Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-226

Proposal Title: Microbial Systems to Improve Soil Resilience to Drought

Project Manager Information

Name: Brett Barney

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

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Project Basic Information

Project Summary: We will study the resiliency of soils collected from across Minnesota to capture water from precipitation, and determine which natural soil microbes can extend this resiliency through biological geoengineering.

ENRTF Funds Requested: $561,000

Proposed Project Completion: June 30, 2029

LCCMR Funding 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 and In the Future

Narrative

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

The frequency and duration of droughts in Minnesota and the Midwest represent an emerging issue that is projected to increase in the future. According to the Minnesota Division of Natural Resources, Minnesota has experienced significant drought conditions every year since 2021. These conditions have a negative impact on our lakes, grasslands, forests and agriculture, placing increased burdens on ecosystems that become severely stressed without sufficient water. Even short-term periods of several weeks without sufficient rainfall can result in drier plants that are more susceptible to disease, significant dieback and increased potential for wildfires.

Soil properties and organic composition play an important role in determining how well soil absorbs and retains, or releases water back into the atmosphere. Longer periods of drought are expected to change soil structure to conditions that are similar to what is found in arid regions of the Southwestern United States. The microbes that inhabit our soils have the ability to alter soils in ways that could improve water retention. Even minor improvements in water retention have the potential to significantly delay the onset of plant stress and drought impacts. Our project seeks to better understand how microbes in Minnesota soils resist conditions of extended drought.

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.

Prolonged periods of drought can drastically alter soil properties. However, soil is far more than just dirt. Soils are a living component of our ecosystems, and harbor some of the most diverse microbiomes found on the planet. Soil microbes represent a diverse and extensive resource, with billions of microbes inhabiting every square inch of soil. These microbes have the potential to actively alter soil-water properties, including water infiltration, water retention and evaporation. Many soil microbes secrete complex carbohydrates that increase water absorption and retention and slow the rates of evaporation. In arid parts of the world, microbes form a protective surface layer on soils known as cryptobiotic crusts that enhance soil water properties. The formation of these crusts can decrease soil erosion by water and wind, and actually capture water from the atmosphere. Residing within our native soils is the potential to adapt to extended periods of drought, but we need to understand how this might occur. Our project will study the potential of Minnesota soils and their microbiomes to adapt to conditions of extended drought, and identify potential future measures we can take to make our native soils more resilient to drought by capturing and retaining water through biogeoengineering.

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 collect soil samples from distinct soil types and locations receiving different rainfall amounts. Soils will be tested in environmental chambers to simulate adequate precipitation and also in conditions of extended drought. We will characterize how the drought conditions alter the soil properties and the microbial composition that constitutes their soil microbiomes. We will carefully monitor how different soils from across the state respond to identify soils that are able to rapidly adapt to retain water and resist evaporation and drainage. We will then identify key microbes that are involved in protecting or enhancing soil resilience against drought.

Activities and Milestones

Activity 1: Collect initial soils and establish methods to characterize soil and water interactions over prolonged periods of time.

Activity Budget: $160,000

Activity Description:
There are various methods described in the soil science literature that characterize soil properties in terms of water retention and losses due to water migration or evaporation. We will survey these different methods and tailor the methods to the goals of this project so that we can screen a large number of soil samples from across Minnesota for the ability to capture and retain water from precipitation, capture atmospheric water in the absence of precipitation, and lower the rates of evaporation in controlled environments. To improve the quality of these procedures, we will construct automated systems that continually monitor soil properties for a large number of samples while requiring minimal external measurements. Our laboratory has developed continual monitoring devices that can function in a variety of environments, and will develop an array of simple instruments to accurately monitor water retention characteristics for a large number of soils. These will then be used in later aims to characterize soils from across the state and identify soils that rapidly adapt to capture and retain water. We will work with various stakeholders from across the state to select representative soils from geographically diverse locations across a range of precipitation profiles.

Activity Milestones:

Description	Approximate Completion Date
Collect initial pilot soil samples from at least eight locations across Minnesota from various biomes.	November 30, 2026
Construct and test long-term soil moisture monitoring devices for extended laboratory tests.	March 31, 2027

Activity 2: Test soils from across Minnesota under drought and non-drought conditions to identify soils and microbes that optimize water capture.

