Environment and Natural Resources Trust Fund
2016 Request for Proposals (RFP)

Project Title: **ENRTF ID: 010-A**

Microbes at SNAs: Preservation of Minnesotas Biodiversity

Category: A. Foundational Natural Resource Data and Information

Total Project Budget: $ 417,324

Proposed Project Time Period for the Funding Requested: 2.5 years, July 2016 to February 2019

Summary:

We will create a foundational state-wide atlas and database linking microbial and plant biodiversity, which will significantly enhance our ability to understand, preserve, and manage Minnesota's diverse ecosystems.

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

In 2014, we conducted a pilot project to explore microbial diversity, richness, and function across selected Minnesota Scientific and Natural Areas (panel a). Based on microbial community composition data collected from our pilot project, we are able to show that our approach is useful to show state-wide patterns in the number of microbial species present (panel b) as well as differences in the abundance of nitrogen cycling microbes (panel c). These preliminary results are important for showing the promise of our proposed approach. In order to develop a more complete state-wide atlas and get a more accurate assessment of spatial and temporal variability, we propose to conduct repeat sampling at selected 2014 sites while adding new locations to be sampled for this project.

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

PROJECT TITLE: Soil Microbes at SNAs: Preservation of Minnesota's Biodiversity

I. PROJECT STATEMENT

We propose to put soil microbes literally on the map in Minnesota, a state with a tremendous wealth of diverse natural habitats. A number of state- and federally-funded projects involving agriculture, habitat restoration, pollution mitigation, invasive species management, and changing weather patterns are currently underway, but there is currently no systematic state-wide baseline dataset against which researchers and managers can compare soil microbial diversity and functioning measurements in natural systems. This strongly limits our ability to effectively manage and preserve our state's sustainable natural resources. Despite being largely invisible, microorganisms are increasingly recognized as the engines that drive ecosystem biodiversity. This is particularly true of microbes present in soils, which have been shown to play an essential role in the health and functioning of many terrestrial ecosystems. The effects of microbial-driven processes are diverse but largely center on the cycling of nutrients, which plays a foundational role in driving the productivity and richness of the plant and animal communities. We will combine state-of-art DNA sequencing with microfluidic assays to generate a robust map of microbial species richness and functioning across the state. The characteristics of soil microbial communities will then be linked to the diversity of the aboveground biota, particularly the plant species that define Minnesota's natural ecological communities. To achieve this goal, we will leverage an existing partnership with the DNR to sample a set of Scientific and Natural Areas (SNAs) that represent all of the major ecological habitats present in Minnesota. SNAs provide an ideal platform from which to provide this information as they cover a broad geographic area and range of habitats, have detailed information about plant communities present, and the environmental data (such as temperature and precipitation) for each SNA site is publicly available. Moreover, data from the SNAs where restoration activities, invasive species reduction, and/or pollution mitigation are occurring will help to directly link natural systems with managed landscapes. Collectively, this project will provide a key benchmark for research and management aimed at preserving the richness and functioning of Minnesota's terrestrial ecosystems.

In 2014, we conducted a pilot project characterizing soil microbial community composition at 46 sites across the state (35 of which were SNAs). Our initial coverage was literally corner-to-corner in Minnesota; sites sampled spanned 600km north to south and 500km east to west (Figure 1a) and represented 19 different ecological provinces, habitats and biomes (http://www.dnr.state.mn.us/ecs/index.html). We successfully obtained data on soil microbial composition from all the sites and Figure 1b displays how species richness patterns vary across the state. Given the important role that microbes play in nutrient cycling, we also looked specifically at the distribution of microbes directly involved in nitrogen cycling (Figure 1c). This nutrient is considered one of the most important limiting nutrients in agriculture in Minnesota, but can also negatively impact the ecological health of our state's rivers, streams, and lakes as well as human populations (i.e. blue baby syndrome). Our initial results show that there is clearly important variation across the state in microbial species richness and understanding the ecological drivers and consequences of that variation will significantly enhance our ability to manage both natural and human-modified landscapes.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Project Sampling and Data Collection* **Budget: $ 319,844**

