Environment and Natural Resources Trust Fund
2020 Request for Proposals (RFP)

Project Title: **ENRTF ID: 027-A**

Soil and Plant Microbiomes: A Foundational Database for Environmental Health

Category: A. Foundational Natural Resource Data and Information

Sub-Category:

Total Project Budget: $ 758,860

Proposed Project Time Period for the Funding Requested: June 30, 2023 (3 yrs)

Summary:

We will create a statewide database of soil and plant microbiomes to enhance understanding, guide management, and inform policy to preserve Minnesota's environment and natural resources.

Name: Linda Kinkel

Sponsoring Organization: U of MN

Job Title: Dr.

Department: Plant Pathology

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Web Address:

Location:

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

The visual includes a snap shot of some of the key ecosystems within MN significantly impacted by plant and soil microbiomes, including a short description of the key outcomes of our proposed project.

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

Project Title: Soil and plant microbiomes: A foundational database for environmental health

I. PROJECT STATEMENT

Here we propose to create a statewide database of soil and plant microbiomes to enhance understanding, guide management, and inform policy to preserve Minnesota's environment and natural resources. Specifically, we propose to create, develop, and deploy a novel database to facilitate better understanding among scientists, decision-makers, and the public of: a. WHAT microbes are present, and where, in Minnesota soils; b. the frequency of potentially pathogenic, invasive, and beneficial microbes in habitats across the state; c. variation in microbes associated with major Minnesota biomes (natural, agricultural, forest, grassland), and with biome health; and d. microbial responses to weather and climate.

This project will leverage substantial federal and state investments at the University of Minnesota and elsewhere in environmental microbiome data. We presently lack a unified platform for integration and analysis of these complex environmental datasets. Moreover, these data are largely unavailable to decision-makers (e.g. Minnesota Department of Agriculture), scientists, policy-makers, and citizens, which fundamentally limits our capacities to turn these datasets into actionable information to improve the long-term environmental health of managed and natural habitats. These data will provide a significant resource for understanding our microbial natural resources, for guiding regulatory decision-making (e.g. review and regulation of experimental environmental releases of microbes for supporting crop production in Minnesota), and for guiding optimization of microbiomes for diverse purposes (e.g. prairie restoration, crop production, forest health). 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 database to support microbiome data analysis and integration across diverse Minnesota ecosystems.

Soil and plant microbes are a critical and understudied component of Minnesota's and indeed our nation'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 native soil microbes, and of their roles in supporting environmental health across our diverse landscapes. Such information is critical to managing natural, agricultural, and forestry resources, and for decision-making regarding the presence and prevalence of beneficial, pathogenic, and invasive microbes across the landscape.

II. PROJECT ACTIVITIES AND OUTCOMES

ACTIVITY 1: Establish database platform for Minnesota environmental microbiomes. Budget: $330,873

The database platform will be established within the existing GEMS resource at the University of Minnesota (https://agroinformatics.org). This database fosters public-private research relationships by enabling secure, user-managed sharing and analysis of agricultural and natural resource-related datasets. The database will incorporate information on bacterial and fungal populations in soils and plants across Minnesota, as well as soil physicochemical characteristics, habitat type and quality, and, where appropriate, spatial referencing. The database will allow citizens and policy-makers to pose queries on what microbes are present across Minnesota and the relationships of soil parameters, geography, or environment to soil and plant microbiome composition or diversity. This database will provide a foundation for comprehensive understanding of soil and plant microbiomes in Minnesota; a database for evaluation of microbial invasive species and microbiome responses to climate change; and a resource for both regulatory and management decision-making by state agencies.
Evaluation *of outcomes will consider success in establishing the database, and documentation of data management and analysis quality control, and expert feedback.*

Outcome	Completion Date
1. Creation of database schema in consultation with domain experts	Nov. 1, 2019
2. Prototype graphical interface to the database ready for testing	May. 1, 2020
3. Converge on improved data model for database using iterative feedback from domain experts	Sept 1, 2020
4. Refined graphical interface for data upload and basic analysis ready	Jan. 1, 2021

ACTIVITY 2: Create synthesis, analytical, and query tools within the database to facilitate microbiome understanding. **Budget: $165,786**

Once established, development of appropriate synthesis, query, and analytical tools within the database is critical to facilitating accessibility of complex microbiome data to scientists, policy-makers, and the public. We propose to sit down with each of these stakeholders and identify their critical questions in relation to microbiome data across Minnesota. We will work with our software engineers, User-experience/User-interface (UXUI) experts, and develop software tools with advanced graphic visualization to address these analysis inquiries.
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. Convene scientists, policy-makers and public in forums to brainstorm critical questions related to microbiome analyses	Oct. 1, 2019	
2. Prototype first two analysis tools and begin UXUI testing with public	Mar. 1, 2020	
3. Testing of additional synthesis, analysis and query tools with users	Sept 1, 2020	
4. Testing of new tools based on synthesis of data now available in platform that reveal new questions we can ask	Sept. 1, 2021	

