Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-383

Proposal Title: Impacts of Drought and Biodiversity on Prairie Plants

Project Manager Information

Name: Julie Etterson

Organization: U of MN - Duluth

Office Telephone: (218) 726-8110

Email: jetterso@d.umn.edu

Project Basic Information

Project Summary: The project will measure the next-generation impacts of biodiversity and drought on prairie plants through gene expression, disease exposure, and metabolism measurements.

ENRTF Funds Requested: $94,000

Proposed Project Completion: August 31, 2027

LCCMR Funding Category: Small Projects (G)

Secondary Category: Resiliency (A)

Project Location

What is the best scale for describing where your work will take place?

Region(s): NE

What is the best scale to describe the area impacted by your work?

Region(s): NW, SE, SW,

When will the work impact occur?

In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Most people agree that biodiversity is valuable. It provides ecosystem stability, clean air and water, pollination, genes for crop improvement, and human inspiration that enriches our well-being. Here, we will drill deeper into this issue and ask whether biodiversity itself is a source of natural selection that impacts neighboring plants in beneficial ways conferring resilience to environmental stressors.

From countless experiments, we understand how drought affects plants. From fewer ecosystem-level experiments, we know that biodiversity confers resilience on whole communities. But, we know much less about how these two factors interact with each other to modify the selective environment of individual species within communities. Here we ask, does biodiversity exert natural selection on other community members such that they are more resilient to environmental stress?

We sampled plants from the longest-running biodiversity experiment in North America that was established at Cedar Creek Ecosystem Science Reserve thirty years ago. The experiment includes plots that range in biodiversity, 1-32 species. Eight years ago, a drought treatment was overlaid on the biodiversity plots. With this LCCMR support, we will ask how biodiversity has modified offspring from these plots in terms of gene expression, photosynthetic capacity, and resistance to both drought and disease.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

We are focusing on eight of the most common grass, legume, and forb species that grow in Minnesota prairies. We sampled seeds from four contrasting treatments at Cedar Creek Ecosystem Science Reserve. To hone in on the value of biodiversity, we sampled from 1-species plots and 16-species plots. For each of these levels of biodiversity, we also sampled plots receiving ambient rainfall and plots receiving 43% reduced rainfall, mimicking drought. From these seed collections, we currently are growing ~ 5,300 first-generation plants (F1) from diverse species and treatment histories in a UMD greenhouse.

The long-term goal of this project (funded by NSF with colleagues at UM-Twin Cities and IU-Bloomington) is to cross-pollinate the greenhouse-grown plants to produce the second generation. These F2 plants will be reciprocally transplanted back into the original treatments at Cedar Creek to determine whether the biodiversity and drought treatments resulted in adaptation, representing fixed genetic change.

But, adaptation can also come from more flexible mechanisms - turning genes on and off - rather than changing the genetic code itself. These flexible mechanisms of adaptation are sensitive to the parental environment and are called “epigenetic transgenerational effects.” This is the mechanism of adaptation we will explore

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state’s natural resources?

We will improve our understanding of the inherent value of Minnesota’s biodiversity for both ecosystems as a whole and individual plant species. If biodiversity buffers species from natural selection under stress, we will provide a new justification for increasing the species richness in restorations and protected areas. With intensifying environmental challenges, this work could demonstrate another mechanism by which biodiversity confers resilience in Minnesota’s natural communities. Although many prairie restorations typically include a high diversity of plant species, 90% of forest restorations include low levels of biodiversity, and 45% include single species. If this is counterproductive, we need to know.

Activities and Milestones

Activity 1: Metabolism Measurement

Activity Budget: $23,313

Activity Description:
Several plant traits will be measured that are known to be influenced by drought. Under water shortage, plants tend to produce thicker leaves (lower SLA) that conserve water. Drought also disrupts the process of photosynthesis, reducing its efficiency. It is also well known that drought tends to produce plants that are shorter, have fewer leaves, and flower earlier. Although this provides solid hypotheses for environmental carryover effects on offspring from the watering treatments experienced by parental plants at Cedar Creek, we do not know whether these traits will also be affected by the biodiversity treatments or if the biodiversity+drought treatment buffers plants against natural selection due to drought stress.

SLA and other growth measurements will be taken on all plants using standard methods. Photosynthetic efficiency will be assessed using chlorophyll fluorescence. Fluorometer measurements will be limited to two species, wild lupin and big bluestem, for which we will also extract RNA for gene expression analysis. If the preliminary results show a large difference in photosynthetic efficiency, we will also do gas exchange measurements to confirm the results. Gene expression analysis will reveal offspring genes that are up- or down-regulated and trace to the environmental treatments that their parents experienced.