We have identified 26 sites from our original 2014 survey to continue sampling, and 24 new sites to be added (Figure 1a). Sampling multiple habitat types within a single site will bring the total number of sampling sites to 75, the vast majority of which are outside the metro area. To minimize within-year variation, site visits will be concentrated in a six-week period between early June to mid-July. At each site, a small volume of soil (less than 1 cup) will be removed and processed at the University of Minnesota for microbial identification and functioning using high-throughput barcode DNA sequencing, microfluidic gene-chip assays, and quantitative PCR. From the same samples, we will conduct a series of soil chemical analyses to determine soil carbon and nitrogen status.

We will compile that information, along with publicly available climate and weather data and plant community richness from each site, to build a series of predictive models of how soil microbial diversity drives aboveground plant diversity as well as responds to variation in environmental conditions.

Outcome: State-wide map of soil microbial diversity and functioning	Completion Date
1. Sampling of Minnesota SNAs for microbial diversity and functioning	*July 2017*
2. Microbial identification and functioning assays	*June 2018*
3. Statistical analyses and predictive diversity models	*August 2018*

Activity 2: *Project Outreach* **Budget: $ 90,000**

We will produce new interactive displays and kiosks at the new Bell Museum of Natural History and the Science Museum of Minnesota that highlight Minnesota's SNAs, their associated microbial and plant biodiversity, and their importance for preserving ecosystem functioning. Both of these facilities host thousands of visitors each year, which will allow us to reach a large portion of the state-wide community. By establishing these exhibits, we will share our data with the public in easy-to-understand formats and bring to the forefront the importance of microbial diversity in nutrient cycling and the preservation of biodiversity throughout Minnesota's diverse habitats.

Outcome	Completion Date
1. Diorama about microbial diversity at Bell Museum of Natural History (BMNH)	*January 2019*
2. Kiosk about microbial diversity at Science Museum of Minnesota (SMM)	*January 2019*

Activity 3: *Project Data Dissemination* **Budget: $ 7,480**

We will create a database and website for researchers, land managers, state agencies, and the general public (including students) to publicly access all of the data collected. In addition to making data publicly accessible, this website will describe the goals of this study, summarize project results using straightforward language, and include links to relevant scientific publications as well as those resulting from this study.

Outcome	Completion Date
1. Database of microbial diversity and functioning	*December 2018*
2. Interactive website of microbial diversity and functioning	*December 2018*

III. PROJECT STRATEGY

A. Project Team/Partners. The project will be carried out under the direction of Drs. Peter Kennedy (PI) and co-PIs Mike Sadowsky, Brent Dalzell, John Rotenberry, Chris Staley, and Satoshi Ishii. Funded project partners will include the Science Museum of Minnesota (SMM) and the Bell Museum of Natural History (BMNH). We will collaborate with Peggy Booth at the Minnesota Department of Natural Resources, Pat Hamilton at SMM, and Susan Weller at BMNH for dissemination activities.

B. Timeline Requirements. The project will be completed in 2.5 years. The first 1.5 years will be dedicated to sampling and data analyses. The final year will focus on analyses, outreach, and dissemination of results.

C. Long-term Strategy and Future Funding Needs. This request will provide the basis for long-term, continuing study of the microbial and plant diversity of the state of Minnesota and future restoration efforts such as the Minnesota Prairie project. Additional funding for more extensive analyses will be sought from the National Science Foundation, Department of Energy, and private foundations.

