# Environment and Natural Resources Trust Fund
# 2017 Request for Proposals (RFP)

**Project Title:** **ENRTF ID: 004-A**

Healthy Prairies II: Preserving MN Prairie Plant Diversity

**Category:** A. Foundational Natural Resource Data and Information

**Total Project Budget: $** 938,000

**Proposed Project Time Period for the Funding Requested:** 3 years, July 2017 - June 2020

**Summary:**

We will collect and preserve germplasm of plants throughout Minnesotas prairie region, study microbial effects on them, and discover the scale of local adaptation and rate of ongoing adaptation.

**Name:** Ruth Shaw

**Sponsoring Organization:** U of MN

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**Web Address** https://ruthgshaw.wordpress.com/

**Location**

**Region:** Southeast

**County Name:** Yellow Medicine

**City / Township:**

**Alternate Text for Visual:**

MN map displaying scheme for collecting and locations of field experiments in western MN. Graphics displaying prairie and plant-microbe interactions are also included.

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

## I. PROJECT STATEMENT

Minnesota prairies harbor an extraordinary diversity of plant and microbial life, while also nurturing wildlife, retaining water and topsoil, and beautifying rural landscapes. Yet habitat loss and environmental variability threaten the persistence of the once immense prairie landscape and its stunning biotic diversity. Moreover, limited understanding of this diversity and insufficient seed availability hinder cost-effective and sustainable management of this iconic Minnesota biome.

We propose Healthy Prairies (HP) Phase II to build on the extensive accomplishments under current funding (2014-2017). Our team and volunteers spent over 1000 hours scouting 27 prairie remnants and cataloging locations over MN prairie regions for 40 of the more common and widespread native prairie species. We collected seed from thousands of individuals, retaining extensive genetic variation while tracking locality. For experimental work, we have cultured over 5000 plant-associated microbes. We established seed-increase plots for 6 plant species (from 12 sites) and used these in. experimental plantings at three locations spanning the latitudinal range of MN prairies. To realize this tremendous investment in the preservation of MN prairie plant diversity, while providing essential resources and information for prairie restoration, we will:

- Preserve diverse seed from 20 of the more rare prairie species, requiring yet more extensive collection efforts.
- Obtain and maintain cultures of an additional 5000 naturally occurring microbial partners for grasses.
- Determine the geographic scale important to plant survival and reproduction in a varying environment.

Four major MN geographic regions across the native prairie will be served. Providing locally-sourced seed, the project will help restore and conserve the diversity of MN prairies and their associated wildlife, pollinator and microbial diversity.

## II. PROJECT ACTIVITIES AND OUTCOMES

### Activity 1: Preserving prairie plant diversity for conservation and restoration Budget: $168,000

We will increase availability of locally-sourced seed for use in MN prairie restorations by working with partners to increase seed collection, distribution, and to develop transfer agreements. Twenty of the more rare but important prairie species additional to the 40 species obtained in 2014-17 are targeted and these will entail greater time and scouting to collect. Efforts will be evaluated via the amount and diversity of seed collected and by the level and quality of partner involvement.

| Outcome | Completion Date |
|---|---|
| 1. Increase availability of diverse, local-sourced seed for prairie restorations by expanding our network of collectors and collection locations. Implement material transfer agreements with producers. | 2019 |
| 2. Collect locally-sourced seed for 20 rarer prairie plant species. Deposit voucher specimens at UM herbaria, deposit seed at USDA facility for long-term storage, transfer seed to producers. | 2020 |

### Activity 2: Finding your friends in unlikely places – beneficial microbes for prairie plants Budget: $382,000

We will assess the diversity and effect of naturally occurring plant-associated microbes for two types of plants essential to healthy prairies – legumes and grasses. Results will inform land managers about the use of microbes to improve prairie plant establishment in restorations, a practice common in agriculture but not yet applied to natural systems.

| Outcome | Completion Date |
|---|---|
| 1. Use microbe collections to determine beneficial microbes' potential for enhancing prairie clover (*Dalea spp.*) survival and reproduction in experimental plantings and greenhouse studies. | 2019 |
| 2. Determine the diversity of microbial communities associated with little bluestem grass (*Schizachyrium scoparium*) and collect 5000 new microbes. Store living cultures at UM and USDA. | 2019 |

| | |
|---|---|
| 3. Determine effects of plant-associated microbes on little bluestem establishment and reproduction in experimental plantings and in greenhouse studies. | 2020 |

