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

LCCMR ID: 063-C1+2

Project Title: Conserving Prairie Plant Diversity and Evaluating Local Adaptation

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

Total Project Budget: $ $787,000

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

Other Non-State Funds: $ 0

Summary:

We will conserve the genetic diversity of plants of the MN tallgrass prairie and develop a scientific basis for identifying adapted seed sources for restoring prairie ecosystems.

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Sponsoring Organization: U of MN

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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:

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

2011-2012 MAIN PROPOSAL

PROJECT TITLE: Conserving prairie plant diversity and evaluating local adaptation

I. PROJECT STATEMENT

At one time, native MN prairie covered vast expanses of approximately 18 million acres, but today are reduced to small remnants totaling less than 200,000 acres, only 1% of the original stands. While 200,000 acres is an impressive commitment to conservation by Minnesotans, genetic diversity within each of over a hundred prairie species has been drastically reduced and will severely limits plants' ability to adapt to future climatic and ecological change.

Minnesota's prairie plants have been adapting to 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 and instead, climate change threatens loss of native plants and invasion of noxious weeds. The prairie's long-term stability and adaptability is threatened.

At the same time, we recognize the tremendous value of prairies, and of prairie plants, for wildlife habitat, for roadside stabilization, for sustainable bio-fuel production, and for improvement of water quality. In addition to these essential ecological services, the natural beauty of prairies and prairie plants provides for enjoyment and recreation to future generations. The concerns of diverse stakeholders have spurred efforts to restore diverse prairie communities on extensive scales and to conserve existing resources. However, large-scale prairie restorations and conservation efforts face daunting challenges.

In order to thrive, large-scale restorations require large quantities of seeds adapted to local environment in which they will be grown. We may well have these resources as even small remnants of prairie, scattered over the 4 subsections of MN's Prairie Parkland Province likely harbor diverse plant populations. Protecting these remaining genetic resources now is like putting money in the bank; not only will the remaining genetic variation be invaluable as germplasm for restoration in the short-term, but also it's value accrues as genetic variation is necessary to adaptation to future climate change and for new human uses.

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
- Elucidation of the scale of local adaptation in plants and their associated microbes.

The proposed work will provide information fundamentally necessary to the state's effort to establish both scientifically sound and economically feasible criteria for use and conservation of 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 their associated microbes.

II. DESCRIPTION OF PROJECT ACTIVITIES

Activity 1: Collect and conserve prairie plant genetic diversity. Budget: $100,000

We will collect seeds of 24 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 will assess viability of seeds. Facilities and staff at the Fort Collins would be quite expensive to duplicate in MN. The state of MN and this project retains ownership of all seeds and these will not be deployed to Colorado or any other state or private agency. 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 24 prairie species. *Completion Date:* October 2011. **2.** Measures of the initial viability of seed samples. *Completion Date***:** December 2011. **3.** Estimates of the longevity of the stored seeds. *Completion Date:* December 2014.

Activity 2: Conduct long-term studies of plants' local adaptation. Budget: $222,427

To rigorously evaluate the scale and degree of adaptation to local conditions currently, 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 the 4 subsections of MN's Prairie Parkland Province. We will significantly reduce costs by using UM Research and Outreach Centers at 3 of the 4 sites. 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. Evaluate effects of geographic distance between seed source and planting location on establishment of prairie plants. *Completion Date:* August, 2013. **2.** Evaluate effects of geographic distance between seed source and planting location, as well as habitat characteristics, on early survival and success of plants. *Completion Date:* August, 2014, continuing over long term.

Activity 3: Evaluate the potential of prairie populations for future adaptation. Budget: $221,890

The rate at which plants adapt 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.

Outcomes: 1. Predict rates of adaptation based on genetic variation and natural selection. *Completion Date:* August, 2013, continuing over long term.

Activity 4: Will microbes help or hurt survival of prairie plants? Budget: $242,683

Newly established plant populations are quickly found by their pathogens because the pathogens move by air-borne spores. In addition, both helpful and harmful microbes follow plants because seed cleaning does not remove microbes within seeds. Research proposed here will determine the extent to which helpful microbes aid prairie plant establishment and conservation, and harmful microbes limit prairie plants. 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:* August, 2013, 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 initial establishment.

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 three years. This position will be responsible for seed sampling and field experiments investigating local adaptation. 83% salary, 17% benefits	$ 150,000
Personnel: Graduate Student - Two half-time positions for three years. One position will be responsible for seed sampling and field experiments investigating local adaptation. The other position will work on the microbial studies. 61% salary, 39% benefits	$ 267,000
Personnel: Research Scientist - Two half-time positions for three years. 73% salary, 27% benefits	$ 160,000
Personnel: Undergraduate Student - Eight students for two months each during the summer. These positions will assist with fieldwork. 91% salary, 9% benefits.	$ 57,000
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.	$ 26,000
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).	$ 31,000
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	$ 787,000

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/