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

Project Title: **ENRTF ID: 025-A**

Healthy Prairies III: Restoring MN prairie plant diversity

Category: A. Foundational Natural Resource Data and Information

Sub-Category:

Total Project Budget: $ 1,128,000

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

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 the capacity for ongoing adaptation.

Name: Ruth Shaw

Sponsoring Organization: U of MN

Job Title: Professor

Department: Department of Ecology, Evolution and Behavior

Address: 1479 Gortner Ave.

St. Paul MN 55108

Telephone Number: (612) 624-7206

Email shawx016@umn.edu

Web Address: http://ruthgshaw.wordpress.com/

Location:

Region: Central, Metro, Northwest, Southwest, Southeast

County Name: Becker, Clay, Cottonwood, Douglas, Houston, Jackson, Lac qui Parle, Lyon, Mahnomen, Murray, Nobles, Norman, Pipestone, Polk, Pope, Ramsey, Rock, Stearns, Stevens, Wabasha, Washington

City / Township:

Alternate Text for Visual:

Illustrations of the three Activities: gathering seeds in prairie remnants, evaluating microbial effects on Dalea, map of experimental sites, as well as collection sites.

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

PROJECT TITLE: Healthy Prairies III: Resources for restoring MN prairie plant diversity

I. PROJECT STATEMENT

We request a third funding allocation to the Healthy Prairies Project to further realize the tremendous investment in the preservation of MN prairie plant diversity, and to provide essential resources and information for prairie restoration. We will:

- Preserve diverse seed from 20 of the rarer prairie species, and develop methods for propagating them.
- Evaluate roles of beneficial microbes in successful conversion of marginal agricultural land to resilient prairie.
- Evaluate the decline of prairie plant survival and reproduction with distance from source.

We will build on the extensive accomplishments of two previous phases of funding (2014-2020) and garner the materials and knowledge necessary to prairie restoration that is resilient to environmental challenges. Our team at UM-TC and UM-Morris and more than 50 volunteers have devoted over 2500 hours at 66 prairie remnants, collecting seeds of 90 native prairie species, retaining extensive genetic variation while tracking locality. We have also cultured over 5000 microbes from prairie plants. Among our experimental results are indications that a) Dalea (prairie clover) transplanted closer to their source site establish more beneficial microbial associations and b) prairie plant adaptation depends on environmental similarity as well as proximity. All our efforts address the critical need to maintain and restore Minnesota's native prairies.

Project results will guide seed deployment and optimize the success of new plantings across the greatly varied environments of MN prairies, thereby addressing pressing challenges to the preservation and restoration of the extraordinarily diverse plant and microbial life harbored in MN prairies. This work is critically important as habitat loss and rapid environmental change threaten the persistence of the once vast prairie and its stunning biotic diversity that nurtures wildlife, purifying water and retaining topsoil. Moreover, limited understanding of this diversity and insufficient seed availability hinder cost-effective and sustainable restoration of the iconic Minnesota prairie biome. We actively communicate with stakeholders in prairie restoration to provide essential resources and information emerging from our work. Thus, project outcomes contribute to the economic and ecological well-being of Minnesota's public by providing information and materials supporting prairie restoration.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Preserving prairie plant diversity for conservation and restoration

ENRTF BUDGET: $185,187

Description: Working with our partners across MN, we will increase the availability of source-identified seed for use in MN prairie restorations. New collections will target 20 rarer yet important prairie species. Efforts will be evaluated via the amount and diversity of seed collected, by the number of species for which propagation methods are developed, and by the degree of partner involvement.

Outcomes	Completion Date
1. Establish material transfer agreements with producers.	*2021*
2. Research propagation methods for species that are currently difficult to propagate.	*2022*
3. Increase availability of source-identified seed for use in MN prairie restorations through collection of 20 additional species from geographically widespread locations. Deposit voucher specimens at UM.	*2023*

Activity 2: Beneficial microbes: hidden partners in prairie restoration.

