

**Environment and Natural Resources Trust Fund
2018 Request for Proposals (RFP)**

Project Title:

ENRTF ID: 017-A

Minnesota Soil Microbiomes: Foundational Database for Environmental Health

Category: A. Foundational Natural Resource Data and Information

Total Project Budget: \$ 924,000

Proposed Project Time Period for the Funding Requested: 3 years, July 2018 to June 2021

Summary:

We will develop a systematic, statewide database of Minnesota soil microbiomes. This will provide a critical foundation to enhance understanding and guide management of Minnesota's environments and microbial natural resources.

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Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Visual of tracking microbes in different environments in MN.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____ %



PROJECT TITLE: Minnesota soil microbiomes: foundational database for environmental health

I. PROJECT STATEMENT

Soil microbes are a critical and understudied component of Minnesota’s natural resources. They provide the foundation for the health and productivity of forest, crop, and natural environments. However, we have little understanding of the diversity, abundance, and variation of indigenous soil microbes across Minnesota, and of their roles in supporting environmental health across our diverse landscapes. Such information is critical to managing natural, agricultural, and forestry resources, and to decision-making regarding the wide-scale use of microbial inoculants to improve plant productivity in Minnesota.

Here we propose to develop a foundational database of soil microbiomes across Minnesota, providing information on:

- a. WHAT microbes are present, and where, in Minnesota soils;
- b. the frequency of pathogenic, invasive, and beneficial microbes in habitats across the state;
- c. variation in soil microbes associated with major biomes (natural, agricultural, forest), and different soil characteristics;
- d. microbial responses to weather and climate, and a baseline for tracking invasive microbial species;

In addition, these data will provide a significant resource for scientists, policy-makers, and citizens in Minnesota, both for understanding our microbial natural resources, and for guiding regulatory decision-making in reviewing experimental environmental releases of microbes for supporting crop production in Minnesota.

This will be, to our knowledge, the first statewide assessment of the soil microbiome in the U.S., and will serve as a novel model for microbiomes nationally. Within Minnesota, these data will complement long-term survey information focusing on plant, animal, soil physical and chemical, and water resources with new information on soil microbes. There is at present no systematic statewide assessment of terrestrial microbes.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Characterize soil microbiomes across Minnesota.

Budget: \$542,334

We will collect soil samples from abundant habitat types (agricultural, forested, wetland, or urban/suburban) within every township (n = 2775 townships) in Minnesota. Soil microbiomes and physicochemical characteristics will be determined for every sample. Molecular, sequence-based techniques used here will provide a broad overview of the relative abundance of different bacteria and fungi across Minnesota, the diversity of bacterial and fungal communities, and the relationships of soil microbiomes to soil physicochemical properties, habitat type, and geography.

Evaluation of outcomes: documented completion of microbiome analyses from Minnesota townships.

Outcome	Completion Date
1. Sample soil microbiomes in every township in Minnesota.	Oct. 1, 2018
2. Extract DNA from soil samples, process samples for analyses.	Jan. 1, 2019
3. Sequencing of samples to determine soil microbial community composition.	May 1, 2019
4. Process microbiome and physicochemical data for inclusion in database.	July 1, 2019

Activity 2: Establish a broad database of soil microbiomes across Minnesota natural habitats (prairie grassland, deciduous forest, coniferous forest, tall grass, aspen parkland, wetlands), focusing on state-owned lands.

Budget: \$236,084

To provide more detailed insights into the microbiomes associated with our natural habitats, we will focus on intensive sampling of 50 state-owned, natural environments across Minnesota, including Minnesota state parks, state forests, and scientific and natural areas. Within each of the 50 targeted sites, we



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will collect 10 individual samples, and characterize the soil microbiomes for every sample (n = 500 samples) as noted above. As publicly held lands, samples will be referenced with GPS coordinates, providing fine-scale mapping of soil microbes within and across natural sites. Additional data for every sample will include habitat type (coniferous forest, hardwood forest, wetland, prairie, etc.) and plant species composition.

Evaluation of outcomes: completion of statewide natural habitat microbiome assessments.

Outcome	Completion Date
1. Sample collection across 50 Minnesota natural habitats.	Oct. 1, 2019
2. DNA extraction and soil processing.	Jan. 1, 2020
3. Sequencing of samples to determine microbial community composition.	May 1, 2020
4. Process microbiome and soil physicochemical data for inclusion in database.	Aug. 31, 2020

Activity 3: Create an open-access database of Minnesota soil microbiomes.