Activity Budget: $200,000

Activity Description:
Once we have the soil moisture monitoring devices in place, we will initiate two sets of laboratory experiments. The first experiment will test how soils from different locations interact with water. We will accomplish this by testing rates of evaporation and rates of soil drainage. Various methods described in the literature will be applied to these soils to establish benchmark data sets for each soil. In a parallel experiment, we will also subject a set of soils to a simulated drought (low precipitation, elevated heat and low humidity) while subjecting a second set of sample of the same soils to conditions with continuous precipitation. The soils will be measured weekly, and after one month, they will be tested for the ability to retain water to determine which soils are able to rapidly adapt to better capture moisture. Samples will be tested for several months, to determine if specific soils are more resilient to drought. Samples will be taken from different locations across the state with historically varied average rainfalls to determine if any correlations exist, and this will be compared to various physical parameters include organic carbon content and soil composition using the services of the UMN Soils Testing Laboratory.

Activity Milestones:

Description	Approximate Completion Date
Test at least 20 soil samples from across Minnesota for baseline soil retention properties.	August 31, 2028
Complete initial studies of soil resilience to prolonged drought conditions versus adequate precipitation.	December 31, 2028

Activity 3: Characterize the microbial communities in soils that capture and retain moisture provided by precipitation and humidity.

Activity Budget: $201,000

Activity Description:

Once we have tested an adequate number of soils for resilience to drought, we will attempt to identify the microbes within the soils that improve water retention. Many soil microbes produce complex polysaccharides (chains of sugars) that act like a sponge to capture water and hold it in place. During the experiments conducted as part of Activity 2, we will also be supplementing the soils with simple nutrients that mimic plant root exudates (common organic carbon compounds provided to microbes by plants through their roots) to support the continued growth and maintenance of the soil microbes. Soils that show strong resilience to drought will be selected, along with those that do not, to compare and contrast the dominant microbes that are present in the drought resistant soils. We will perform soil microbiome analysis and also attempt to isolate prominent microbes from the drought resilient soils to determine their ability to produce compounds that capture and retain moisture. We will also catalog these microbes for future studies or application. Finally, we will attempt to improve the performance of low-resilience soils by supplementing these soils with specific microbes that are present in high-resilience soils.

Activity Milestones:

Description	Approximate Completion Date
Test microbiome structure of 5 drought resistant soils and 3 non-resistant soils.	December 31, 2028
Isolate key microbes from established drought-resistant soils from Minnesota.	December 31, 2028
Determine potential for isolated microbes to improve non-drought-resistant soils.	May 31, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Neil Olszewski	University of Minnesota	co-PI	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 work be funded?

This project is a new direction for our laboratory, and the experimental design is intended to survey a broad variety of soils across the state. While there is precedence for the potential success of this project, this specific aspect of soil and microbiome characteristics is poorly studied. We anticipate many potential opportunities to expand on this project in the future through the USDA, NSF, EPA and DOE. Drought is an area of constant concern that is expected to increase in the future, and we hope to identify methods that will allow us to combat this through sustainable approaches.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Minnesota Microbes for Enhanced Biodegradation of Microplastics	M.L. 2024, , Chp. 83, Art. , Sec. 2, Subd. 08g	$524,000

Project Manager and Organization Qualifications

Project Manager Name: Brett Barney

Job Title: Professor

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

Dr. Brett Barney (Project Manager) received his PhD in 2003. Prior to his PhD work, he spent six years in the medical device manufacturing sector. Following his PhD, he spent six years as a postdoctoral fellow and project manager. He has been a professor with the Department of Bioproducts and Biosystems Engineering and a member of the Biotechnology Institute at the University of Minnesota since 2009. He was the Director of the Microbial and Plant Genomics Institute from 2020 to 2022. 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 environmental spaces including various constant temperature rooms and greenhouse space sufficient for this work is conveniently located in close proximity to Dr. Barney's laboratory space.

Dr. Barney's laboratory is focused on minimizing the environmental impacts associated with biofuels and agriculture, and finding innovative methods to remove contaminants from water and wastewater. 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 including academia and industry. 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), the Legislative-Citizen Commission on Minnesota Resources (LCCMR), Minnesota's Discover, Research and InnoVation Economy (MnDRIVE), the Forever Green Initiative and the Initiative for Renewable Energy and the Environment (IREE).

