Environment and Natural Resources Trust Fund
2018 Request for Proposals (RFP)

Project Title: **ENRTF ID: 191-F**

Are We Turning Wild Prairie Plants into Crops?

Category: F. Methods to Protect or Restore Land, Water, and Habitat

Total Project Budget: $ 555,441

Proposed Project Time Period for the Funding Requested: 3 years, July 2018 to June 2021

Summary:

Prairie restorations use native plant seeds produced in agricultural conditions. Is this reducing plant diversity and establishment, thereby undermining restoration success? Our experimental and genetic studies will answer this question.

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

The figure illustrates examples of how wild seed collection and subsequent farming of those seed can alter the traits of the seed produced, and how those actions can create plants that are no longer adapted to a restoration setting.

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

PROJECT TITLE: Are we turning wild prairie plants into crops?

I. PROJECT STATEMENT

This project will determine if farm production of native seed for restoration is essentially turning them into crops, resulting in the loss of genetic and trait diversity that allow them to survive in harsh natural settings. Mass quantities of native seed are required for prairie restorations, and the native seed industry has increasingly relied upon large-scale farming methods to bump up seed harvest. However, wild seed collection and farm production can unintentionally reduce native plant diversity and lead to plants maladapted to the restoration environment. **This loss in trait and genetic diversity may lead to failure of plant establishment and restoration goals, but the extent to which this occurs is unknown.** We propose to test the effects of native seed collection and farm production on genetic and trait diversity, and on plant success in a restoration setting.

There are two plant restoration steps where traits and genetic diversity may be altered. For example:

1) When seed are collected from the wild, the timing of flowering and seed maturation may be lost if seeds are collected on a single date (Fig. 1), and genetic diversity may be lost if few plants are sampled.

2) Seed harvesting on the farm at the peak of seed maturation may increase uniformity in reproductive traits (Fig. 1), and machine harvesting may eliminate dispersal by selecting plants that hold onto their seeds.

Combined, these actions may eliminate genetic diversity that allows plants to thrive in restoration environments (Fig. 1), which may imperil ecosystem function, long-term persistence, and habitat management goals.

As Minnesota works to expand prairies and bolster their essential functions, restoration projects will rely increasingly upon commercial seed sources. **However, we do not know the extent to which commercially grown seed differs from seed in natural populations**. Our research will fill this critical knowledge gap. **We will perform experiments to evaluate the effects of commonly used seed collection and plant propagation methods on genetic diversity and plant traits important for the success of prairie restoration.** We will conduct seed collections using different methods and rear these plants in a farm production garden to generate additional seed. We will compare wild-collected and farm-produced seeds in a greenhouse to monitor establishment, survival, and reproduction traits, and analyze DNA for changes in genetic diversity. Finally, we will compare establishment and survival of wild-collected and farm-produced seeds in field restoration plots.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Assess trait and diversity changes due to seed collection methods **Budget: $178,600**

We will collect seeds for Activities 1–3 in 2018 from two grass (little bluestem & sweet grass) and two wildflower (beeplant & bee balm) species at four sites at early, peak, and late times during seed production. To determine if the timing of seed collection alters diversity, we will weigh seeds, sow them in greenhouse pots and measure phenological (timing of germination, flowering, and seed maturation), reproductive (flower production, pollen viability), and growth (height and biomass) traits, and collect tissue for DNA extraction and sequencing. Analyses will show if collection techniques are curtailing diversity that is essential for long-term survival and adaptation.

Outcome	Completion Date
1. Collect, clean, and weigh seeds	Nov 2018
2. Germinate seed, grow plants in the greenhouse, and measure them	Jan-July 2019
3. Collect tissue, extract DNA, and measure genetic diversity for two wildflowers	June-Aug 2019
4. Interpret trait and genetic changes due to collection bias	Nov 2020

Activity 2: Evaluate trait and diversity changes occurring through farm seed production **Budget: $220,262**

In spring 2019, we will plant seed collected in Activity 1 at the UMD Research and Field Studies Center following protocols of commercial growers such as tilling, watering, applying fertilizer, and weeding. We will machine-harvest seed in the fall and replant in the spring in 2019 and 2020. After two generations on the farm, we will

conduct a greenhouse trial and compare DNA from the original wild-collected and farm-raised seeds to evaluate trait and genetic changes that occur due to inadvertent selection on the farm.

