Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-152

Proposal Title: Assessing Benefits of Enhancing Biodiversity in Habitat Fragments

Project Manager Information

Name: Forest Isbell

Organization: U of MN - Cedar Creek Ecosystem Science Reserve

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Project Basic Information

Project Summary: Habitat fragmentation is driving loss of plant and animal diversity, thereby eroding several benefits people obtain from nature. This project experimentally tests how diverse seed inputs can reverse these impacts.

Funds Requested: $498,000

Proposed Project Completion: 2024-06-30

LCCMR Funding Category: Foundational Natural Resource Data and Information (A)

Project Location

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

Region(s): Metro

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

Statewide

When will the work impact occur?

During the Project and In the Future

Narrative

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

Biodiversity experts estimate that approximately one out of every three species of plants and animals are threatened with extinction. Habitat fragmentation is the single greatest threat to biodiversity. Long before plant and animal species become globally extinct, they become locally extinct at many of the places they once existed. Habitat fragmentation drives species loss not only in the places where grasslands and forests are converted to croplands or urban areas, but also where these ecosystems persist, but become isolated habitat fragments. Species in remaining habitat fragments are gradually lost over time because they have reduced population sizes and limited dispersal. These gradual losses of species from remaining habitat fragments are known as extinction debts.

Extinction debts are creating ecosystem service debts. That is, the erosion of biodiversity is causing an erosion of benefits that people obtain from remaining fragments of habitat. Ecologists worldwide know Minnesota and Cedar Creek as the location of the world's longest-running biodiversity experiment. Over the past quarter century, this study has shown that loss of grassland plant diversity causes substantial losses of plant productivity, insect diversity, soil carbon, and ecosystem stability. Economists refer to this erosion of ecosystem services as the depreciation of nature.

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

We propose that diversity inputs may be needed across extensive landscapes of habitat fragments to reverse the ongoing erosion of biodiversity and its benefits. Although it is already common to sow diverse seed mixes when establishing prairie restoration projects, it is not yet known whether recurring investments in, and more widespread application of, diverse seed inputs would also be useful. Such diversity inputs may be necessary to prevent extinctions and may be profitable after accounting for biodiversity's societal benefits.

We propose to conduct two landscape-scale experiments to test the extent to which diversity inputs enhance biodiversity (plants, pollinators, wildlife, and soil microbes) and several ecosystem services (forage production, soil carbon storage, pollination, and ecosystem stability). The first experiment will test whether diversity inputs can reverse the erosion of biodiversity and its benefits in low-quality degraded habitat fragments. The second experiment will test whether diversity inputs can enhance biodiversity and its benefits in high-quality remnant oak savannas that are grazed by bison and managed with prescribed fire. In both studies, we will quantify the return on investment in diversity inputs.

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 plan to achieve the following project outcomes:
(1) Discover a way to reverse the ongoing erosion of biodiversity and its benefits;
(2) Quantify the extent to which diversity inputs (i.e., sowing a diverse seed mix) can enhance biodiversity (plants, pollinators, wildlife, and soil microbes) and several ecosystem services (forage production, soil carbon storage, pollination, and ecosystem stability) in habitat fragments;
(3) Determine whether bison grazing and fire management can enhance the benefits of diversity inputs; and
(4) Engage Minnesotans in the project through online citizen science and on-site K-12 field trips.

Activities and Milestones

Activity 1: Experimentally test whether diversity inputs can reverse the erosion of biodiversity and its benefits in degraded habitat fragments

Activity Budget: $245,000

Activity Description:
In a new landscape-scale habitat fragmentation experiment at Cedar Creek, we propose to test whether diversity inputs can prevent the loss of biodiversity and its benefits in degraded habitat fragments. The experiment is one of only eight habitat fragmentation experiments in the world. It includes all combinations of four habitat loss treatments (destruction of 0%, 50%, 95%, or 99% of local habitat), crossed with two seed addition treatments (no seeds added or sowing a diverse mix of native prairie species), with 8 true replicates of each of the 8 treatment combinations, for a total of 64 experimental plots, each 780 square meters in size. Treatments are currently being established with support from an NSF CAREER grant. Here we propose to: (1) add trail cameras and acoustic recording devices to continuously monitor animals; and (2) collect samples for environmental DNA analyses that will provide comprehensive lists of taxa for five groups of species: vertebrates (including mammals and birds), arthropods (which provide pollination), plants (which provide forage for livestock), and soil bacteria and fungi (which regulate soil carbon storage); and (3) conduct a cost-benefit analysis to determine the return on investment for diversity inputs, using economic valuation of ecosystem services.