Budget: \$145,582

Data collected in this study will be summarized and made available to the public through the IAA database at the University of Minnesota. The database will provide spatially-referenced data, allowing citizens and policy-makers to pose queries on what microbes are present across Minnesota and the relationships of soil physicochemical parameters, geography, or environment to soil microbiome composition or diversity. This database will provide a foundation for comprehensive understanding of soil microbiomes in Minnesota; a database for evaluation of microbial invasive species and microbiome responses to climate change; and a resource for regulatory decision-making regarding experimental release of microbes in Minnesota.

Evaluation of outcomes will consider both success in establishing the database, and documentation of the use of this database by citizens, scientists, and regulators into the future.

Outcome	Completion Date
1. Develop data modeling effort for microbiomes	March 1, 2019
2. Data integration for statewide township microbiomes (Aim 1 data).	Oct. 1, 2019
3. Integrate and upload natural environment surveys (Aim 2 data).	Oct. 1, 2020
4. Finalize programmatic interface, make data fully available to end-users.	June 30, 2021

III. PROJECT STRATEGY

A. Project Team/Partners

Dr. Linda L. Kinkel, UM. Overall project lead, with responsibility for overall budget allocation and management. Will manage all soil processing, DNA sequencing effort, and data quality control and initial processing.

Dr. Jonathan Schilling, UM. Project partner and co-lead.

Dr. Kathy Kromroy, MDA. Lead on statewide sampling. Will manage funds for year 1 summer sampling crews.

Jeanne Ciborowski, MDA. Co-lead on statewide sampling.

Dr. Phil Pardey, UM IAA Board Chair, lead on database development and management.

Dr. Kevin Silverstein, UM IAA Alliance Operations Manager, co-lead on database development. Will manage all funds associated with database development.

B. Project Impact and Long-Term Strategy

This project will generate a systematic, statewide characterization of Minnesota soil microbiomes, which is critical for understanding and management of Minnesota’s environment and natural resources. This work complements existing plant, animal, and soil survey databases that currently lack microbiome data.

C. Timeline Requirements: 3 years

2018 Detailed Project Budget

Project Title: Minnesota microbiomes in agricultural, forested, and natural habitats

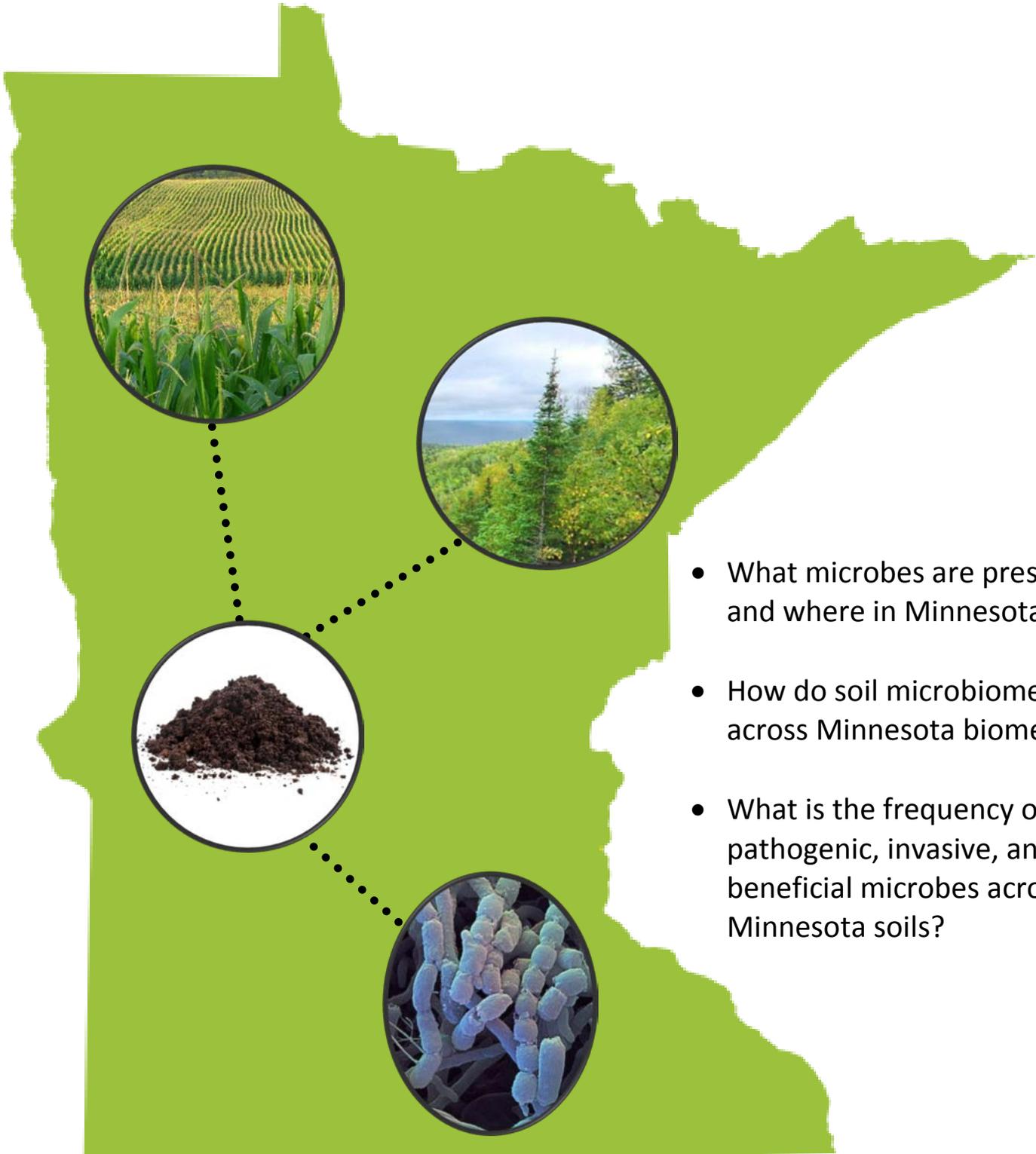
IV. TOTAL ENRTF REQUEST BUDGET [3] YEARS

