



# Environment and Natural Resources Trust Fund

## 2021 Request for Proposal

### General Information

**Proposal ID:** 2021-304

**Proposal Title:** Minimizing Agricultural Impacts through Biological Nitrogen Fixation Alternatives

### Project Manager Information

**Name:** Brett Barney

**Organization:** U of MN, College of Food, Agricultural and Natural Resource Sciences

**Office Telephone:** (612) 626-8751

**Email:** bbarney@umn.edu

### Project Basic Information

**Project Summary:** Our project seeks to isolate and characterize beneficial microbes associated with key crops in Minnesota that would benefit agriculture through broader introduction as a natural nitrogen-accumulating biofertilizer.

**Funds Requested:** \$196,000

**Proposed Project Completion:** 2024-06-30

**LCCMR Funding Category:** Small Projects (H)

**Secondary 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?**

During the Project and In the Future

## Narrative

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

Prior to the introduction of industrially derived nitrogen fertilizers, farmers understood that rotating crops such as soybeans, alfalfa and clover on alternating years resulted in improved yields of wheat or corn the following year. Decades of research have taught us that the reason why certain crops improve soils is due to a beneficial symbiotic relationship between these plants and microbes living within or around the roots of these plants. These symbiotic relationships have several benefits. The plant is fed a continuous supply of nitrogen from the microbe as long as it provides nutrients in exchange with the microbe, which minimizes or eliminates the need for direct human intervention via nitrogen fertilizer application. However, this root-nodule based symbiosis generally occurs only within the roots of specific crops, while other key crops (corn and wheat) and native plants important to the economy of Minnesota, still require external application of nitrogen to achieve desired yields. Determining the factors that govern beneficial associations between plants and microbes would enable the expanded application of these microbes in a manner that benefits the plants and lowers the requirements for added industrial fertilizers.

### **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 goal of this project is to bestow upon plants the ability to obtain nitrogen through sustainable biological processes by improving associations between plants and targeted nitrogen-fixing bacteria that live within the above-ground tissues of the plant. Our laboratory has made substantial progress in recent years toward attaining this goal that could provide revolutionary solutions to feeding a growing population while minimizing losses of nitrogen applied through conventional fertilizers. We are currently addressing the final remaining technological hurdle toward realizing the potential of this technology. This project will enable the rapid application of this technology to benefit Minnesota agriculture by lowering the demands for industrial fertilizers. Less application of industrial fertilizers will result in less losses of fertilizer to watersheds, which will limit the impacts of this important industry on our shared environment.

Complementing or replacing industrial nitrogen production with natural nitrogen-fixation processes will lower emissions from industrial processes, providing a sustainable and locally produced commodity product with commercial value. This will establish Minnesota as a global leader in sustainable agriculture.

### **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?**

Minnesota is a major agricultural state and requires long-term solutions to environmental issues associated with farming. Sustainable production of internally-produced nitrogen with minimal runoff potential through a biologically derived process would build the local economy and save farmers money while lowering the impact of farming on water quality. Success from this project would be truly transformative, replacing an antiquated process that has been responsible for enormous quantities of carbon added to the atmosphere, and damage to our lakes and streams related to nitrogen over-application and severe weather events.

## Activities and Milestones

### Activity 1: Boosting Nitrogen Fixation through Minnesota Microbes

**Activity Budget:** \$196,000

**Activity Description:**

This activity will focus on determining methods to enhance the natural processes associated with beneficial microbes that colonize specific crops including corn and wheat, and enhance the general health of the plant through these associations. With a focus on symbiotic bacteria native to Minnesota, we aim to obtain a large catalog of microbes, with the goal of studying the potential to expand their distribution, developing methods and practices that supplement or replace the requirement for industrially-provided fertilizers. By producing the nitrogen directly within the plant, we will minimize or eliminate the migration of this nitrogen into our soils and groundwater, lakes and streams, and combat eutrophication in these waters.

**Activity Milestones:**

Description	Completion Date
Develop a collection of natural nitrogen-fixing microbes from various native plants across Minnesota.	2021-12-31
Confirm the ability to reintroduce nitrogen-fixing microbes into selected crops through established delivery techniques.	2022-06-30
Down-Select target nitrogen-fixing microbes with the highest potential to displace the need for industrial fertilizers.	2023-08-31
Sequence strains of down-selected nitrogen-fixing microbes to understand optimal features of these microbes.	2024-01-31

## 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?**

This research goal is a primary aim of our laboratory, and other aspects of this research have been funded for the past decade through funding from the University of Minnesota, the MnDRIVE program through the State of Minnesota, and most recently, through the United States Department of Agriculture. This funding would allow us to expand this work further so that direct applications of our research progress can be immediately applied to local agriculture in a manner that significantly decreases the needs to apply external sources of nitrogen fertilizer. Such improvements would be truly transformative to both agriculture and the environment.

## Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Transformation of Plastic Waste into Valued Resource	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04j	\$225,000

## Project Manager and Organization Qualifications

**Project Manager Name:** Brett Barney

**Job Title:** Associate Professor and Director

**Provide description of the project manager's qualifications to manage the proposed project.**

Dr. Brett Barney (Project Manager) received his PhD in 2003. He spent six years in the medical device manufacturing sector, and another six years as a postdoctoral fellow and project manager. He has been a professor with the Department of Bioproducts and Biosystems Engineering at the University of Minnesota since 2009. The Bioproducts and Biosystems Engineering Department serves as a core department combining Agricultural Engineering, Biological Engineering and Environmental and Ecological Engineering. The University of Minnesota provides a range of facilities and sufficient laboratory space to perform each of the activities described in this proposal. Additionally, controlled environments including greenhouse space sufficient for this work is conveniently located next door to Dr. Barney's laboratory space.

Dr. Barney's laboratory is focused on biological nitrogen fixation for minimizing costs and environmental impacts associated with biofuels and agriculture. Dr. Barney has 30 years of experience in both basic and applied research in both academia and industry, including experience managing projects and laboratories in a range of settings. Previous research funding has come from the National Science Foundation (NSF), the United States Department of Agriculture (USDA), the United States Department of Energy (DOE), the Defense Advanced Research Projects Agency (DARPA), Minnesota's Discover, Research and Innovation Economy (MnDRIVE) and the Initiative for Renewable Energy and the Environment (IREE).

**Organization:** U of MN - Twin Cities

**Organization Description:**

The University of Minnesota (UMN) was founded in 1851, and is the state's primary research university. UMN is the land-grant university in Minnesota, with strong ties to agriculture, medicine, science, engineering and the arts. UMN has a strong tradition of education and public service, with faculty of national and international reputation. UMN is an R1 Research Institution, and ranks among the nations top 10 public research universities, as assessed by the National

Science Foundation's Higher Education Research and Development survey (HERD). The UMN Sponsored Projects Administration (SPA) is the entity authorized by the Board of Regents to manage project agreements with the LCCMR program.

## Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
<b>Personnel</b>								
Brett Barney		Principal Investigator, funding for one week of summer support for all three years of the project period.			36.5%	0.06		\$11,708
Graduate Research Assistant		Research Assistant performing laboratory experiments and data analysis, supervised by the project director. Half time appointment for all three years of the grant period.			45%	1.5		\$125,177
Undergraduate Research Assistant		Research Assistants performing laboratory experiments and data analysis, supervised by the project director and graduate students. Plans are to support three undergraduate students each year.			0%	0.9		\$24,000
							<b>Sub Total</b>	<b>\$160,885</b>
<b>Contracts and Services</b>								
							<b>Sub Total</b>	<b>-</b>
<b>Equipment, Tools, and Supplies</b>								
	Tools and Supplies	Non-Capitalized Laboratory Scientific or Field Supplies	Laboratory Supplies: General Laboratory Chemicals, Media, and Reagents (\$400 per month) and Kits for Performing Routine Molecular Biology (\$400 per kit), Analytical Reagents, DNA Synthesis of Primers (\$100 per month), Liquid Nitrogen for Strain Storage (\$400 per year).					\$24,000
	Tools and Supplies	Non-Capitalized Lab Scientific or Field Equip	Laboratory Services: Genomic Sequencing (\$1500 per run) and Analysis using Next Generation Sequencing Facilities at the University of Minnesota.					\$6,615
							<b>Sub Total</b>	<b>\$30,615</b>

<b>Capital Expenditures</b>								
							<b>Sub Total</b>	-
<b>Acquisitions and Stewardship</b>								
							<b>Sub Total</b>	-
<b>Travel In Minnesota</b>								
	Miles/ Meals/ Lodging	Travel to various sampling sites across Minnesota	Travel to various sites across Minnesota to collect samples to build the libraries of beneficial microbes described in Activity One.					\$4,500
							<b>Sub Total</b>	<b>\$4,500</b>
<b>Travel Outside Minnesota</b>								
							<b>Sub Total</b>	-
<b>Printing and Publication</b>								
							<b>Sub Total</b>	-
<b>Other Expenses</b>								
							<b>Sub Total</b>	-
							<b>Grand Total</b>	<b>\$196,000</b>

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
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Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
<b>State</b>				
			<b>State Sub Total</b>	-
<b>Non-State</b>				
			<b>Non State Sub Total</b>	-
			<b>Funds Total</b>	-

## Attachments

### Required Attachments

#### *Visual Component*

File: [54a1df70-f06.pdf](#)

#### *Alternate Text for Visual Component*

Graphic illustrating nitrogen-fixing microbes associated with plant in Minnesota.

## 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

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