2015 Detailed Project Budget

Project Title: Soil Microbes at SNAs: Preservation of Minnesota's Biodiversity

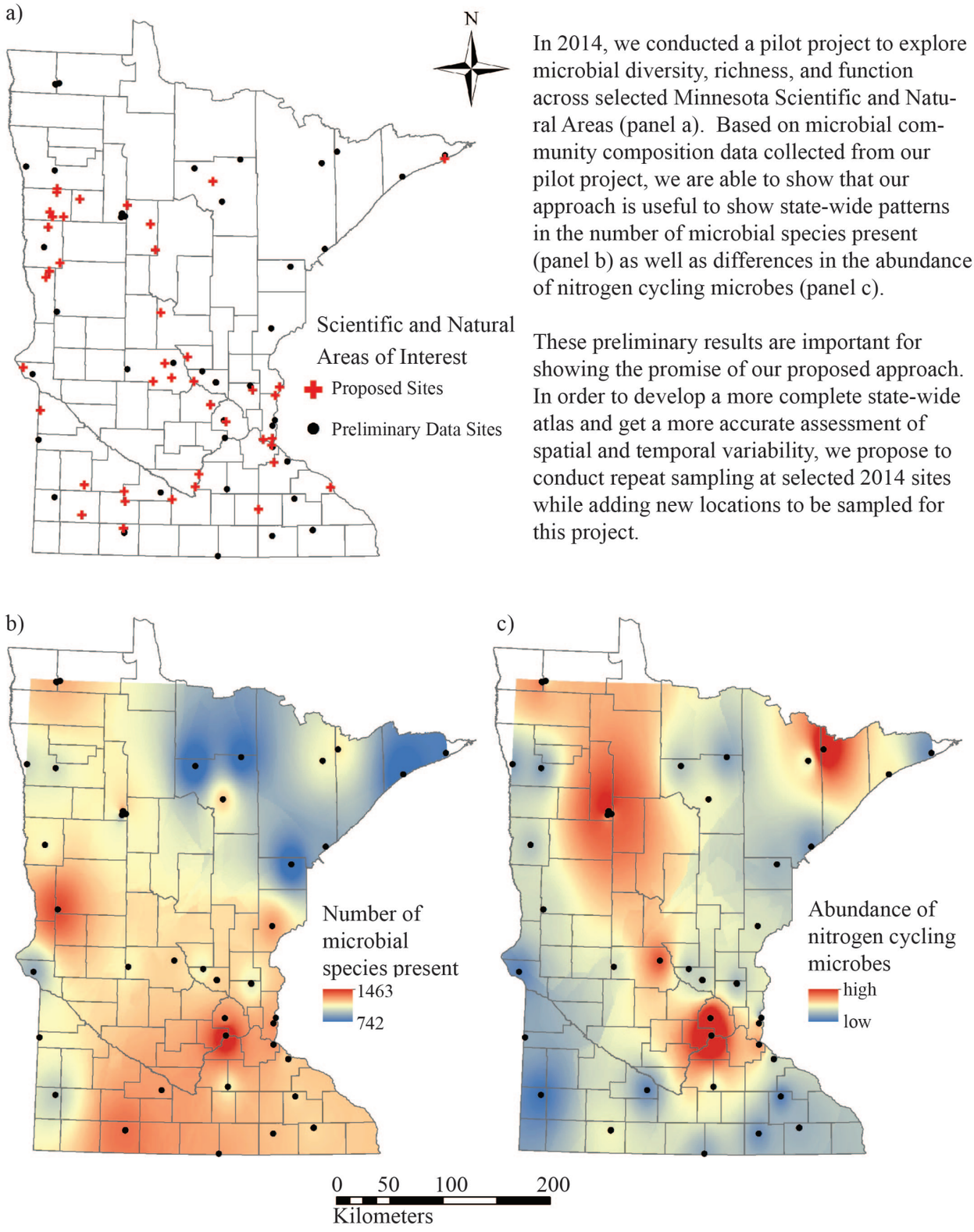
IV. TOTAL ENRTF REQUEST BUDGET 2.5 years