BUDGET ITEM (See "Guidance on Allowable Expenses", p. 13)	AMOUNT
Personnel: U OF M-KINKEL (Microbiome). One Professional & Academic (P&A) employee (100% time) for 3 years (33.5%FB), with 2% annual salary increase per year. Year 1 total = \$64,649 (\$48,426 salary, \$16,223 FB), Year 2 total = \$65,942 (\$49,395 salary, \$16,547 FB), Year 3 total = \$67,261 (\$50,383 salary, \$16,878 FB). This P&A employee will coordinate soil sample storage, processing, microbiome analysis and data collection in the Kinkel lab.	\$ 197,852
Personnel: U OF M-KINKEL (Microbiome). Two undergraduate scientists for Year 1 & 2 (\$15,000 for each student/yr; total for 2 students per year = \$30,000); summer (100% time), school year (30% time). Undergraduate scientists will aid in soil sampling, sample storage and processing, and extraction of DNA in the Kinkel lab.	\$ 60,000
Personnel: U OF M-IAA (Database mgmt). Year 1 : Professional & Academic employee (P&A), with 2% annual increase (40% time for 9 months, base \$74,000). Year 1 total = \$29,637: \$22,200 salary, \$7437 (33.5% FB). This P&A employee will data model, alter database schema, & build DAL links. Year 3, this individual's efforts will be 40% time for 3 months for refining model data (base \$76,990): Year 3 total = \$10,278 : \$7699 salary, \$2579 (33.5%FB) .	\$ 39,915
Personnel: U OF M-IAA (Database mgmt). Year 1 : One P&A employee salary, with 2% annual increase (40% time for 9 months, base \$98,000). Year 1 total = \$39,249: \$29,400 salary, \$9849 (33.5% FB). This P&A employee will provide microbiome-specific query filtering and GUI components. Year 3, this individual's efforts will be 40% time for 3 months for updates for the user interface (base salary \$101,959): Year 3 total = \$13,611: \$10,195 salary, \$3416 (33.5%FB).	\$ 52,860
Personnel: U OF M-IAA (Database mgmt). Year 2 : One Civil Service (CS) employee, with 2% annual increase (40% time for 6 months, base \$48,960). Civil service Year 2 total = \$12,455: \$9792 salary, \$2663 (27.2% FB). This CS employee will add microbiome metadata and conduct data cleaning and ingestion. Year 3, this individual's efforts will be 40% time for 3 months for continued ingestion of data (base salary \$49,939): Year 3 total = \$6352: \$4994 salary, \$1358 (27.2%FB).	\$ 18,807
Professional/Technical/Service Contracts: Research Analytical Lab at the University of Minnesota for processing soil physiochemical properties of collected samples (for example, pH, organic matter, soil type/texture; approx. \$30/sample for 3275 samples)	\$ 98,250
Professional/Technical/Service Contracts: DNA sequencing costs (amplification, sequencing) for 3275 soil samples at the University of Minnesota Genomics Center (UMGC) over 2 years. Year 1 (\$230,000) & Year 2 (\$50,000)	\$ 280,000
Equipment/Tools/Supplies: U OF M-KINKEL (Microbiome). We will need to purchase a -80C freezer to store 3275 soil samples for soil edaphics, DNA extraction, and amplicon sequencing (-80C storage is standard protocol for samples be processed for microbiome analysis). ThermoScientific; Revco, Ultra-low temp, 20 cu ft chest freezer.	\$ 12,316
Equipment/Tools/Supplies: U OF M-KINKEL (Microbiome). Expendables for materials and supplies, i.e., supplies for sample collection (plastic bags, soil probes, coolers, ice packs), items for processing soil in the lab, & items for extracting bacterial and fungal DNA from soil samples (\$21,000/year)	\$ 42,000
Travel: U OF M-KINKEL (Microbiome). Gas, fleet vehicle rentals, and hotel costs, to travel to sample location sites (50 state/regional parks) for natural habitat soil sampling throughout MN (Year 2).	\$ 15,000
Additional Budget Items: U OF M-IAA (Database mgmt). IAA will need to purchase a separate a federated IAA node (\$20,000). IAA will also required \$7000/year for Year 2&3 (\$14,000 total) for ongoing costs and maintenance of the database.	\$ 34,000
Additional Budget Items: SUBCONTRACT (MN Dept of Agriculture). Total budget \$73,000: Includes 4 personnel (100% time for 3 months) to collect the township samples in Year 1 (2775 samples), soil sampling supplies, mileage and vehicle rental for each individual.	\$ 73,000
BUDGET ITEM (See "Guidance on Allowable Expenses", p. 13)	\$ 924,000

