



Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-166

Proposal Title: Survey of Overlooked Natural Resource: Plant Growth-Stimulating Microbes

Project Manager Information

Name: Jannell Bazurto

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Project Basic Information

Project Summary: We will survey plant-associated microbial communities and adapt them to resist weather stress to increase crop yields, promote the maintenance of plant diversity, and support restoration of Minnesota's ecosystems.

Funds Requested: \$339,000

Proposed Project Completion: 2024-06-30

LCCMR Funding Category: Foundational Natural Resource Data and Information (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.

Microbes are central to environmental nutrient cycling and thus indirectly support higher life forms such as plants and animals. Additionally, microbes can live in association with specific organisms and directly contribute to their growth. Microbiomes, or host-associated communities, are increasingly appreciated for their central role in host health and function. Soil and plant-associated microbiomes are known to have profound impacts on plant growth, synthesizing nutrients and plant growth hormones, making nutrients accessible, and preventing pathogen invasion. Microbiomes also help plants survive stressors such as those related to extreme weather. As key players in the success of plants, microbiomes are a valuable natural resource in their own right.

Plants are an invaluable state resource that are subject to extreme weather. Changing weather patterns have already begun taking their toll on Minnesota-based agriculture and native ecosystems. In the near future, changing weather patterns will continue to present challenges to cultivating Minnesotan plants, including native plants as well as important crop species. Endangered species may be particularly susceptible to climate shifts. Therefore, finding ways to enable plants to tolerate and thrive under climatological changes is of paramount importance, and targeting microbiomes to aid plant fitness is a rapid avenue to achieve this outcome.

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.

Because environmental microbes are critical components of healthy ecosystems, microbial communities native to Minnesota are deserving of investigation. Native plant-associated microbiomes are specifically adapted to improve the health of Minnesota's plants and buffer them against stressful conditions. We seek funding to survey the biodiversity of microbiomes associated with a variety of Minnesota's plant species and evaluate their capacity to increase plant stress tolerance. Our proposed project includes characterizing microbiome compositions, mapping their physical distribution across the state, and monitoring their dynamics long-term. Additionally, we will specifically adapt communities in the presence of stress conditions related to changing weather patterns, such as increased temperatures paired with desiccation and excessive soil moisture. The purpose of these adaptive studies is twofold: i) to inform us about the impact of extreme weather on native microbiomes and ii) to yield a subset of communities that possess enhanced capacities for tolerating and thriving under these stressful conditions. We will specifically test the contribution of these stress-adapted communities to promote plant stress tolerance, which will allow plants to withstand and thrive in more extreme climate conditions. Our work will link Minnesota's microbial natural resources to enhanced plant growth and survival under extreme weather conditions.

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 project will yield a catalog of microbial communities that exist on Minnesota's plant species, including ones that are protected and endangered. We will characterize the impacts of stressful weather conditions on these communities and their plant hosts. By adapting communities to a range of stressful weather conditions, we will determine the pending impact of changing weather patterns on Minnesota's native microbiomes and be able to preemptively adapt them to surviving harsh conditions. In doing so, we will preserve their ability to perform plant-associated functions, where they might promote plant stress resistance.

Activities and Milestones

Activity 1: Survey and assessment of Minnesota’s microbial natural resources: soil and plant-associated microbiomes

Activity Budget: \$177,000

Activity Description:

Plant-associated beneficial microbiomes profoundly impact plant health by producing growth stimulating molecules and nutrients, as well as conferring plant tolerance to stressors. By sampling microbiomes across the ten distinct ecological sections of the state, including those at Itasca Biological Station, we will survey and assess one of Minnesota’s greatest, yet often overlooked, natural resources: its soil and plant-associated microbiomes. Initial short-term sampling will be used to profile the microbiomes with sequencing technologies and capture the existing diversity across variable ecosystems. Additionally, we will characterize how these catalogued microbiomes contribute to the health and stress tolerance of plants. To do this we will use these microbiomes to inoculate a sterilized plant model organism (*Arabidopsis thaliana*) and agricultural crops pennycress and maize. Plant growth outcomes will be assessed in non-stress and stress conditions such as extreme temperatures, desiccation, and salinity. Microbiomes found to have impressive growth stimulating properties will be examined on a handful of Minnesota’s most valuable and/or endangered plant species. Longer-term sampling will include a subset of the original sites repeatedly sampled across seasons for five years. Weather parameters over this timeframe will be reported to provide context for how climate influences microbial communities.

