Environment and Natural Resources Trust Fund
2011-2012 Request for Proposals (RFP)

Subd: 03i

Project Title: Conserving Prairie Plant Diversity and Evaluating Local Adaptation

Category: C1+2. Protection, Restoration, and Enhancement

Total Project Budget: $ $525,000

Proposed Project Time Period for the Funding Requested: 3 yrs, July 2011 - June 2014

Other Non-State Funds (secured): $ 0

Summary:

Seeds of prairie plants will be gathered from throughout MN and archived for long-term conservation. Experiments will evaluate local adaptation, adaptive potential, and beneficial and deleterious interactions with micro-organisms.

Name: Ruth Shaw

Sponsoring Organization: U of MN

Address: 450 McNamara Alumni Center, 200 Oak Street SE
Minneapolis MN 55455-2070

Telephone Number: 612-624-7206

Email shawx016@umn.edu

Web Ad http://www.cbs.umn.edu/eeb/faculty/ShawRuth/

Location:

Region: NW, Central, SW

Ecological Section: Lake Agassiz, Aspen Parklands (223N), Red River Valley (251A), North Central Glaciated Plains (251B)

County Name: Dakota, Douglas, Polk, Redwood

City / Township:

2011-2012 MAIN PROPOSAL

PROJECT TITLE: Conserving prairie plant diversity and evaluating local adaptation

I. PROJECT STATEMENT

Since European settlement, the once vast expanses of MN prairie, approximately 18 million acres, have been diminished to small remnants totaling less than 1% of their former extent. Similarly, the once tremendous genetic diversity within each of over a hundred prairie species has been drastically reduced. Consequently, remnant populations are subject to severe inbreeding depression, which can lead to further population decline. Increasingly, it is recognized that prairies play important roles for:

- support of diverse wildlife
- roadside stabilization
- sustainable harvest of biomass for fuel production
- improvement of water quality.

In addition to valuing these essential ecological services, interest in preserving the natural beauty of prairies for future generations is spurring efforts to restore diverse prairie communities on extensive scales. However, such large-scale prairie restorations face daunting challenges.

Large-scale restorations that will thrive require large quantities of seeds adapted to the environment in which they will be grown. Even small remnants of prairie, scattered over the 4 subsections of MN's Prairie Parkland Province, contain valuable genetic resources. Measures to protect these remaining genetic resources now can preserve the remaining genetic variation, which will be available as germplasm for massive restorations and also for adaptation to climate change and to new human uses. Minnesota's prairie plants have been adapting to their local climates and soils since the glaciers receded 14,000 years ago. Associated pathogens and beneficial microbes such as nitrogen-fixing bacteria adapted along with the plants. However, climate change is now occurring at a rate too fast for plants to adapt. Consequently, it is likely that climate change will be accompanied by losses of native plants and invasion of noxious weeds. With the GOAL of preserving prairie plant diversity in Minnesota, we propose to accomplish the following OUTCOMES: preservation of germplasm of prairie species from locations throughout the prairie region of MN and elucidation of the scale of local adaptation in plants and their associated microbes. This work will provide fundamental information necessary to the state's effort to establish both scientifically sound and economically feasible criteria for use of these prairie resources. We will gather seeds and archive them in conditions to maximize their longevity, and we will conduct experimental studies to evaluate the scale of local adaptation of plants and the associated microbes.

II. DESCRIPTION OF PROJECT ACTIVITIES

Activity 1: **<u>Collection and conservation of prairie plant genetic diversity.</u>** **Budget:** $75,000

We will collect seeds of at least 16 species characteristic of Minnesota prairies for conservation and research. We will sample moist and dry habitats in at least 3 populations in each of 4 ecologically defined subsections of the state, taking care both to ensure that genetically representative samples are obtained for each population and to avoid severely depleting seed input to the site. Samples will be stored in the state-of-the-art facility at the USDA National Center for Genetic Resources Preservation in Fort Collins, Colorado, *at no cost* to the state of MN. This federal facility has developed best practices to maximize seed viability over long-term storage, and facilities and staff there cannot feasibly be duplicated in MN. Seed resources will not be deployed to Colorado or any other state or private agency, and the state of MN and this project retains ownership of all seeds. Staff at the seed facility will assess viability and study the longevity of seeds. This genetic material will be made available to MN seed producers at nominal cost. **Outcomes: 1**. A lasting archive of a well-designed sample of genetic diversity of at least 16 prairie species. **Completion Date:** October 2012. **2.** Measures of the initial viability of seed samples.

Completion Date: December 2012. **3.** Estimates of the longevity of the stored seeds. **Completion Date:** December 2014.

Activity 2: <u>Establishment of long-term studies of local adaptation</u>. Budget: $<u>165,000</u>

To rigorously evaluate the scale and degree of local adaptation, we will focus on 6 species that typify MN prairie, including iconic prairie grasses and legumes. We will plant seeds from all sampled populations at sites within 3 of the subsections of MN's Prairie Parkland Province. We will significantly reduce costs by utilizing existing UM Research and Outreach Centers. We will monitor survival and growth of plants from each sampled population at each site and determine the relationship between plant survival and geographic location, and soil moisture differences across a local site.

