwaters by determining if the use of glyphosate is contributing to an increase in harmful algal blooms. We will use results of this study to propose remediation practices that should minimize the impact of glyphosate in Minnesota waters.

Activities and Milestones

Activity 1: 1. Survey Minnesota lakes for glyphosate, phosphonate and cyanobacteria

Activity Budget: $253,000

Activity Description:
Objective: Here, we will determine if there is any relationship between glyphosate and its primary degradation product, AMPA, and the relative abundance of cyanobacteria. We hypothesize that there will be a positive relationship between these variables due to the fact that glyphosate and AMPA are phosphonate compounds that are not commonly encountered in freshwater systems.

Tasks: We will survey 30 lakes throughout Minnesota in spring and late summer and measure concentrations of total algal biomass, the fraction of the biomass that is composed of cyanobacteria and the concentrations of glyphosate, AMPA and phosphonate. Sampling will focus both in agricultural regions and parts of the state that are little impacted by agriculture. Land owners who live on lakes will be recruited with the help of Minnesota Lakes and Rivers Advocates to help us conduct the surveys. We will provide them with sampling kits and train them how to collect samples for us. We will also visit the lakes in late summer to quantify cyanobacteria levels.

Specific outcomes: Surveys will be conducted in the first two years of the project (2022-23) and sample analyses will be completed by the end of the project (2024).

Activity Milestones:

Description	Completion Date
Identify lakes to be sampled and connect with land owners	2021-08-31
Quantify phosphonate concentrations in lake water and sediments	2023-11-30
Cyanobacteria quantification	2023-11-30
Glyphosate/AMPA quantification	2023-11-30

Activity 2: Determine if glyphosate promotes the growth of cyanobacteria (blue-green algae) and bacteria

Activity Budget: $253,000

Activity Description:
Here, we will attempt to answer several questions. First, does glyphosate inhibit non-cyanobacteria more than it does cyanobacteria? Second, are cyanobacteria able to use glyphosate either as a supplemental phosphorus source or as a sole phosphorus source? Lastly, which strains of heterotrophic bacteria are best able to degrade glyphosate to inorganic phosphorus? The answer to these questions is important because the first two will tell us whether cyanobacteria are better at dealing with moderate to high concentrations of glyphosate and potentially leading to algal blooms and the third question will tell us if we can use bacteria to remediate glyphosate.

Activity Milestones:

Description	Completion Date
Determine concentrations of glyphosate that inhibit growth of cyanobacteria and other algae	2023-07-31
Determine if cyanobacteria can use glyphosate as a supplemental or sole phosphorus source	2023-12-31
Identify the best strains of bacteria for degrading glyphosate	2024-06-30

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Daniel Tush	USGS Lawrence, KS	Chemist responsible for glyphosate and AMPA analyses	Yes
Rachael Lane	USGS Lawrence, Kansas	Chemist: will be responsible for glyphosate and AMPA analyses	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 be funded?

If we successfully identify microbes that are able to metabolize glyphosate and its degradation products (phosphonate-compounds), we will develop remediation methods. It is likely that organisms that are able to use this class of compounds jwill also convert phosphonate into more commonly used forms of phosphorus such as phospho-esters (which is how they are primarily used in the cell in RNA and DNA). Therefore, organisms that are able to do this could be used to transform phosphonate into these more common forms before runoff is discharged into receiving streams, lakes and wetlands, thereby removing the advantage for blue green algae.

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. 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 culture work that is proposed for this project. There are very few laboratories in the country that have as many microbial isolates from freshwater systems as we do and are capable of characterizing how these organisms grow. 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.

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. We are particularly interested in how variation in microbial metabolism can affect ecosystem dynamics. Heterotrophic bacteria represent a greater proportion of pelagic biomass and production in oligotrophic than eutrophic systems and their biomass stoichiometry can be incredibly plastic. What does this mean for ecosystem structure and function?