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

Organization Description:
In the College of Food, Agricultural and Natural Resources Sciences (CFANS) at the University of Minnesota, we look at the bigger picture. When we envision a better tomorrow, it includes disease-resistant crops, products that protect our health, lakes free from invasive species, and so much more. We use science to find answers to Minnesota and the world's grand challenges and solve tomorrow's problems. Almost 93 percent of students who earn CFANS undergraduate degrees find jobs in their career field or enter graduate school within six months of graduation.

The Department of Bioproducts and Biosystems Engineering, in CFANS, discovers and teaches solutions for the sustainable use of renewable resources and the enhancement of the environment. We discover innovative solutions to address challenges in the sustainable production and consumption of food, feed, fiber, materials, and chemicals by integrating engineering, science, technology, and management into all degree programs.

We have a public impact through community engagement and extension efforts. We develop and deliver high quality, regionally and nationally-recognized research-based programs to meet current and emerging needs of industry and communities. We also have a long-standing tradition of close partnerships with alumni, industry professionals, organizations, government agencies, donors, and community members.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Lead Principal Investigator		Oversee all aspects of project, supervise students and researchers, plan monthly meeting with entire research group and quarterly meetings with broader group of stakeholders. These funds represent partial summer support for the lead Principal Investigator.			36.6%	0.15		$29,000
Graduate Student Research Assistant		Conduct laboratory and field experiments, train and educate undergraduate students in field and laboratory research. Participate in outreach efforts with stakeholders from across the state. Write research papers related to project findings and share results with the broader research community through presentations. These funds represent support throughout the duration of the grant period of two graduate students.			83.6%	3		$359,000
Co-Principal Investigator		Oversee experiments and analysis associated with soil and microbiome interactions. Supervise Graduate Students. These funds represent partial summer support for the Co-Principal Investigator.			36.6%	0.06		$20,000
Undergraduate Research Assistants (2-3)		Collect data, assist graduate students and learn about laboratory and field research. Participate in outreach efforts with stakeholders from across the state. These funds represent summer support and part-time support during the academic year for two or three undergrads throughout the duration of the grant period.			0%	2.01		$72,000
							Sub Total	**$480,000**
Contracts and Services								
DNA Sequencing Laboratory Services (Internal and External)	Service Contract	External costs to contract laboratories to perform sequencing runs to identify microbiomes and specific microbes. Anticipating two runs per year, $4000 per run, for all three years. Projections are based on historical costs for similar projects.				0		$24,000

Soil Testing Laboratory Costs	Service Contract	Internal and external laboratory testing services provided by the University of Minnesota Soils Testing Laboratory and other testing facilities that will provide soil characterization services through an established service contract.				0		$6,000
							Sub Total	**$30,000**
Equipment, Tools, and Supplies								
	Tools and Supplies	Lab Supplies	Laboratory Supplies: General Laboratory Chemicals, Media, Reagents and Safety Materials for students, including gloves ($200 per month) and Kits for Performing Routine Molecular Biology ($200 per kit), Analytical Reagents ($300 per month), Liquid Nitrogen for Strain Storage ($400 per year). Materials to construct customized soil measurement devices to enable long-term experiments. Budget projections are based on established long-term cost estimations for similar projects.					$36,000
							Sub Total	**$36,000**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Other	Travel to various sampling sites to meet with stakeholders and collect soil samples. Approximately three day trips per year, with a combined travel of under 200 miles per trip, including two or more persons.	Collect geographically diverse soils of distinct soil types during the duration of the grant					$6,000

							Sub Total	**$6,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Publication of three papers in Scientific and Engineering Journals	Many engineering journals have charges associated with publications, generally around $4000-$2000 per journal. We plan to publish one manuscript before the end of 2027, and another two before the end of 2029.					$9,000
							Sub Total	**$9,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$561,000**

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				
			State Sub Total	**-**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**-**

Total Project Cost: $561,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 4d1027d5-a7c.pdf

Alternate Text for Visual Component

Summary of proposal tasks and outcomes, including visuals of potential sampling sites across Minnesota and examples of drought impacted soils....

Supplemental Attachments

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

Title	File
Letter of Authorization to Submit	4ea37128-fa3.pdf
Audit	356c71ca-e50.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?

Yes

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

Yes

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

No

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

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:

Wendy Moylan, Finance Professional, University of Minnesota

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

Yes, I understand