ENRTF BUDGET: $503,303

Description: We will use experimental plots to determine the diversity and effect of naturally occurring microbes for two types of plants essential to healthy prairies - legumes and grasses. Results will inform land managers about the use and role of beneficial microbes for successfully establishing new prairie restorations after conversion of marginal agricultural land.

Outcomes	Completion Date
1. Determine changes in soil nutrients, organic matter, and microbial communities after conversion of marginal agricultural fields to prairie plantings.	*2022*

2. Assess the role of beneficial microbes in drought tolerance of little bluestem in greenhouse and field experiments.	*2022*
3. Evaluate the role of beneficial nitrogen-fixing microbes for prairie clover (Dalea spp.) establishment and growth in new restorations, compare local and more distant plant-microbe combinations.	*2023*

Activity 3: Adaptive genetic diversity of prairie plants **ENRTF BUDGET: $439,510**

Description: Continue field experiments to characterize the spatial scale of local adaptation for 6 prairie perennials, evaluate genetic variation for survival and reproduction of little bluestem grass, and assess effects of interbreeding between its populations. Results will inform methods of prairie conservation and restoration that maintain genetic diversity.

Outcomes	Completion Date
1. Continue monitoring established experiments with over 6000 plants in 3 sites to evaluate the effect of seed source on survival, growth, and reproduction in prairie plants within restorations.	*2023*
2. Evaluate pedigreed little bluestem populations in field experiments to assess their genetic capacity to adapt to varied environmental conditions.	*2023*

III. PROJECT PARTNERS AND COLLABORATORS:

A. Project Team/Partners

Project Team - R. G. Shaw, UM-TC; G. May, UM-TC; L. Kinkel (UM-TC collaborator); M. Kuchenreuther UM-Morris (collaborator; coordinating efforts in Western MN), S. Flint and A. Pozzi (postdocs). *Partners* – MN DNR; Drs. D. Moeller and D. Wyse UM-TC; J. Shaub (collector, N. MN); MN Crop Improvement Association; The Nature Conservancy (TNC); MN Native Plant Society; MN Master Naturalists, US Fish and Wildlife Service Prairie Restoration Initiative.

B. Project Impact and Long-Term Strategy

With LCCMR funding 2014 and 2017, the Healthy Prairies team committed their efforts to build this project over at least 10 yr because the conservation of these long-lived perennials is necessarily a long-term effort. We are now poised to translate the information and materials developed through previous funding into contributions to successful prairie preservation and restoration – methods to improve propagation of source-identified seed collections for 90 prairie species and of microbial symbionts that promote prairie plant establishment, improved practices widely disseminated through our extensive outreach, and continued evaluation of plant survival and reproduction in experimental plantings. The HPP serves four major MN geographic regions across the native prairie through our active outreach to citizens, the TNC, the DNR, and seed suppliers. Increasing supply of source-identified seed and beneficial microbes, while addressing open questions, the project will help restore and conserve the diversity of MN prairies and of their associated wildlife and pollinators, and improve soil and water quality.

The HP project leverages funding and expertise from seed collection infrastructure developed with NSF funding (Shaw and colleagues), from NSF-funded microbial research (May and colleagues), and from cooperative agreements with TNC 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 is facilitated through our material transfer agreements with local producers of native plant seed. The production of inoculum for beneficial microbes will be funded through the USDA or contracts with commercial providers.

IV. LONG-TERM IMPLEMENTATION AND FUNDING:

Given the long lifespans of prairie plants and complexity of microbial plant communities, continuing the established projects through three more field seasons (2020 – 2023) is required to advance the stated goals.