Outcome	Completion Date
1. Plant seeds collected in 2018 and harvest the 2019 seed cohort	May-Oct 2019
2. Plant the 2019 seed cohort and harvest the 2020 seed cohort	May-Oct 2020
3. Plant the 2020 seed cohort in the greenhouse alongside wild-collected seed and repeat steps described in Activity 1, #2-3	May-June 2021
4. Interpret trait and genetic changes due to inadvertent selection on the farm	June 2021

Activity 3: Compare restoration success of wild and cultivated seed **Budget: $156,579**

We will plant wild-collected and farm-raised seeds into an experimental field restoration site in the spring of 2020 and quantify plant germination and early survival. Comparisons of plants from wild and farm sources will allow us to determine how farm propagation of wild species ultimately affects restoration success.

Outcome	Completion Date
1. Plant wild-collected seed and the 2020 cohort of farm-raised seed into a restoration site	May 2021
2. Measure plant germination, survival, growth, and reproduction	May-June 2021
3. Evaluate effects of collection bias and farm selection on initial restoration success	June 2021
4. Provide recommendations on the effect of farm-raised seed to seed production companies and agencies engaged in prairie restoration	June 2021

III. PROJECT STRATEGY

A. Project Team/Partners: Our UMD Project Team will share responsibilities for this project. Dr. Dustin Haines will oversee field, greenhouse, and lab components that focus on plant traits. Dr. Briana Gross will oversee DNA lab work. Dr. Julie Etterson will provide field/lab space and expertise in experimental design. Dr. Randel Hanson (UMD Sustainable Ag. Project) will provide assistance with farm machinery for planting and harvesting. All team members will mentor graduate and undergraduate students, analyze data, and prepare manuscripts. Project Partners include the Leech Lake Band of Ojibwe, which will identify culturally important plants as potential focus species, and Prairie Restorations, Inc. and Prairie Moon Nursery, who will provide information on commercial seed collection and production practices used in MN. Results will also be shared with the Minnesota Department of Natural Resources, and environmental NGOs engaged in restoration practices. Project Team members Haines, Gross, and Etterson will receive ENRTF funds; Project Partners will not receive ENRTF funds, nor will they contribute funds or resources from other sources.

B. Project Impact and Long-Term Strategy: Our research will fill a critical knowledge gap by providing information about when and how diversity is lost during the processes of native seed collection and plant production, and how loss of diversity impacts restoration success. Our findings will inform commercial seed producers and state and NGO organizations as to methods that best help maintain plant diversity required for restoration success. We plan to expand upon this project over 12 years to include additional species important for prairie restoration and tribal concerns, to obtain a deeper time horizon to assess long-term selection impacts, and to incorporate climate change impacts on selection that occurs in seed production. It is anticipated that the long-term scope of this project will require approximately $2.2 M.

C. Timeline Requirements: Activity 1: 1 yr; Activity 2: 3 yrs; Activity 3: 1 yr. This is the minimum amount of time required to understand the compounded genetic effects of seed collection and farm propagation. After three years, we will have addressed the question for multiple species and have a solid foundation for continued assessment of changes in plant traits and genetics on native seed farms and their impact on restoration success.

2018 Detailed Project Budget

Project Title: Are we turning wild prairie plants into crops?

