Environment and Natural Resources Trust Fund
2019 Request for Proposals (RFP)

Project Title: **ENRTF ID: 211-F**

Does Native Seed Farming Reduce Prairie Restoration Success?

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

Sub-Category:

Total Project Budget: $ 449,962

Proposed Project Time Period for the Funding Requested: June 30, 2022 (3 yrs)

Summary:

Prairie restorations use native plant seeds produced in agricultural conditions. Has this altered traits required for survival, thereby undermining restoration success? Our experimental and genetic studies will answer this question.

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Sponsoring Organization: U of MN - Duluth

Title: Research Associate

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Conceptual and real-world examples of wild seed collection and subsequent seed increase on farms that unintentionally alter plant traits, creating 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	_____%
____ If under $200,000, waive presentation?			

PROJECT TITLE: Does native seed farming reduce prairie restoration success?

I. PROJECT STATEMENT

This project will determine if farm production of native seed for restoration is essentially turning plants into crops, resulting in the loss of trait and genetic diversity that allow them to survive in harsh, competitive, 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 plant cultivation can unintentionally alter critical plant traits (Fig. 1). **We suspect that these changes can threaten plant establishment, long-term adaptability, and restoration goals, but the extent to which this occurs is unknown because it has not been tested.** Reports of restoration failures are common. This partnership with The Nature Conservancy and commercial seed producers will help us figure out if farm cultivation of native species is part of the problem and, if so, what to do about it.

How do wild plants become more like crops? (see Fig. 1)

- **A.** Variation is limited if wild seed comes from a small number of dates or populations.
- **B.** Seed growers inadvertently select for traits, such as uniform timing of seed production and larger plants.
- **C.** The result is a restoration seed source that is not genetically diverse and is maladaptive in the wild.

What are the consequences? Farm-cultivated seeds with altered plant traits may establish at low rates or fail to establish at all, and the plants that do establish may have lost the adaptability that allows them to persist in the long term. This not only imperils habitat management goals and ecosystem function, but it also results in lost time and funds for already lengthy, costly restoration projects.

Our GOALS are to evaluate the effects of seed collection and plant propagation practices on traits and genetic diversity important for the success of prairie restoration, and to provide recommendations to restoration practitioners and seed producers on providing the best seed for restorations. To achieve these goals, we will compare establishment and survival of plants from wild-collected and farm-produced seed at active restoration sites. We will also collect wild seed, use this seed to produce additional seed on farm plots, and perform greenhouse studies to monitor trait and DNA changes due to seed collection methods and farming practices.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: ***Compare restoration success of wild and cultivated seed***
ENRTF BUDGET: $150,178

Description: We will monitor plants grown from wild-collected and commercial farm-raised seeds of the same species at field restoration sites over three growing seasons. Wild and farmed seed will be sown in separate plots at restoration sites in Kandiyohi County in spring of 2019, prior to ENTRF funding (this proposal is not a restoration project). We will monitor traits related to establishment success on field plots, and examine plant performance traits at a detailed level in a greenhouse assay. **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. Identify trait differences in wild vs. farm plants in greenhouse experiments	*April 2020*
2. Determine effects of seed source on restoration success after 3 growing seasons	*December 2021*
3. Provide recommendations on wild vs. farm seed use to restoration practitioners	*February 2022*

Activity 2: ***Assess trait and diversity changes due to seed collection methods***
ENRTF BUDGET: $153,735

Description: We will collect seeds for Activities 2 & 3 in 2019 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 seed collection methods alter 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 the diversity essential for long-term survival**.

Outcome	Completion Date
1. Identify trait differences due to seed collection methods in greenhouse experiments	*September 2020*
2. Determine effects of seed collection methods on genetic diversity	*November 2020*
3. Provide seed collection recommendations to seed vendors and restoration practitioners	*November 2021*

Activity 3: *Evaluate trait and diversity changes occurring through farm seed production*
ENRTF BUDGET: $146,049

Description: In spring 2020, we will plant seed collected in Activity 2 at the UMD Research and Field Studies Center and follow protocols of commercial growers such as tilling, watering, applying fertilizer, and weeding. We will machine-harvest seed in the fall, replant in spring 2021, and harvest again. We will conduct greenhouse trials and compare DNA from the original wild-collected and second-generation farm-raised seeds. **Analyses will show whether trait and genetic changes occur due to inadvertent selection on the farm.**

Outcome	Completion Date
1. Determine effects of seed increase on genetic diversity	*December 2021*
2. Identify trait differences in wild vs. 1st and 2nd generation farm seed on plant traits	*April 2022*
3. Provide seed increase recommendations to seed vendors and restoration practitioners	*June 2022*

III. PROJECT PARTNERS:

A. Partners receiving ENRTF funding: N/A (only investigators at UMD will receive funding)

B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
Dr. Marissa Ahlering	Prairie Ecologist	The Nature Conservancy	Coordinate the collaborative work between TNC and UMD for Activity 1
Dr. Randel Hanson	Assistant Professor	UMD	Provide farm equipment, expertise
Ron Bowen	President	Prairie Restorations, Inc.	Provide seed production advice
Bill Carter	President	Prairie Moon Nursery	Provide seed production advice

IV. LONG-TERM- IMPLEMENTATION AND FUNDING: 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. We will share our research with state and NGO organizations and commercial seed producers, including specific methods that will 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, and to obtain a deeper time horizon to assess long-term selection impacts. It is anticipated that the long-term scope of this project will require $2 M.

V. TIME LINE REQUIREMENTS: Total project length: 3 years. This is the minimum amount of time required to understand the compounded genetic effects of seed collection and farm propagation. After 3 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.