V. OTHER FUNDS (This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State \$ To Be Applied To Project During Project Period: N/A	\$ -	Indicate: Secured or Pending
Other State \$ To Be Applied To Project During Project Period: N/A	\$ -	Indicate: Secured or Pending
In-kind Services To Be Applied To Project During Project Period: N/A	\$ -	Indicate: Secured or Pending
Past and Current ENRTF Appropriation: N/A	\$ -	Indicate: Unspent? Legally Obligated? Other?
Other Funding History: N/A	\$ -	

Minnesota Soil Microbiomes: Foundational Database for Environmental Health



- What microbes are present and where in Minnesota soils?
- How do soil microbiomes vary across Minnesota biomes?
- What is the frequency of pathogenic, invasive, and beneficial microbes across Minnesota soils?

PROJECT TITLE: Minnesota soil microbiomes: foundational database for environmental health

Project Manager Qualifications and Organization Description:

Dr. Linda Kinkel is well-positioned to provide a leadership role to the development of the Minnesota soil microbiome project. Her research focuses on soil and plant microbiomes and their relationships to plant productivity in agricultural and prairie ecosystems. Her work integrates diverse 'omics approaches to build our understanding of the factors that mediate the capacities of soil microbiomes to increase plant productivity, reduce use of pesticides in agriculture, and enhance nutrient cycling. She is a national leader in the Phytobiomes Initiative, which emphasizes inclusion of microbiome knowledge for creating sustainable food production systems. She represented the US at the European Plant Microbiome workshop in February, 2016, and was a lead author of the white paper resulting from that workshop. In addition, she was a participant in both the September, 2015 White House Office of Science and Technology Policy (OSTP) workshop on Microbiomes, and the OSTP May, 2016 Microbiome Initiative kickoff event at the White House. Dr. Kinkel's research program has been funded by diverse groups, including grants from the NSF, USDA-NIFA, MDA, LCCMR, MAES, and local commodity groups. She has previous experience managing large budgets within her own program, as well as budgets spanning multiple research groups or units. Her work has been published in a wide array of outlets, spanning high quality basic and applied science journals, and has been highlighted in publications ranging from Bioscience to Modern Farmer.

Dr. Kinkel will serve as project coordinator, working with collaborators at the University of Minnesota, the Minnesota Department of Agriculture (MDA), and the IAA to conduct the project. Dr. Kinkel and Dr. Schilling will supervise a research fellow working on the project at the UM. This research fellow will coordinate all sample processing, including DNA extraction, physical processing, and archiving, as well as data cleanup prior to submission to the database. Dr. Kathy Kromroy at the MDA will supervise summer staff in collection of field samples across Minnesota townships. Drs. Phil Pardey and Kevin Silverstein, with the UM IAA, will manage database development and incorporation of the Minnesota microbiomes into the IAA. Dr. Kinkel has sought and will continue to seek funding from other funding entities (e.g. USDA, UM Grand Challenges) to expand the integration of microbiome datasets across Minnesota and Minnesota and nationally.

University of Minnesota – The University of Minnesota is a land-grant institution of higher education, and ENRTF funding granted for this project would be managed by the University of Minnesota.