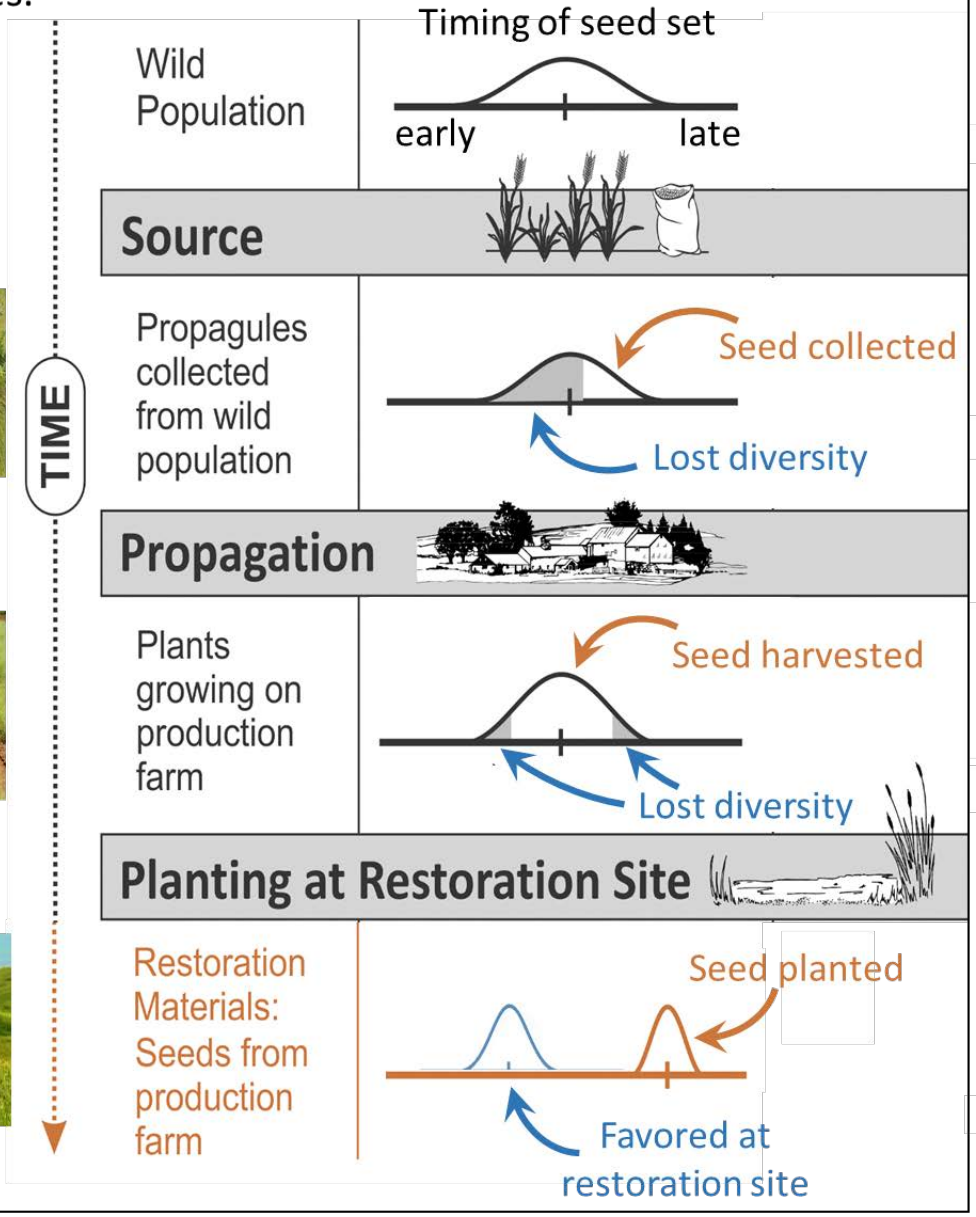
IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel:	**$ 468,656**
Dustin Haines - For three years of supervision and full time participation in research. (77.6% salary, 22.4% benefits: 100% FTE) (12 mo/yr; July 1, 2018-June 30, 2021).	$ 207,831
Briana Gross - For effort 1/2 month in summer (66.3% salary, 33.7% benefits: 8% FTE) (3 summers)	$ 16,817
Julie Etterson - For effort 1/2 month in summer (66.3% salary, 33.7% benefits: 8% FTEs) (3 summers)	$ 21,196
Field/Lab Technician - 1 position (72.6% salary, 24.7% benefits: 100% FTE) (12 mo/yr; July 1, 2018-June 30, 2020). For two years of work on field, greenhouse, and lab work, including maintaining experimental plants.	$ 86,265
MS student - 1 position (82.4% salary, 17.2% benefits: 50% FTE) (12 mo/yr, 2 yr; July 1, 2019-June 30, 2021). For two years of work on data collection and analysis.	$ 75,235
MS students - 2 summer research positions (82.4% salary,17.4 % benefits: 25% FTE) (2 summers). For field, greenhouse, and lab work, data collection and entry	$ 12,718
Undergraduate students - 3 summer positions (100% salary, 0% benefits: 25% FTE) (3 summers), and 3 fall/spring positions (3 years). For seed cleaning, field and greenhouse experiment setup, lab work and data collection and entry.	$ 48,594
Professional/Technical/Service Contracts:	**$ 57,050**
Research plot fees at UMN Research and Outreach Center for experimental field restoration site - 1 site, 1 acre, 2 years	$ 550
UMN Genomics Center Sequencing-Based Genotyping sample preparation and sequencing services (DNA extraction, library preparation, and Illumina sequencing) - ($25/sample * 565 samples for activity 1 + 565 samples for activity 2) = $28,250 * 2 species = $56,500	$ 56,500
Equipment/Tools/Supplies:	**$ 11,632**
Field supplies - Data logger for monitoring temperature and humidity in the field ($260), coin envelopes (10 cases of 250, $25/case), dessicant (3 5-pound bags, $35/bag), aluminum storage clip boards (3 at $20 each), hand tally counters (3 at $12 each), gloves (10 pairs, $12 each), hand trowels (8 at $6 each), weatherproof printer labels (4 boxes, $32/box), plastic plant tags (6 boxes, $30/box)	$ 1,347
Greenhouse supplies - potting soil (24 bails*$45/bail = $1080), fertilizer (2 bags @ $25/bag = $50), 5500 cone-tainer pots (5 boxes*$125.40/box = $627), cone-tainer trays (50*$7.55/tray= $377.50), plastic plant labels (10 @ $30/box = $300), weatherproof printer labels (7 @ $32/box = $224), bamboo plant skewers (50 @ $2/bag = $100), plant tie tape (5 @ $10/roll = $50), tie staples (5 @ $17/box = $85), jewelry tags (6 boxes @ $3.50/box = $21), glassine coin envelopes (8 @ $25/box = $200), glassine bags (2 @ $68/box = $136), hand tally counter (3 @ $12 = $36)	$ 3,386
Lab supplies - Paper bags (31 @ $20/case = $620), staplers (4 @ $5 = $20), staples (10 @ $5/case = $50), markers (3 @ $10/box = $30), pens (3 @ $25/box = $75), lab notebook (6 @ $16 = $96), celophane tape (3 @ $10/box = $30), lab tape (3 @ $40/box = $120), germination trays (5 @ $156/case = $780), germination blotters (3 @ $65/case = $195), microcentrifuge tubes (4 @ $70/box = $280), pipette tips (4 @ $42/box = $168), phenol (500ml, $200), glycerine (500ml, $40), lactic acid 250ml, $44), aniline blue (25g, $65).	$ 2,899
Molecular supplies - Dry ice and liquid nitrogen ($1000), plastic tubes ($1000), liquid nitrogen dewar ($1700), and misc. supplies (scissors, EtOH, sharpies, forceps; $300) for sample collection and storage.	$ 4,000
Travel:	**$ 16,603**
UMD fleet vehicle rental, mileage, lodging and meals for seed collection, planting, and measuring crew (all within MN): 3-day seed collection visits to all 4 sites at early, peak and late seed production for each species in year 1 (~500 miles round-trip), weekly trips to farm propagation site in years 1 & 2 (~10 mile round-trip), 16 3-day visits to restoration site over years 2 & 3 (~500 mile round trip)	$ 16,603
Additional Budget Items:	**$ 1,500**
Shipping charges - Mailing samples to UMN Genomics Center ($500), shipping equipment, tools & supplies to Duluth ($1000)	$ 1,500
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	**$ 555,441**

