Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-527

Proposal Title: Land and Water Management to Minimize Herbicide Exposure

Project Manager Information

Name: James Cotner

Organization: U of MN - College of Biological Sciences

Office Telephone: (612) 625-1706

Email: cotne002@umn.edu

Project Basic Information

Project Summary: The project aims to develop novel methods to trace the source and fate of glyphosate and its degradation products when used for weed management on land and in water.

ENRTF Funds Requested: $293,000

Proposed Project Completion: June 30, 2030

LCCMR Funding Category: Small Projects (G)
Secondary Category: Resiliency (A)

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.

Glyphosate, an active ingredient of Roundup®, is the most commonly used herbicide in the United States with an estimated use of 287 million pounds in 2019, of which > 20 million pounds were applied in Minnesota (USGS, 2019). Glyphosate's excessive application is in part due to its effectiveness and lower cost for land and water management to control weeds and a lower 'claimed' toxicity relative to other herbicides. An unintended consequence of increased glyphosate use is that its being found outside its intended target areas, including soils, water bodies, and animals. Theoretically, glyphosate is non-toxic to animals because it only affects the shikimic acid pathway, which does not exist in humans and animals. However, follow-up studies have found adverse effects of glyphosate such as reduced development rate and fertility in insects and amphibians, endocrine and renal toxicity in largemouth bass, and hindered cognitive functions in honeybees. Here, we aim to shed new light on modern land and water management practices where excessive glyphosate is being applied to better understand and constrain glyphosate's impact on Minnesota soils, waterways, and animals.

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.

The microbial degradation of glyphosate in agricultural soils has previously been reported to predominately generate AMPA, a more toxic and persistent product than glyphosate, although more recent studies have found sarcosine or glycine to be more dominant in wetland soils. The abiotic degradation of glyphosate catalyzed by metals and radicals is known to generate sarcosine or glycine, which are less toxic products and are readily degradable in the environment. This means that glyphosate degradation could be biased towards safer products under certain biotic and/or abiotic environmental conditions to reduce its impact on the environment. Furthermore, phosphate oxygen isotope signatures of glyphosate are uniquely distinct from most phosphorus containing compounds including all organic phosphorus compounds and orthophosphate. This allows for source tracing of glyphosate to establish parent-daughter relationships and differentiating degradation products that also have non-glyphosate origins (e.g., glycine, formaldehyde, AMPA). Current analytical methods cannot connect products to parent molecules and differentiate from naturally occurring compounds. This, in fact, highlights an existing void on the accountability of environmental and potential human exposures to glyphosate.

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?

This research will contribute to the sustainability of Minnesota's agricultural goods and services, while minimizing negative environmental impacts to soil health and water quality. Findings obtained from this research will be of great importance to the Minnesota Department of Agriculture as well as Minnesota Department of Natural Resources to monitor glyphosate. Additionally, Minnesota farmers and individual users will benefit from this research as it establishes the safety and accurate assessment of glyphosate's environmental impact. Therefore, the outcomes of this research will be overreaching and contribute to the future of sustainable land and water management for the long-term benefit of society.

Activities and Milestones

Activity 1: Develop multi-isotope tools to track and determine the persistence of glyphosate in Minnesota soils and waters

Activity Budget: $100,000

Activity Description:
Activity 1 will be achieved by first measuring the original isotope signatures (δ18OP, δ13C, and δ15N) of several commercially available glyphosate-based products. A series of controlled batch experiments will be performed using these glyphosate-based products with metals under agricultural soil conditions. Ranges of selected metals—Mn, Fe, Cu, Zn— (reported for catalytic effect and commonly present in soil or supplemented for crop growth) will be tested in a series of batch experiments as well in agricultural field plots following the published methods. Specific microbial isolates will be used for degradation experiments to determine if they are able to utilize glyphosate or its degradation products as nutrient sources. An extraction and derivatization method will be used to quantify glyphosate and products from soils. The multi-isotope values of glyphosate will be measured using mass spectrometry methods.These results using advanced analytical tools will identify degradation products and bias the degradation pathways towards safer products. The isotope tracking method will determine the accurate half-lives of several glyphosate degradation products, which was not possible in the past due to multiple origins of these products.

Activity Milestones:

Description	Approximate Completion Date
Determine the original isotope signatures (δ18OP, δ13C, and δ15N) of several commercially available glyphosate-based products	June 30, 2028
Determine the abiotic controls for glyphosate degradation and major products formed	December 31, 2028
Determine whether microbes can utilize glyphosate as a nutrient source	June 30, 2029

Activity 2: Determine the source and fate of glyphosate in Minnesota soils and waterways

Activity Budget: $143,000

Activity Description:
Field sampling of soil and water collected from agricultural fields and open waters in the state will be performed and analyzed for glyphosate and its products to identify the region's environmental degradation pathways. Sampling will occur pre-application and up to 100 days post application. State wide data on loading will be integrated to calculate residence times of glyphosate and its products to verify particular pathways of degradation. Soil and water chemistry will be evaluated and appropriate conditions will be identified to bias the degradation to generate less toxic products for the environment.