2019 Proposal Budget Spreadsheet

Project Title: Does native seed farming reduce prairie restoration success?

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

BUDGET ITEM (See "Guidance on Allowable Expenses")	**AMOUNT**
Personnel:	**$ 400,486**
Dustin Haines, Postdoctoral Associate (Principal Investigator) - For three years of postdoctoral support for project management and full time participation in research. (77.6% salary, 22.4% benefits: 1.0 FTE) (12 mo/yr; July 1, 2019-June 30, 2022).	$ 211,985
Briana Gross, Associate Professor (Co-PI) - For effort 1/2 month in summer (66.3% salary, 33.7% benefits: 0.08 FTE) (3 summers)	$ 17,201
Julie Etterson, Professor (Co-PI) - For effort 1/2 month in summer (66.3% salary, 33.7% benefits: 0.08 FTE) (3 summers)	$ 21,742
Field/Lab Technician - 1 position (72.6% salary, 24.7% benefits: 1.0 FTE) (12 mo/yr; July 1, 2019-June 30, 2021). For two years of work on field, greenhouse, and lab work, including maintaining experimental plants.	$ 87,119
MS students - 2 summer research positions (82.4% salary,17.4 % benefits: 0.25 FTE) (2 summers). For field, greenhouse, and lab work, data collection and entry	$ 12,972
Undergraduate students - 3 summer positions (100% salary, 0% benefits: 1.0 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.	$ 49,467
Professional/Technical/Service Contracts:	**$ 16,920**
UMN Genomics Center Sequencing-Based Genotyping sample preparation and sequencing services (DNA extraction, library preparation, and Illumina sequencing) - (282 samples for activity 2 + 282 samples for activity 3 @ $30/sample) = $15,313	$ 16,920
Equipment/Tools/Supplies:	**$ 10,774**
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), 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), plastic bags (6 boxes, $20/box)	$ 1,211
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)	$ 3,250
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).	$ 2,813
Molecular supplies - Dry ice and liquid nitrogen ($800), plastic tubes ($800), liquid nitrogen dewar ($1700), and misc. supplies (scissors, EtOH, sharpies, forceps; $200) for sample collection and storage.	$ 3,500
Travel:	**$ 17,282**
UMD fleet vehicle rental and mileage, lodging and meals for plant monitoring and seed collecting crews (all within MN): 20, 3-day visits to restoration site over years 1, 2 & 3 (420 mile round trip); 4, 4-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).	$ 17,282
Additional Budget Items:	**$ 4,500**
Shipping charges - Mailing samples to UMN Genomics Center ($500), shipping equipment, tools & supplies to Duluth ($1000)	$ 1,500
Publishing fees for open access publications (1 paper per Activity)	$ 3,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	**$ 449,962**

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:	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:	**$ 340,268**	
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)	$ 34,063	Secured
Julie Etterson (1 month salary each during academic year x 3 years)	$ 43,053	Secured
UMD travel and registration to meetings for faculty and graduate students (3 yrs)	$ 7,145	Pending
Unrealized indirect cost return for additional Salaries/Fringe Benefit, and Travel	$ 242,007	Secured
Past and Current ENRTF Appropriation:	N/A	N/A
Other Funding History:	N/A	N/A

Conceptual example

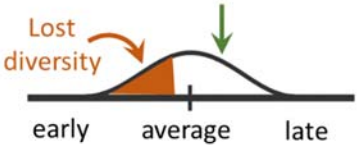
Plants in a wild population flower at diverse times

Case study

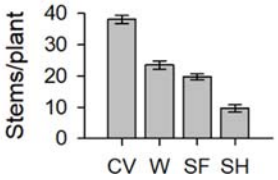
Blue wildrye plants in a wild population vary in size

A. Collect seed from wild populations

Only seed from later-flowering plants collected; Plants grown from these seeds flower late

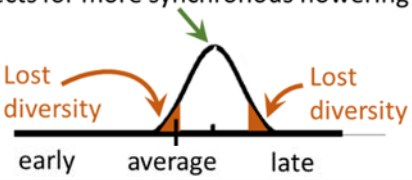


Plant size from seed at 4 sites varies; Unknown how this represents population

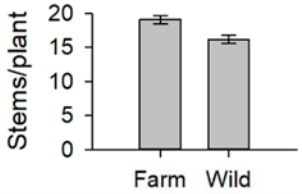


B. Grow plants on a production farm and harvest seed

Harvesting on a single peak date selects for more synchronous flowering

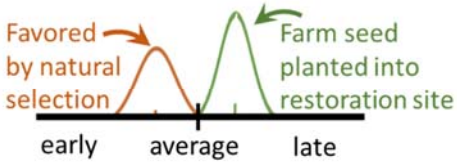


Farm plants are larger than wild



C. Plant farm-raised seeds into restoration sites

Restoration site favors early-flowering plants, but this diversity has been lost



Unknown effect of larger plants on restoration success

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Figure 1. Conceptual example and case study of how unintentional selection can affect restoration projects. A) Plant traits vary considerably across the landscape. If seed is only collected late or from one site, considerable diversity is lost. B) Farm production can reduce diversity or shift plant traits significantly away from wild populations. C) Plant traits unintentionally selected for can reduce their ability to survive in the restoration setting. Blue wildrye case study graphs in A & B: Adapted from Dyer et al. 2016. Ecological Restoration 34:39-48.

Project Manager Qualifications

Project Manager: Dr. Dustin F. Haines
Affiliation: University of Minnesota Duluth, Department of Biology
Mailing Address: 207 Swenson Science Building, 1035 Kirby Drive, Duluth, MN, 55812
Telephone: 218-726-8723
Email: dhaines@d.umn.edu

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.