Activity Milestones:

Description	Completion Date
Inventory of statewide samples of soil, plant-associated microbiomes, cataloging by geographic coordinates and plant species.	2021-09-30
Sequence-based profiling members of microbiome and assessment of growth benefits bestowed on plants.	2022-09-30
Long-term collection of microbiomes across seasons/years to monitor microbiome dynamics across time and weather.	2024-06-30

Activity 2: Impact and adaptation of plant-associated microbiomes in response to harsh weather conditions

Activity Budget: \$162,000

Activity Description:

Climate models predict that changing weather patterns will continue to impose new environmental challenges for plant species. The growth of native plants and agricultural crops is largely influenced by their microbiomes. To assess the impact of changing weather patterns on Minnesota’s plant-associated microbiomes, we will adapt them on *A. thaliana* with long-term exposure to stressful growth conditions comparable to those caused by extreme weather conditions. Weather-based stress conditions will include elevated temperatures paired with desiccation to mimic hotter, drier summers, and increased soil moisture to mimic flooding, and fluctuations between these. Changes in the profile of the microbiome (i.e., identity and abundance of community members) will be monitored by sequencing. Next, we will investigate the extent to which stress-adapted microbiomes can alleviate host stress when their plant hosts are exposed to weather-related stress. Stress-adapted microbiomes will be examined for their ability to confer tolerance to extreme weather stress on agricultural plants (e.g., pennycress and maize), as well as endangered plant species (e.g., Minnesota dwarf trout lily). Stress-alleviating microbiomes identified, and individual member species within them, will be examined in greater detail through community sequencing to assess composition and abundance of community members.

Activity Milestones:

Description	Completion Date
Adapt microbiomes to stress conditions that mimic extreme weather conditions (temperature and precipitation fluctuations/extremes).	2023-06-30
Characterize effects of extreme weather conditions on microbiomes composition by tracking changes in microbiome profiles.	2023-12-31
Determine extent to which extreme weather adapted microbiomes allow plants to tolerate extreme weather stress.	2024-06-30

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Trinity Hamiilton	University of Minnesota	Professor Trinity Hamilton from the Department of Plant and Microbial Biology has been characterizing microbial communities in extreme conditions and their adaptation to environmental change. She will participate in site sampling and assist with the sequence-based profiling of microbiomes.	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?

We expect this project to be long-term. To obtain a comprehensive description of plant microbial communities and determine their overall stability, we will sample during different seasons and across years. Furthermore, we intend to characterize microbiomes from a few plant species, but feel that expanding this scale would allow for the identification of broader plant community trends. The ability to harness and enhance the native microbiome will increase crop yields, promote the maintenance of plant diversity, and support restoration of Minnesota's ecosystems. Funding for additional work will be sought after by application to the National Science Foundation.

Project Manager and Organization Qualifications

Project Manager Name: Jannell Bazurto

Job Title: Assistant Professor

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

I am well-suited to execute the proposed work as a microbial physiologist with extensive experience adapting microbes to stress conditions and integrating approaches that span experimental scales. I have abundant experience working with genetically tractable model microbes, including *Methylobacterium*, a key microbe in many plant communities.

My core expertise was gained in my doctoral training where I integrated in vivo genetics and biochemistry to understand metabolic integration. I was trained by Dr. Diana Downs, and rigorously studied the mechanistic basis of metabolic integration and plasticity in *Salmonella* and *Escherichia coli*. To describe the global consequences of metabolite imbalance, I began integrating additional approaches to studying metabolic stress during my postdoctoral studies in Dr. Downs's lab. This work was done in collaboration with Dr. Shawn Campagna at the University of Tennessee, where I received extensive hands-on training to perform untargeted metabolomics and subsequent data analysis. In pursuit of understanding cellular coordination surrounding metabolic toxins, I developed my research program during my postdoctoral position in the laboratory of Dr. Christopher Marx. There, I continued to integrate new approaches into my work to gain system-level insights on the stress response systems that counteract formaldehyde toxicity in *Methylobacterium*.