BUDGET ITEM	AMOUNT
Personnel:	
Research Associate Dalzell (2.5 yrs @ 25% time = $34,354.88 salary + $11,611.95 fringe)	$ 45,967
Research Associate Staley (2.5 ys @ 20% time = $22,143.90 + $11,306.10 fringe)	$ 33,450
Research Associate Rotenberry (10 months @ 75% tim = $36542.04 salary + $18,657.60 fringe)	$ 55,200
Postdoctoral Associate (2.5 yrs @ 100% time =$95,160 salary + $26,840 22% fringe)	$ 122,000
GIS support, UMN Soil & Landscape Anlaysis Laboratory ($1,500 / yr for 2.5 years)	$ 4,500
Website staff (1 month @ 100% time = $5,500 salary + $1980 fringe)	$ 7,480
Contracts:	
Exhibit at Science Museum of Minnesota (staff time and materials)	$ 50,200
Exhibit at Bell Museum	$ 39,800
Equipment/Tools/Supplies:	
Laboratory and field supplies: $5,100 per year × 2 years	$ 10,200
Acquisition (Fee Title or Permanent Easements):	$ -
Travel:	
Car rental for in-state travel @$726 per year x 2 years	$ 1,452
In-state travel to collect 75 samplings per year × 2 years @3000 mi × $0.50/mi	$ 3,000
Room & board for field sampling @ $3,663 per year x 2 years	$ 7,326
Additional Budget Items:	
Sample analysis: 150 soil samples: microbial identification as @$80/sample = $11,942, microbial functioning @$59/sample = $8,850, soil physiochemical analysis @$106.38/sample= $15,957.50). All these analyses are done most cost effectively in specialty facilities that charge by the sample.	$ 36,750
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 417,324

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ Being Applied to Project During Project Period: College of Biological Sciences support for pilot sampling and microbial identification	$ 19,500	*Spent*
Other State $ Being Applied to Project During Project Period:	0	
In-kind Services During Project Period: The University of Minnesota does not charge the State of Minnesota its typical overhead rate of 52% of the total direct costs	$213,897	
Remaining $ from Current ENRTF Appropriation (if applicable):	$ -	
Funding History: LCCMR project, *Mississippi Water Quality – Deeper Look, Broader Impacts will be leverage to this project (July 2011-December 2014).*	$557,000	

Figure 1. Sampling Locations and Preliminary Results.



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Project Manager Qualifications and Organization Description

Project Manager Team
Peter Kennedy (PI) (UMN, Plant Biology)
Mike Sadowsky (co-PI) (UMN, BTI and Soils, Water, Climate)
John Rotenberry (co-PI) (UMN, EEB)
Brent Dalzell (co-PI) (UMN, Soils, Water, and Climate)
Chris Staley (co-PI) (UMN, BTI)
Ishii Satoshi (co-PI) (UMN, BTI)

Organization Description
We have assembled a managerial team that has the collective expertise to ensure the success of the proposed research and outreach. PIs Kennedy, Sadowsky, Rotenberry, Dalzell, and Staley have collaborated in the pilot data collection for this project and established an excellent combined workflow. Co-PI Ishii brings additional expertise to the team and has collaborated with co-PIs Sadowsky and Staley on previous projects. Below are the specific tasks of each PI. In addition to those tasks, all PIs will be involved in the analysis and publication of the project data, as well as public outreach.

Kennedy: overall project coordinator, lead member of fungal microbial analyses, and post-doc mentor
Sadowsky: project outreach coordinator, co-lead member of bacterial and archaeal microbial analyses, and post-doc mentor
Rotenberry: project sample collection coordinator, lead member of ancillary SNA data collection
Dalzell: project soil nutrient collection coordinator, leader on GIS analyses
Staley: co-lead member of bacterial and archaeal microbial analyses, lead member of statistical modeling
Ishii Satoshi: lead member of microbial functioning analyses, post-doc mentor

We will have monthly in-person PI meetings throughout the duration of the project to discuss progress and any challenges that arise. Once the data is collected and analyzed by the managerial team, we will all work closely with our partners at the Bell Museum and Science Museum of Minnesota to create the exhibits regarding microbial and plant diversity at the state SNAs and their roles in ecosystem functioning.