**Activity 3: Adaptive genetic diversity of prairie plants** **Budget: $388,000**

Continue field experiments to characterize the spatial scale of local adaptation for 6 prairie perennials and to evaluate genetic variation for survival and reproduction of the iconic little bluestem grass. Results will inform methods of prairie conservation and healthy prairie restoration that maintain diversity.

| Outcome: | Completion Date |
|---|---|
| 1. Monitor survival, growth, and reproduction in established experiments with 6 species and over 6000 plants to evaluate effect of seed source on establishment and success of prairie plants in restorations. | 2020 |
| 2. Plant pedigreed little bluestem seed into field experiments to assess its capacity to adapt to varied environmental conditions, and the role of microbes (identified in Activity 2) in that process. | 2020 |

## III. PROJECT STRATEGY

### A. Project Team/Partners

*Project Team (receive funding)* - Ruth G. Shaw, UM-TC; Georgiana May, UM-TC (co-PIs); Margaret Kuchenreuter UM-Morris (collaborator; coordinating efforts in Western MN), Shelby Flint (postdoc), Kane Keller (postdoc). *Partners (funding from other sources)* – MN DNR; Dave Moeller, UM-TC (collaborator; plant-pollinator interactions); Donald Wyse UM-TC; MN Crop Improvement Association; The Nature Conservancy; MN Native Plant Society; MN Master Naturalists.

### B. Project Impact and Long-Term Strategy

Prairie plant conservation is necessarily a long-term effort as these long-lived perennials often require several years' growth before reproduction. With the LCCMR 2014-2017 funding, the HP team committed their efforts plan to build the HP project over at least 10 yr. Current efforts must be carried forward to obtain the information and materials essential to successful prairie preservation and restoration – locally-sourced seed collections for 60 total prairie species, infrastructure for their best use, microbial symbionts beneficial to prairie plant establishment, and continued evaluation of plant survival through reproduction in experimental plantings. Results will guide seed deployment and optimize the success of new plantings across the greatly varied environments encompassing the magnificent MN prairies. Looking ahead, novel approaches such as providing microbe cultures for naturally occurring beneficial microbes to companies wishing to develop inoculum for commercial use promises new partnerships and innovations, all aimed at healthy prairies for Minnesota.

The HP project has benefited from seed collection infrastructure developed with NSF funding (Shaw and colleagues), from NSF-funded microbial research (May and colleagues), and from cooperative agreements with The Nature Conservancy and MN DNR. Continuation of this work will greatly expand the knowledge base and improve the guidance to land managers and our outreach to the MN public**.** Future research to address basic questions may be funded through NSF, while the production of locally sourced and certified seed could be funded through the USDA and native seed producers. The production of inoculum for beneficial microbes will be funded through the USDA or contracts with commercial providers.

### C. Timeline Requirements

Given the long lifespans of prairie plants, three field seasons (2017 – 2020) are required to advance the stated goals.

# 2017 Detailed Project Budget

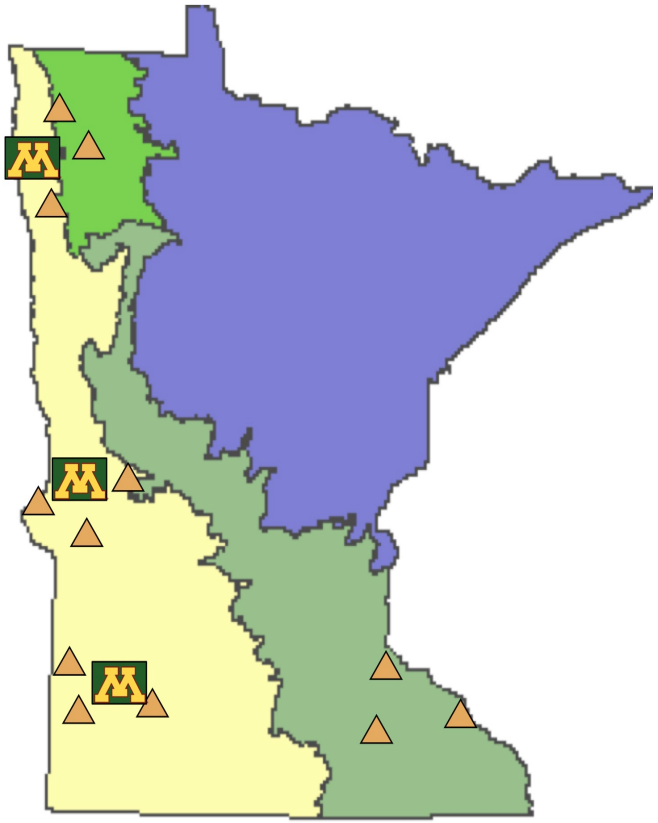
**Project Title: Healthy Prairies II: Preserving MN prairie plant diversity**