Activity Milestones:

Description	Approximate Completion Date
Determine residues of glyphosate and its degradation products in natural environments.	June 30, 2029
Determine the fate of glyphosate and downstream environmental impacts	June 30, 2030

Activity 3: Determine the greenhouse gas impact of glyphosate application

Activity Budget: $50,000

Activity Description:

Glyphosate can have effects on the two most important greenhouse gases: carbon dioxide and methane. The degradation of glyphosate leads primarily to the production of carbon dioxide which warms the atmosphere. Although this represents small amounts globally, we can precisely constrain the quantities if we can more accurately constrain the degradation rates of glyhosate and metabolites. This will enable us to determine the amount of carbon dioxide emitted during application, land management practices, etc. which will give us an overall picture of climate impacts of glyphosate use at current business as usual. Also, research has suggested that glyphosate coupled with 2,4-Dichlorophenoxyacetic acid (2,4-D) can increase methane production in lakes and wetlands. Methane is particularly problematic because it warms the atmosphere 25-80 times more than does carbon dioxide. We will conduct multiple experiments with wetland soils to determine how glyphosate and 2,4-D impact methane production, both separately and in combination.

Activity Milestones:

Description	Approximate Completion Date
Quantify the production of carbon dioxide via the degradation of glyphosate in soils and sediments.	June 30, 2029
Estimate the impact of glyphosate degradation on carbon dioxide production in Minnesota	December 31, 2029
Conduct experiments to examine effects of glyphosate on the production of methane from wetlands.	December 31, 2029
Conduct experiments to examine 2,4-D and glyphosate effects on methane production.	June 30, 2030

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Spencer Moller	University of Minnesota-Twin Cities	Project implementation and oversight	Yes

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
We will disseminate results in multiple ways. First, we will present results to multiple Minnesota agencies including the DNR and the Department of Agriculture. Also, we will present at regional, national and international such as the Minnesota Water Conference and the ASLO meetings when possible. We will publish the results of this project in refereed scientific publications. Data from this project will be made available in at the Data Repository for the University of Minnesota (DRUM).

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 proposed research will yield innovative techniques developed to alleviate the toxicity of glyphosate in Minnesota waterways, including drinking waters. The research will also help identify highly concentrated hot spots and regions where it is abundant that are useful to evaluate the impact on ecosystem health and water quality. The research could lead to science-driven understanding of proper limits on allowable pounds of glyphosate that can be applied per square acre for the protection of potential receiving bodies of leaching/runoff..

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Climate Change and Management Effects on Methane Cycling in Lakes	M.L. 2024, , Chp. 83, Art. , Sec. 2, Subd. 04c	$540,000
Supporting Minnesota Teachers to Implement Culturally Sustaining Environmental Education	M.L. 2024, , Chp. 83, Art. , Sec. 2, Subd. 05c	$295,000

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 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		Oversee project implementation			37%	0.12		$32,552
Moller/Post-doctoral researcher		Implementation of project/analysis of data			26%	1.5		$133,048
Undergraduate researchers		Field sample collection and laboratory analyses			0%	0.9		$18,730
							Sub Total	**$184,330**
Contracts and Services								
Research Analytical Services	Internal services or fees (uncommon)	Analyses including mass spectrometry and nutrient quantification				0.9		$46,824
							Sub Total	**$46,824**
Equipment, Tools, and Supplies								
	Tools and Supplies	Lab consumables (filters, pipette tips, gloves) and field supplies (sample bottles, serum vials, etc.)	These supplies enable us to collect samples and analyze glyphosate and other entities.					$34,164
							Sub Total	**$34,164**
Capital Equipment								
		UV/vis spectrophotometer	Sample analyses	X				$20,000
							Sub Total	**$20,000**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								

	Miles/ Meals/ Lodging	Approximately 6 trips to field sites in Minnesota; 150 miles per trip and two people.	Collect samples for analyses					$4,682
							Sub Total	**$4,682**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Publication fees	To disseminate the results of our project					$3,000
							Sub Total	**$3,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$293,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Equipment		UV/vis spectrophotometer	We cannot complete the work without this instrument. **Additional Explanation :** Our current instrument is no longer functional and this will be used in the project and likely for another 10 years.

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	Potential	$147,000
			Non State Sub Total	**$147,000**
			Funds Total	**$147,000**

Total Project Cost: $440,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 808bec1d-7b8.pdf

Alternate Text for Visual Component

A map showing glyphosate concentrations in Minnesota water bodies...

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
LCCMR Proposal Approval Letter	8380e1c9-34d.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

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

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 pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

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 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

Spencer Moller: University of Minnesota-Twin Cities

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A