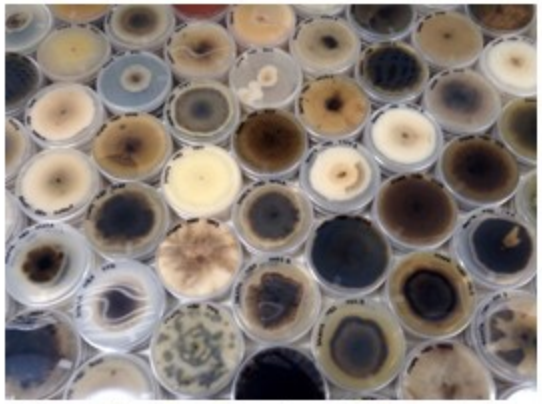
Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Dr. Ruth Shaw, Dr. Georgiana May
Project Title: Healthy Prairies III: Resources for restoring MN prairie plant diversity
Organization: Dept. Ecology, Evolution and Behavior, U. Minnesota
Project Budget: $1,128,000
Project Length and Completion Date: 3 years, completion June 30, 2023
Today's Date: April 4, 2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 1,004,000	$ -	$ 1,004,000
Dr. Ruth Shaw, Co-PI, UMN-Twin Cities, $29,000 (75% salary, 25% benefits), 4% FTE each year			
Dr. Georgiana May, Co-PI, UMN-Twin Cities, $27,000 (75% salary, 25% benefits), 4% FTE each			
Dr. Margaret Kuchenreuter, collaborator, UMN-Morris, $40,000 (75% salary, 25% benefits),			
2 Postdoctoral Associates, $395,000 (81% salary, 19% benefits); 100% FTE - Three years of			
2 Graduate Students, $109,000 (53% salary, 47% benefits during the academic year & 85%			
4 Undergraduate Students, $87,000 (100% salary, 0% benefits); 29% FTE-			
Field Tech, $171,000 (78% salary, 22% benefits), 100% FTE -			
Lab Tech, $146,000 (78% salary, 22% benefits), 100% FTE -			
Professional/Technical/Service Contracts	$ 9,000	$ -	$ 9,000
Consultants - Jeff Shraub (Northern MN seed collections)			
Equipment/Tools/Supplies	$ 28,000	$ -	$ 28,000
Supplies ($28,000) - field and lab (microbial and molecular) supplies			
Travel expenses in Minnesota	$ 55,000	$ -	$ 55,000
Travel - Travel to field sites for seed collection (Activity 1) and microbial sampling (Activity 2), establishing and monitoring experimental plots (Activities 2, 3), and seed increase plots in Rosemount. Total travel estimated: 30K mi in MN, w/ 270-hotel person overnights, over 3 yrs. All travel to be conducted per UMN Policy as required in Guidelines On Allowable Expenses.			
Other	$ 32,000	$ -	$ 32,000
Soil Analyses ($3,000) - 150 analyses @ $20 each, as per UMN STL current rates			
Lab Analyses ($14,000) - UM Genomics Center - sequencing, 10 analyses @ $1,400 each			
Greenhouse Fees ($8,000) - UM GH - 800 sq. ft for 12 months over 3 years, at $0.8 per sq. ft. per month, per current UMN greenhouse rental rates			
Publications ($6,000) - page fees - dissemination through appropriate journals and publications			
Mailing or Courier Fees ($1,000) - send seeds collected by collaborators at outstate sites to UM			
COLUMN TOTAL	$ 1,128,000	$ -	$ 1,128,000

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Indirect costs (54% MTDC) associated with this proposal	secured	$ 592,000	$ -	$ 592,000