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	N/A	N/A
Other State $ To Be Applied To Project During Project Period:	N/A	N/A
In-kind Services To Be Applied To Project During Project Period:	N/A	N/A
UMD IBS summer stipend match for MS Students (2 x 2 years) and PhD student (1 x 1 year)	$ 14,000	Pending
Briana Gross (1 month salary each during academic year x 3 years)	$ 33,299	Secured
Julie Etterson (1 month salary each during academic year x 3 years)	$ 41,973	Secured
UMD travel and registration to meetings for faculty and graduate students (3 yrs)	$ 7,145	Pending
Foregone indirect cost return for additional Salaries/Fringe Benefit, and Travel	$ 316,989	Secured
Past and Current ENRTF Appropriation:	N/A	N/A
Other Funding History:	N/A	N/A

Figure 1. One example showing how plant diversity changes over time as seeds are sampled from wild populations, grown on production farms for seed increase, and then planted into restoration sites.



Project Manager Qualifications

Project Manager: Dr. Dustin F. Haines
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Mailing Address: 207 Swenson Science Building, 1035 Kirby Drive, Duluth, MN, 55812
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Haines has been studying plant ecology 20 years and has successfully managed large-scale field and greenhouse experiments. He has extensive experience supervising large groups, including technicians, graduate students, undergraduate students, and volunteer interns.

Recent Work Experience

2004	Biologist, United States Geological Survey, Las Vegas, NV
2013	Teaching Fellow, Harvard University
2014	Adjunct Professor, Wheelock College, Boston
2014	Postdoctoral Researcher, University of Massachusetts, Amherst
2016	Research Associate, U of MN Duluth

Education

NW Missouri State University	Maryville, MO, US	Wildlife Ecology & Cons.	B.S., 1993
U of MN Twin Cities	Minneapolis, MN, US	Ecology	Ph.D., 2013
University of Massachusetts	Amherst, MA, US	Plant Ecology	Postdoc, 2014-2016

Organization Description

The University of Minnesota Duluth Swenson College of Science and Engineering supports excellence in research and education at the undergraduate and graduate levels. The Department of Biology in particular comprises over 15 research active faculty and attracts hundreds of majors each year. Research focusing on Minnesota's natural areas is a prominent component of our department's teaching and research practices.