Activity Milestones:

Description	Approximate Completion Date
Metabolic Measurement Complete	August 31, 2026
Metabolic Data Analyzed and Results Determined	December 31, 2026
Present results to local restoration professionals and at national or international scientific meeting	August 31, 2027

Activity 2: RNA Sequencing for Gene Expression

Activity Budget: $47,374

Activity Description:
We will test for epigenetic transgenerational effects (i.e., changes in offspring gene expression induced by parental environments) using RNA-seq. This next-generation-sequencing approach characterizes the RNA content of plant tissue samples. This information will determine, on the whole, if offspring gene expression is altered depending upon the environmental treatment experienced by their parents. Moreover, by comparing gene expression over time, we can determine whether the transgenerational effects are transient. If differences in gene expression diminish over time, then they are likely to be due to epigenetic effects that govern gene expression. If differences do not diminish, they are likely to be due to DNA changes and are more permanent and were caused by contrasting selection pressures at Cedar Creek.

Because gene expression analysis is expensive, we will limit this work to one dominant Minnesota prairie grass, big bluestem, and one legume species, wild lupine. One round of gene expression analysis has already been completed for big bluestem. We collected a second bluestem sample for comparison over time and two temporal samples from wild lupine. We are especially interested in identifying changes in the expression of genes that have previously linked to plant response to drought and disease.

Activity Milestones:

Description	Approximate Completion Date
Obtain RNA from big bluestem and have it analyzed at the MN Genomics Center	August 31, 2026
Obtain RNA from wild lupine and have it analyzed at the MN Genomics Center	November 30, 2026
Analyze gene expression data to identify differences between parental treatments	March 31, 2027
Present results to local restoration professionals and at national or international scientific meeting	August 31, 2027

Activity 3: Powdery Mildew Resistance Testing

Activity Budget: $23,313

Activity Description:
Adaptation to one stressor can make plants more resilient to other stressors, a phenomenon known as “cross-tolerance or "cross-adaptation." Plants can pass on stress tolerance to their offspring as a transgenerational effect. For example, parental plants exposed to drought conditions may also exhibit increased tolerance to heat stress. However, it is not known whether parental exposure to drought can confer offspring resistance to disease. Even less is known about the potential role of biodiversity.

We became interested in this question because our wild lupine plants became infected with powdery in an uneven distribution across the greenhouse. To determine whether patterns of infection were related to the parental biodiversity and drought treatments, we scored disease severity on 400 plants. We found that offspring plants were not affected by the parental drought treatment, but were affected by the parental biodiversity treatment. We would like to pursue this question with a formal experimental design where plants are intentionally infected at controlled levels. Powdery mildew doesn’t kill most native perennials but it greatly reduces the photosynthetic capacity of infected plants. Because of its prevalence in prairie and agricultural ecosystems, it is a good model disease to study transgenerational effects.

Activity Milestones:

Description	Approximate Completion Date
Conduct powdery mildew experiment on offspring from contrasting parental treatments	October 31, 2026
Analyze and synthesize data from the powdery mildew experiment	July 31, 2027
Present results to local restoration professionals and at national or international scientific meeting	August 31, 2027

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Crimson Frankum	Graduate student in the Integrated Bioscience program at UMD	This project will be a core component of Crimson Frankum's thesis work. Under Etterson's supervision, she will design the activities and implement them in the greenhouse and lab. She will also co-mentor undergraduate students who will obtain valuable research experience, learn data analysis skills, and present their work on campus	Yes

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?

This project builds upon an existing NSF grant which will result in a long-term experiment at Cedar Creek that will test the value of biodiversity for decades to come. Here we offer an opportunity to glean unique information from an intermediate step in the larger research endeavor. This exploration of environmental carry-over effects, mediated by changes in gene expression, will be completed at the end of the LCCMR grant. Our results will be shared with restoration professionals the MN Land Trust, The Nature Conservancy, and DNR. We will also publish the results and present them widely at MN venues

Project Manager and Organization Qualifications

Project Manager Name: Julie Etterson

Job Title: Distinguished McKnight University Professor; Director Institute on the Environment - Duluth

Provide description of the project manager's qualifications to manage the proposed project.

Etterson is the Project Manager for this proposal and will work with her MS graduate student, Crimson Frankum, to complete the work. Ettersonis a Distinguished McKnight University Professor in the Department of Biology at UMD where she has been for 23 years. She is also the Director of the Institute on the Environment-Duluth (https://ione.d.umn.edu/) where she catalyzes university-community collaborations that advance sustainability in our region. She is an active researcher (>$13.7 million as PI/co-PI; >50 publications; >20 graduate students; >60 undergraduate research projects) and an award-winning teacher. Throughout her career, she has emphasized research that has community-driven applications that result in action on the ground. She is passionate about this project because it will allow her to apply her expertise in ecological genetics to advance biodiversity preservation and restoration.