ACTIVITY 3: Populate the database with existing and in-process Minnesota microbiome data, and build engagement among target users. **Budget: $262,201**

Project staff will engage with researchers across the University of Minnesota and elsewhere to integrate existing and in-process state- and federally-funded microbiome research datasets into the Minnesota Microbiome database, *and support collaborative microbiome data generation, including equipment access (a key limitation to developing additional datastreams)*. Funding agencies require public release of microbiome data, and the database will offer a platform for open or protected access (depending on the dataset funding source) for both release and, most importantly, analysis and integration of microbiome datasets. Project staff will build descriptive summaries of Minnesota plant and soil microbiomes, and provide this information to the public through the GEMS website. In addition, staff will work with state agencies to incorporate microbiome data into decision-making and habitat description through the Minnesota database.
Evaluation *of outcomes will consider both success in establishing the database, the number of microbiome datasets incorporated into the platform, and documentation of the use of this database by citizens, scientists, and regulators into the future.*

Outcome	Completion Date
1. Populate the Minnesota Microbiomes database with existing and in-process microbiome data	March 1, 2021
2. Work with state agencies to incorporate microbiome data into decision-making.	April 1, 2022
3. Create summaries of Minnesota microbiomes for general public.	Oct. 1, 2022
4. Official release of the Minnesota Microbiome database to the general public	Oct. 1, 2022

III. PROJECT PARTNERS AND COLLABORATORS:

Dr. Linda L. Kinkel, UM. Overall project lead, with responsibility for budget allocation and management. Will manage scientist participation in contributing data to the dataset, as well as data quality control and processing.
Dr. Philip Pardey, UM IAA/GEMS Board Chair, lead on database development and management.
Dr. Kevin Silverstein, UM IAA/GEMS Alliance Operations Manager, co-lead on database development. Will manage all funds associated with database development.

IV. LONG-TERM IMPLEMENTATION AND FUNDING:

This project will create an accessible database to enhance systematic, statewide understanding of Minnesota soil and plant microbiomes. This work complements existing Minnesota plant, animal, and soil survey databases, leverages substantial federal and state investments in microbiome science to support Minnesota natural resources decision-makers, and creates a 21st century foundational resource for Minnesota's citizens.

