**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**

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| **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.*

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| **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 |

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| **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.*

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| **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 |  |

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| **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.*

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| **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.