My overall research goal is to understand novel mechanisms used to maintain cellular homeostasis and how they impact organisms in their natural environments. By studying a microbe that generates copious quantities of formaldehyde as a metabolic intermediate, my research program is poised to make exciting contributions to the field of microbial stress response, and to understand cellular strategies for managing metabolic stress, specifically. My findings have led to exciting revelations related to metabolic control, and the adaptive dynamics of organisms encountering transient stress.

Organization: U of MN - College of Biological Sciences

Organization Description:

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								
2 Graduate Student		Perform microbiome analyses and plant-based stress exposure experiments			39%	1.5		\$245,000
2 Undergraduate student		DNA extraction and plant maintenance			0%	0.75		\$15,000
							Sub Total	\$260,000
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	reagents (i.e. oligonucleotides, DNA polymerase, HiFi cloning kits), media, chemicals, consumables (i.e. pipet tips, petri dishes, centrifuge tubes, 96-well plates)	molecular work, microbial/plant growth experiments					\$24,000
	Tools and Supplies	sequencing and analysis expenses	Next-generation sequencing needs for analysis of native plant-associated microbiomes, analyze stress-adapted populations and individual isolates.					\$50,000
							Sub Total	\$74,000
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								

	Other	travel to field sites	initial field work and then long-term survey					\$5,000
							Sub Total	\$5,000
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	\$339,000

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
State				
			State Sub Total	-
Non-State				
In-Kind	Indirect costs for this proposal, though not allowed, are listed as in-kind contribution of 55% MTDC	To pay for administrative and facility expenses for this project	Secured	\$149,974
			Non State Sub Total	\$149,974
			Funds Total	\$149,974

Attachments

Required Attachments

Visual Component

File: [a87d31ec-9c0.pdf](#)

Alternate Text for Visual Component

Two-panel figure. Top panel is entitled "Activity One - Survey and assessment of Minnesota's microbial natural resources: soil- and plant-associated microbiomes." It shows the state of MN divided into ten distinct ecological regions. Each region has a star that represents a sampling site. From one star (site) there is an expanded view of a plant with two arrows to the right of it, to represent a sampling from its leaves and its soil and placing samples in collection tubes. From the collection tubes is an arrow toward a collection of different microbes representing the plant-associated microbiome that is essential for plant growth.

The microbiome connects the top and bottom panels. The bottom panel is entitled, "Activity Two - Impact and adaptation of plant-associated microbiomes in response to harsh weather conditions." Here the collected microbiome from the top panel is used to introduce microbes to seeds and plant growth occurs under stressful weather conditions. At the end of the stress experiment, the microbiome is assessed to determine the impact of stress on the microbiome and how the microbiome has adapted.

Optional Attachments

Support Letter or Other

Title	File
Authorization to submit	cc749819-f85.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

No

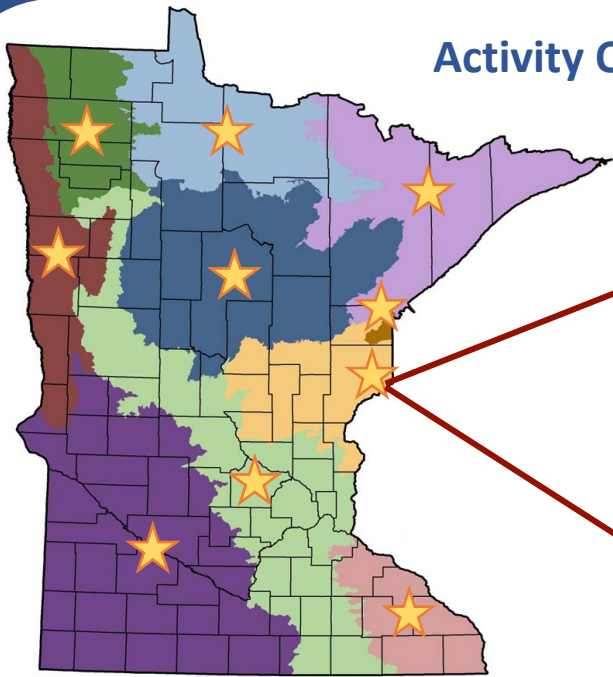
Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

**Activity One - Survey and assessment of Minnesota's microbial natural resources:
soil and plant-associated microbiomes**



**Activity Two - Impact and adaptation of plant-associated microbiomes
in response to harsh weather conditions**