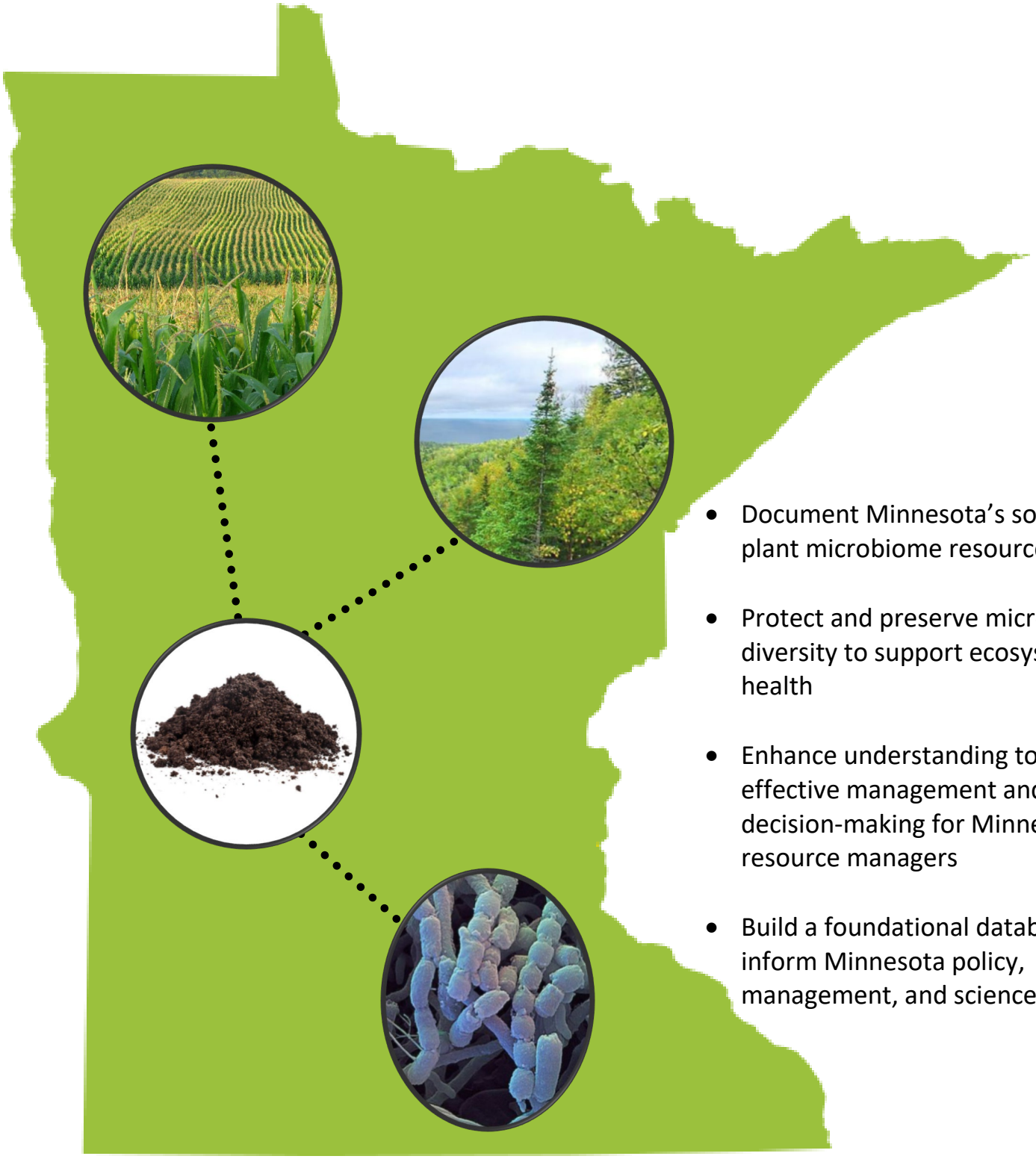
Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Dr. Linda Kinkel
Project Title: Soil and plant microbiomes: A foundational database for environmental health
Organization: University of MN
Project Budget: $758,860
Project Length and Completion Date: July 1, 2020 to June 30, 2023
Today's Date: 4/10/2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 637,840	$ -	$ 637,840
*U OF M-KINKEL (Microbiome). One Professional & Academic (P&A) employee (100% time) for 2 years (Years 2 & 3), with 2% annual salary increase per year (**Total salary $141,181**). Year 2 total =$69,892 ($51,391 salary, $18,501 FB), Year 3 total =$71,290 ($52,419 salary, $18,871 FB). This P&A employee will coordinate soil sample storage, processing, microbiome analysis and data collection in the Kinkel lab.*			
*U OF M-GEMS (FTE Programmer). One Professional & Academic (P&A) employee for 3 years with 2% annual salary increase per year (**Total Salary $285,090**). Year 1 total (75% FTE) = $105,060 ($77,250 salary, $27,810 FB); Year 2 total (75% FTE) = $107,161 ($78,795 salary, $28,366 FB); Year 3 total (50% FTE) = $72,869 ($53,580 salary, $19,289 FB).The Programmer will build the microbiome database and code up the query retrieval tools.*			
*U OF M-GEMS (Data Scientist). One civil service employee for 3 years with a 2% annual salary increase per year (**Total Salary $165,786**). Year 1 total (50% FTE) = $32,375 ($25,000 salary, $7,375 FB); Year 2 total (100% FTE) = $66,045 ($51,000 salary, $15,045 FB); Year 3 total (100% FTE) = $67,366 ($52,020 salary, $15,346 FB).The Data Scientist will write scripts to clean and prepare data for upload into the database.*			
U OF M-GEMS (Project Mgmt/Oversight). One Professional & Academic employee for 3 years with			
Professional/Technical/Service Contracts	$ 42,950		$ 42,950
Base GEMS database subscription for Year 3. Provides 16vCPUs, 2TB block storage, 50 max users, and 4 concurrent sessions.	$ -	$ -	$ -
Equipment/Tools/Supplies	$ 5,670		$ 5,670
Supplies: DNeasy PowerLyzer Powersoil Kit (Qty. 10; $567 each kit). Each Powersoil kit has 100 preps; 10 kits can process 1000 samples.	$ -	$ -	$ -
Capital Expenditures Over $5,000	$ 60,400		$ 60,400
*QIAcube Connect (Qty. 2; $20,000 each, **$40,000 total**). Sequencing machines that allows automated DNA, RNA, and protein sample processing.*	$ -	$ -	$ -
*Bertin Precellys Evolution homogenizer with soil adaptor (Qty. 1; **$10,900**); for homogenizing soil and lysing microbial cells for DNA extraction.*			
*NanoDrop One Spectrophotometer (Qty. 1; **$9500**). The NanoDrop will be used to determine DNA concentration and quality of DNA prior to sequencing.*			
Printing	$ 12,000		$ 12,000
Cost of publishing information in refereed scientific journals (Years 1-3)	$ -	$ -	$ -
COLUMN TOTAL	$ 758,860	$ -	$ 758,860

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind:		$ -	$ -	$ -

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
		$ -	$ -	$ -

Minnesota Soil and Plant Microbiomes: Foundational Database for Environmental Health



- Document Minnesota's soil and plant microbiome resources
- Protect and preserve microbiome diversity to support ecosystem health
- Enhance understanding to build effective management and decision-making for Minnesota resource managers
- Build a foundational database to inform Minnesota policy, management, and science

Project Title: Soil and plant microbiomes: A 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 and plant microbiome database 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 organized and led an international workshop on Agricultural Microbiomes in August of 2018 that brought together over 150 scientists from public and private sectors. 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, and the IAA to conduct the project, as well as the Minnesota Department of Agriculture (MDA) and Minnesota Department of Natural Resources. Drs. Philip Pardey and Kevin Silverstein, with the UM IAA, will manage database development and incorporation of the Minnesota microbiome data 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.