We have examined microbial processes in pelagic and benthic habitats, freshwater and marine, rivers, streams, 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. Prepares students for work and training in the biological and environmental sciences.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Principal Investigator		Direct project personnel, write reports and publish findings			26.74%	0.24		$50,988
Post-doctoral fellow		This person will be in charge of planning and overseeing lab and field work in years 1 and 2. Will work with PI to choose lakes, plan and implement field work and lab experiments.			20.25%	2		$127,281
Graduate student		Assist in field work and in culturing algae and bacteria			43.47%	1.5		$152,933
Undergraduate assistants		Assist with field work in the summer and with culture work during the school year			0%	1.5		$34,320
							Sub Total	**$365,522**
Contracts and Services								
Organic Chemistry Research Laboratory	Professional or Technical Service Contract	This lab will perform analyses for glyphosate and AMPA on water column and sediment samples that we will collect.				-		$31,275
University of Minnesota Genomic Center	Internal services or fees (uncommon)	We will sequence strains that are best able to degrade glyphosate so that we can figure out what genes are responsible.				-		$12,000
							Sub Total	**$43,275**
Equipment, Tools, and Supplies								
	Equipment	Algal growth chamber	This will be used for conducting growth assays with individual algae and bacteria strains					$14,713
	Equipment	Fluoroprobe from Biological, Biophysical Engineering, Inc.	We will use this instrument to detect cyanobacteria in the lakes we will be sampling.					$30,000
	Tools and Supplies	Lab and field supplies for culturing algae and bacteria and processing samples for analyses	Reagents and filters, expendable supplies like filters, pipette tips, etc.					$38,407

							Sub Total	**$83,120**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Travel to field sites	Collecting samples for analyses and culturing					$9,062
							Sub Total	**$9,062**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Travel to ASLO Meeting or equivalent	To present our findings to the scientific community	X				$4,500
							Sub Total	**$4,500**
Printing and Publication								
	Printing	Flier printing	Recruit landowners					$521
							Sub Total	**$521**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$506,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	Travel to ASLO Meeting or equivalent	This expense is for three individuals from our group to travel to national or international conferences to present our research.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
In-Kind	Overhead	University overhead associated with this proposal.	Potential	$226,000
			State Sub Total	**$226,000**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**$226,000**

Attachments

Required Attachments

Visual Component

File: 81df44ef-720.pdf

Alternate Text for Visual Component

Graphic shows where glyphosate is used most heavily in the US and we describe what we will do in the project.

Optional Attachments

Support Letter or Other

Title	File
Letter of Support from USGS partners	76b20c6c-a78.pdf
Authorization to submit from the University of Minnesota (SPA)	e8eb1aa5-0bb.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

No

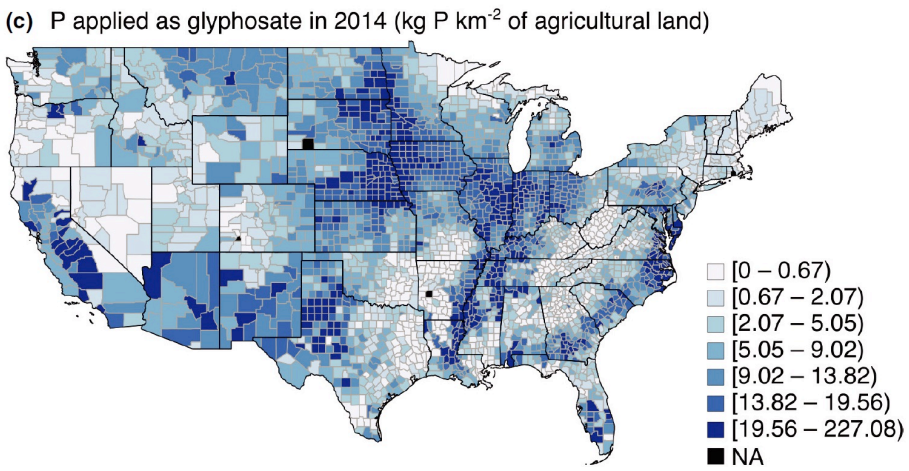
Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Is glyphosate greening our lakes?



9 billion kg of glyphosate (Roundup) applied globally; highest rates occur in Minnesota.

Glyphosate is a phosphorus (P) fertilizer; harmful algal blooms can use glyphosate for nutrition.

In lakes, does glyphosate act as a source of P for algae or act as an inhibitor of growth?

Glyphosate concentration

High → **Low**

Toxicity

- Inhibit growth of all algae

Blue-green algae blooms

- Inhibit growth of non blue-green algae
- Only blue-green algae can use glyphosate-P

Eutrophic, P-rich conditions

- No toxicity
- All taxa use glyphosate-P

Nutrient-poor lakes

- Limited nutrients
- Diverse taxa, limited blue-green algae

Outcomes: 1) determine glyphosate levels in MN lakes and 2) recommended glyphosate thresholds for lakes that will not stimulate blue-green algae.