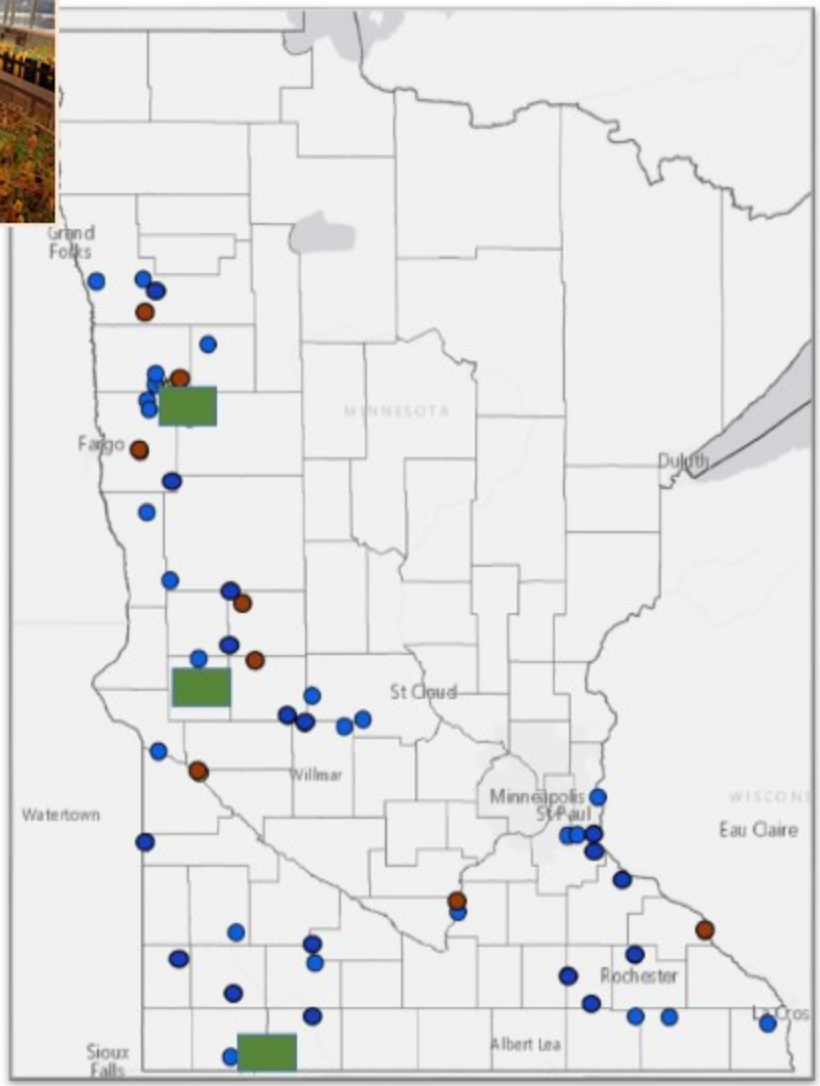
Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
HP I: 2014-2017	$ -	$ 600,000	$ 600,000	$ -
HP II: 2017-2020 obligated funds are for salary and fringe of project personnel	$ 225,754	$ 900,000	$ 490,300	$ 409,700

Activity 1: Preserving prairie plant diversity. With our partners across the state, collect 20 additional rare species from varied environments, develop propagation methods, and transfer to producers.



Microbial diversity cultured from plants

Activity 2: Beneficial microbes: hidden partners in prairie restoration. Characterize beneficial impacts of microbes for little bluestem (grass) and prairie clover (legume). Evaluate changes in beneficial microbes with conversion of marginal ag. land to prairie.



Activity 3: Adaptive genetic diversity of prairie plants. Map of remnant prairie collection sites (blue = SNA, red = TNC) and 3 evaluation sites (green). Seeds of 6 different species from 16 sites are grown in the three evaluation sites to assess capacity for adaptation to differing environmental conditions.

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, North Carolina
Post-doctoral in Genetics	1984-1986	University of Washington, NIH Fellow
Sabbatical	1995-6	Edinburgh University
Guggenheim Fellow	2002-3	Université de Montpellier, France

Throughout my career, my research has addressed fundamental questions regarding evolutionary 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 26 yr at UMN, I have mentored graduate students' research concerning adaptation in prairie plant populations, and for 13 yr I have led UMN'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: 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, is crucially important to the success of the proposed research. Using it, we have recently documented substantial capacity for ongoing adaptation.[7]

[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]Sheth, S. N., et al. 2018. Expression of additive genetic variance for fitness in a population of partridge pea in two field sites. Evolution 72: 2537-2545.

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

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