This project is related to but distinct from NSF-sponsored research Etterson is conducting with colleagues at UM-TC and IU-Bloomington (Collaborative Research: BoCP - Implementation: Biodiversity and stability on a changing planet: plant traits and interactions that stabilize or destabilize ecosystems and populations). The goal of my component of the NSF grant is to determine whether long-term biodiversity treatments (1-species versus 16-species plots) and drought treatments (ambient rainfall versus reduced rainfall) at Cedar Creek Ecosystem Science Reserve have caused adaptive evolution in traits that promote ecosystem stability. This LCCMR proposal will fund a unique direction and asks whether exposure of the parental plants to the biodiversity/ drought treatments has immediate environmental carryover effects that influence the first offspring generation.

Etterson has done previous research on transgenerational effects and their adaptive significance that have been published in top scientific journals (Galloway & Etterson. 2007. Science). She has also published on changes in gene expression that have accrued with climate change (Spear et al. 2023. Molecular Ecology).

Organization: U of MN - Duluth

Organization Description:
The University of Minnesota Duluth (UMD) is a comprehensive regional university. Undergraduate students can choose from 16 bachelor degrees in 89 majors and 76 minors as well as eight certificates. UMD also offers graduate programs in 24 fields, 12 minors, and six certificates. UMD consistently ranks among the top Midwestern, regional universities in U.S. News and World Report's "America's Best Colleges" issue. Providing an alternative to both large research universities and small liberal arts colleges. UMD attracts students looking for a personalized learning experience on a medium-sized campus of a major university

The Department of Biology is the largest unit on campus with more than 650 students enrolled in our majors. We have a strong emphasis on research and teaching on ecology and evolutionary processes and will be starting a new major in Biodiversity, Conservation and Sustainability in fall 2025 (Etterson developed).. Our graduate programs in Water Resources and Integrated Bioscience fuel the pipeline of young professionals into government, nonprofit, and educational careers around natural resource management in our state. Our US EPA Cooperative Training Grant provides students the unique opportunity to learn in both academic and applied settings. In contrast to national trends, enrollment in our department is

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Graduate Research Assistant		This graduate student will take responsibility for organization and implementation of the experiments described herein.			45%	0.5		$54,882
Undergraduate Research Assistants		Assist in performing measurements and taking care of plants, 1,000 hours total			0%	0.48		$15,250
							Sub Total	**$70,132**
Contracts and Services								
University of Minnesota Genomics Center	Internal services or fees (uncommon)	The genomics center will perform the services listed below at speed tier priority. 72 RNA Standard QC 72 Illumina Stranded mRNA Library Preps MiSeq Nano QC Run 2 Lanes NovaSeq X plus 2x150 10B				-		$22,347
							Sub Total	**$22,347**
Equipment, Tools, and Supplies								
	Tools and Supplies	2 Qiagen RNeasy Mini kits for RNA extractions. Misc. Reagents and tool	These kits hold enough reagents for 50 RNA extractions each, we will be performing 72 for our tests and allowing for additional extractions to be performed for quality checking. The RNA extractions obtained from these kits will be provided to the genomics center for QC, library preparation, and sequencing. Performing RNA extractions, metabolism measurements, disease testing, and other testing not included under other costs					$1,521
							Sub Total	**$1,521**

Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
							Sub Total	**-**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$94,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	UMN unrecovered indirect costs are calculated at the UMN negotiated rate for research of 54% modified total direct costs.	UMN negotiated rate for research of 54% modified total direct costs. Indirect costs are those costs incurred for common or joint objectives that cannot be readily identified with a specific sponsored program or institutional activity. Examples include utilities, building maintenance, clerical salaries, and general supplies. (https://research.umn.edu/units/oca/fa-costs/direct-indirect-costs)	Secured	$41,039
			Non State Sub Total	**$41,039**
			Funds Total	**$41,039**

Total Project Cost: $135,039

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 8906d9a2-d8b.pdf

Alternate Text for Visual Component

A visual summary of the proposal. Showing the four treatments at Cedar Creek, the common greenhouse, and the three places we look for treatment effects, metabolism, gene expression, and disease resistance....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
UMN Authorization Letter	b5bf2c5f-885.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

N/A

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

Claudia Carranza <ccarranz@d.umn.edu>; Michael Jacob <jaco2565@d.umn.edu>

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A