**IV. TOTAL ENRTF REQUEST BUDGET 3 years**

| BUDGET ITEM | AMOUNT |
|---|---|
| **Personnel:** Dr. Georgiana May, UM Twin Cities, coPI (75% salary, 25% benefits); 1 month per year for 3 years. Shared supervision of project with Shaw, supervise Activity 2, participate in field work. | $ 49,000 |
| **Personnel:** Dr. Ruth Shaw, UM Twin Cities, Co-PI (75% salary, 25% benefits); 1 month per year for three years. Shared supervision of project with May, supervise Activity 3, participate in field work. | $ 52,000 |
| **Personnel:**Dr. Margaret Kuchenreuter, UM Morris, collaborator (75% salary, 25% benefits); 1 month per year, for 3 years. Supervise undergraduate students in Activity 1, travel to field sites in Western MN with students. | $ 37,000 |
| **Personnel:** 2 Postdoctoral Associates (82% salary, 37% benefits); 100% FTE - Three years of support is requested. One postdoc for each of Activity 2 and 3 - data collection and analysis, also will participate in Activity 1 outreach and education activities. | $ 315,000 |
| **Personnel:** 2 Graduate Students (51% salary, 49% benefits during the academic year & 85% salary, 15% benefits during the summer); 50% FTE - Two years of support is requested | $ 183,000 |
| **Personnel:** UM Twin Cities - 2 Undergraduate Students (100% salary, 0% benefits); 8% FTE - One month per year is requested. UM Morris - 2 Undergraduate Students (100% salary; 0% benefits); 15%FTE - 2 months per year is requested. | $ 32,000 |
| **Personnel:** Coordinator of personnel - volunteers, partners and agency (e.g. DNR, DOT) interactions (e.g. permit requests), supervise undergrad workers (79% salary, 21% benefits); 100% FTE - Two years of support is requested. | $ 103,000 |
| **Personnel:** Technical assistant (79% salary, 21% benefits); 100% FTE - Two years of support is requested. Oversee seed cleaning and storage, maintain greenhouse experiments, assist in Activity 2 and 3 lab and field work. | $ 81,000 |
| **Equipment/Tools/Supplies:** Lab Supplies - (Activity 2) Microbial culturing and storage (~ 6000 cultures per year), microbial detection in plant materials and identification of organisms using molecular methods and microscopy. | $ 24,000 |
| **Equipment/Tools/Supplies:** Field supplies and prep work - (Activity 1-3) envelopes and bags, blaze hats and vests, galvanized nails and landscape staples, tape measures, fencing materials, knee pads, mallets, field notebooks. | $ 18,000 |
| **Travel:** Travel to field sites for seed collection (Activity 1), and microbial sampling (Activity 2). Monitoring experimental plots (Activities 2, 3), and seed increase plots in Rosemount. Total travel estimated: 25,000 miles in MN, with 150 hotel-person overnights, over 3 years. | $ 20,000 |
| **Additional Budget Items:** Shipping seeds to Nat'l Center for Genetic Resources Preservation (NCGRP), USDA facility in Ft. Collins, CO. (see below). $100 per shipment x 20 shipments. | $ 2,000 |
| **Additional Budget Items:** Detection, indentification, and distribution of naturally occurring microbes in native prairie plants using rapid, cutting edge "metagenomics" approaches. | $ 10,000 |
| **Additional Budget Items:** Greenhouse space rental - evalutating microbial effects on plant growth and reproduction (Activity 2), seedlings for outplanting, plant genetic variation analyses (Activity 3). 500 sq. ft. x $0.81/sqft per month x 30 months. Seed increase plot fees. | $ 12,000 |
| **TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =** | $ 938,000 |

**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:** The Nat'l Center for Genetic Resources Preservation (NCGRP), a USDA facility in Fort Collins, CO provides the invaluable service of seed preservation. We are not able to replicate that state of the art service. | $ - | *Secured* |
| **Other State $ To Be Applied To Project During Project Period:** | $ - | |
| **In-kind Services To Be Applied To Project During Project Period:** Indirect Costs (53% MTDC in FY18 and 54% MTDC in FY19 & FY20) associated with this proposal. Office, lab, and meeting space, accounting and secretarial services, phone & office equipment, security, and library access, for all project personnel. | $ 461,000 | *Secured* |
| **Funding History:** Current 2014 ENTRF funding was awarded with a work plan that extended through June 30, 2017. | $ 600,000 | |
| **Remaining $ From Current ENRTF Appropriation:** Unspent funds as of Jan. 2016 on current ENRTF award. We are 50% through the current funding period (2014-2017) and have used approximately 50% of the current funding. | $ 329,756 | *Unspent* |