Outcomes: 1. Experiments to evaluate effects of seed source distance on establishment and long-term success of prairie plants in restorations. **Completion Date:** August, 2013. **2.** Relationship between early performance of plants and distance to source as well as habitat characteristics. **Completion Date:** August, 2013, continuing over long term.

Activity 3: <u>Evaluation of the potential of prairie populations to adapt.</u> Budget: $<u>125,000</u>

The rate at which plants adapt to climate changes depends on the amount of genetic variation available for adaptation to geographic location, soil conditions, and to climate change. We will assess the available genetic variation by conducting quantitative genetic studies of plant characteristics involved in adaptation; for example, leaf thickness is often important for adaptation to drought. These studies will focus on 1 species that is also represented in the local adaptation experiment (Activity 2).

Outcomes: 1. Prediction of rates of adaptation based on genetic variation and natural selection.
Completion Date: June, 2014, continuing over long term.

Activity 4: <u>Assessment of effects of microorganisms' on prairie plants.</u> Budget: $<u>160,000</u>

New plant populations are quickly found by their pathogens. Moreover, seed cleaning typical of restoration efforts does not remove pathogenic fungi within seeds. On the other hand, some plants require particular microbes to survive and grow. Absence of the necessary microbes can preclude establishment of these species. Information on local adaptation in plant-associated microbes will help to manage these resources to enhance restoration efforts.

Outcomes: 1. Identification of beneficial and pathogenic microbial associates of prairie plants.
Completion Date: June, 2014, continuing over long term.

III. PROJECT STRATEGY

A. Project Team: UMN faculty, Drs. Shaw, Wyse, May. **Partners:** UMN faculty Galatowitsch, Tiffin, MN DNR's Garms have agreed to contribute in-kind services, as has the Federal seed storage lab. We are discussing cooperation with MN DOT, The Nature Conservancy, and the White Earth Band of Ojibwe.

B. Timeline Requirements: Three years are required for evaluation of degree and scale of local adaptation of plants through the period of emergence and establishment, as also for the quantitative genetic studies of potential for ongoing adaptation. The microbial studies, involving isolation and identification of microbes, followed by evaluation of their effects on plants, also demand minimally three years.

C. Long-Term Strategy and Future Funding Needs: We plan to build this project over at least 10 years, and expand the project to include more plant species and more locations within MN. As the project expands, we anticipate requesting funding supplements from LCCMR. Funding of this proposal for the labor-intensive establishment of study plots will be *leveraged* into federal funding from the National Science Foundation (NSF). Such an expanded, federally funded project would yield greater insight into differences among species and habitats regarding local adaptation, as well as providing educational and outreach programs to the MN public.

2011-2012 Detailed Project Budget

IV. TOTAL TRUST FUND REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel: - Prof. Ruth Shaw - One month summer salary per year is requested for supervision of the seed sampling and field experiments investigating local adaptation component of the project. 76% salary, 24% benefits	$ 44,000
Personnel: Prof. Georgiana May - One month of summer salary per year is requested for the microbial studies component of the project. 76% salary, 24% benefits.	$ 40,000
Personnel: **Prof. Donald Wyse** - No salary is requested. He will supervise the seed sampling and field experiments investigating local adaptation component of the project (along with Prof. Ruth Shaw).	$ -
Personnel: PostDoc - One full-time position for two years. This position will be responsible for seed sampling and field experiments investigating local adaptation. 83% salary, 17% benefits	$ 98,000
Personnel: Graduate Student - Two half-time positions for two years. One position will be responsible for seed sampling and field experiments investigating local adaptation. The other position will work on the microbial studies. 62% salary, 38% benefits	$ 192,000
Personnel: Research Scientist - One half-time position for two years and one quarter-time position for three years. 73% salary, 27% benefits	$ 70,000
Personnel: Undergraduate Student - Four students for two months each during the summer. These positions will assist with fieldwork. 93% salary, 7% benefits.	$ 28,000
Contracts:	$ -
Equipment/Tools/Supplies: Supplies - Greenhouse and field supplies include materials for gathering seeds; pots, soil, and tags for establishing plants in the greenhouse; and stakes for delineating plots in the field. Lab supplies include petri dishes, media and reagents.	$ 20,000
Acquisition (Fee Title or Permanent Easements):	$ -
Travel: Travel within MN to sites for collecting seeds and to locations of experimental plots ($0.50 per mile).	$ 21,000
Additional Budget Items: DNA Sequencing - to identify microbes associated with plants; includes sample prep and analyses @ $10/sample x 1200 samples (300 per	$ 12,000
TOTAL ENVIRONMENT & NATURAL RESOURCES TRUST FUND $ REQUEST	$ 525,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ Being Applied to Project During Project Period:	$ -	
Other State $ Being Applied to Project During Project Period:	$ -	
In-kind Services During Project Period:	$ -	
Remaining $ from Current ENRTF Appropriation (if applicable):	$ -	
Funding History:	$ -	

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

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, France

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 17 yr at UM, I have mentored graduate students' experimental studies of adaptation in prairie plant populations, and for 10 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]. Because this new approach provides far more precise inferences about adaptation than previously possible, it will be crucially important to the success of the proposed research.

[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.

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. http://www.cbs.umn.edu/eeb/