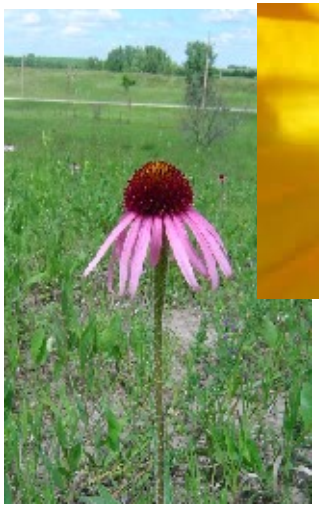


Evaluation sites
– UM Outreach stations

Collection sites


**Plant-associated microbes**
nutrient uptake
N-fixation
protection against disease

**Soil microbes**
decomposition
mineralization



**Project Manager Qualifications: Ruth Geyer Shaw**
Professor, Department of Ecology, Evolution, and Behavior, University of Minnesota-TC

**Education and Research Leaves:**

| | | |
|---|---|---|
| B.A. Biology | 1976 | Oberlin College, Oberlin, Ohio; |
| Ph.D. Botany and Genetics | 1983 | Duke University, N. Carolina |
| Post-doctoral in Genetics | 1984-1986 | University of Washington, NIH Fellow |
| Sabbatical | 1995-6 | Edinburgh University |
| Guggenheim Fellow | 2002-3 | Université de Montpellier II, France |
| Sabbatical | 2010-2011 | York University, York, England |

Throughout my career, my research has addressed fundamental questions regarding adaptation in native plant populations and has also yielded guidance for managing impacts of human disturbance, including climate change, introduction of invasive plants, and the fragmentation of populations into small remnants. In my 23 yr at UM, I have mentored graduate students' experimental studies of adaptation in prairie plant populations, and for 16 yr I have led UM's participation in an NSF-funded long-term experimental study investigating the evolutionary consequences of severe fragmentation of prairie populations of purple coneflower, *Echinacea angustifolia* (collaboration with Dr. S. Wagenius of the Chicago Botanic Garden, see http://echinacea.umn.edu). Among the key results of these studies are demonstration of: degree of local adaptation to present-day habitats and limits to rates of adaptation to climate change in partridge pea, *Chamaecrista fasciculata*[1,2], dramatic reduction in seed production of progeny from crosses between prairie plant populations[3], large differences in survival and fecundity among remnant populations[4], and exceptionally severe inbreeding depression affecting growth and fitness in purple conflower[5,6] (selected references in leading scientific journals below). Moreover, my colleagues and I have recently developed an approach for analyzing data on individual survival and fecundity, the central measures of adaptation[4,5]. This new approach, which provides far more precise inferences about adaptation than previously possible, will be crucially important to the success of the proposed research, as we have described in recent papers[7,8].

[1]Etterson, J. R. and R. G. Shaw. 2001. Constraint to adaptive evolution in response to global warming. Science 294: 151-154. [2]Davis, M.B. and R. G. Shaw. 2001. Range shifts and adaptive responses to quaternary climate change. Science 292: 673-679. [3]Heiser, D.A. and R.G. Shaw. 2006. The fitness effects of outcrossing in *Calylophus serrulatus*, a permanent translocation heterozygote. Evolution 60:64-76. [4]Geyer, C. J., S. Wagenius, and R. G. Shaw. 2007. Aster models for life history analysis. Biometrika, 94: 415-426. [5]Shaw, R.G., et al. 2008. Unifying life history analyses for inference of fitness and population growth. American Naturalist 172: E35-E47. [6]Wagenius, S., et al. 2010. Biparental inbreeding and inter-remnant mating in a perennial prairie plant: fitness consequences for progeny in their first eight years. Evolution 64:761-771. [7]Shaw, R. G. and J. R. Etterson. 2012. Tansley Review: Rapid climate change and the rate of adaptation: insight from experimental quantitative genetics. New Phytologist 195:752–765. [8]Shaw, R. G. and F. H. Shaw. 2014. Quantitative genetic study of the adaptive process. Heredity 112: 13-20.

**Organization Description:** The mission of the Department of Ecology, Evolution and Behavior is to advance and disseminate knowledge in these fields through excellence in theoretical, experimental, and field research; undergraduate and graduate education; scholarly activities; and outreach. The integration of this knowledge across levels of biological complexity is a prerequisite to addressing many of the biological and environmental challenges facing society.