Activity Milestones:

Description	Completion Date
Install trail cameras and acoustic recording devices in experimental plots	2022-05-31
Sample plants, pollinators, soils, trail cameras, and recording devices	2022-09-30
Produce comprehensive species lists from environmental DNA analyses	2023-05-31
Sample plants, pollinators, soils, trail cameras, and recording devices	2023-09-30
Analyze results and submit manuscripts for publication	2024-05-31

Activity 2: Experimentally test whether bison grazing and fire management enhance the benefits of diversity inputs in remnant oak savannas

Activity Budget: $220,000

Activity Description:
In an ongoing landscape-scale bison grazing experiment, we propose to add a new diversity input treatment. The experiment includes 28 plots inside a bison enclosure, with pairs of plots that are either grazed or ungrazed by bison, replicated across landscape units that have received prescribed fires at a range of frequencies over the past 55 years. The bison grazing experiment was established by a previous LCCMR grant and has already attracted funding from NSF. Here we propose to: (1) add 28 new experimental plots; (2) add a new diversity input treatment in subplots, (3) collect samples for environmental DNA; and (4) conduct a cost-benefit analysis of diversity inputs. We anticipate that bison grazing and burning will enhance the benefits of diversity inputs by increasing light availability and spatial heterogeneity, thereby promoting seed germination and establishment of diverse plant communities, which will then support diverse animal communities and provide high levels of several ecosystem services. This experiment is in one of Minnesota's highest-quality remnant oak savanna ecosystems. Thus, it will test whether diversity inputs might be valuable not only in degraded habitat fragments, but also in high-quality remnant habitat fragments, which also face several inescapable drivers of biodiversity loss.

Activity Milestones:

Description	Completion Date
Add 28 new plots and apply the diversity input treatment in the bison experiment	2022-03-31
Sample plants, pollinators, soils, and trail cameras	2022-09-30
Produce comprehensive species lists from environmental DNA analyses	2023-05-31
Sample plants, pollinators, soils, and trail cameras	2023-09-30
Analyze results and submit manuscripts for publication	2024-05-31

Activity 3: Engage citizen scientists and disseminate results to K-12 students and visitors

Activity Budget: $33,000

Activity Description:

We propose to engage Minnesotans in the project through online citizen science and on-site K-12 field trips. We will build on the success of our previous LCCMR project, which established the Eyes on the Wild website for engaging citizen scientists in classifying animals observed in trail camera images. In its first year, the website engaged more than 5,300 registered users who provided more than 3.2 million classifications. We propose to build a new online workflow for this website for users to help classify trail camera images generated by the two experiments described above. We also propose to offer field trips for K-12 students to visit these experiments. Cedar Creek's public programs now serve more than 7,000 K-12 students and teachers, plus 7,000 additional community members, each year. For many students, a field trip to Cedar Creek provides their first encounter with nature, their first introduction to a scientist, their first time seeing an experiment, and their first chance to collect and analyze data. The quality and impacts of our K-12 field trips are formally evaluated through anonymous post-visit teacher and student surveys.

Activity Milestones:

Description	Completion Date
Develop new online workflow for engaging citizen scientists	2022-05-31
At least 7,000 K-12 students and visitors engage with the projects at Cedar Creek	2024-05-31
At least 7,000 citizen scientists help identify animals in trail camera images	2024-05-31

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Chad Zirbel	University of Minnesota	Dr. Zirbel is a postdoctoral researcher investigating the effects of bison grazing on plant productivity and oak regeneration at Cedar Creek Ecosystem Science Reserve. He will contribute to Activity 2, including the study design.	No
Caitlin Barale Potter	University of Minnesota	Dr. Potter is the Education and Community Engagement Coordinator at Cedar Creek Ecosystem Science Reserve. She will contribute to Activity 2, including overseeing the development of the new online workflow for engaging citizen scientists and coordinating and leading K-12 student field trips and other education programs.	No

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 be funded?

Our results would guide efforts by state and federal agencies, conservation organizations, and private land managers to enhance biodiversity and its benefits in habitat fragments. We at Cedar Creek regularly engage with these stakeholders. To maximize what is learned through these large, landscape-scale experiments, we plan to maintain these studies for multiple decades. We have successfully obtained major research funding from the National Science Foundation and the US Department of Agriculture and will continue to seek federal support for the continuation of these studies.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Evaluating the Use of Bison to Restore and Preserve Savanna Habitat	M.L. 2017, Chp. 96, Sec. 2, Subd. 08c	$388,000
Cedar Creek Natural Area Wolf Recolonization Assessment	M.L. 2017, Chp. 96, Sec. 2, Subd. 03k	$398,000

Project Manager and Organization Qualifications

Project Manager Name: Forest Isbell

Job Title: Associate Director, Cedar Creek Ecosystem Science Reserve, UMN

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

As Associate Director of Cedar Creek Ecosystem Science Reserve, Dr. Isbell designs, conducts, and reports independent ecological research; manages Cedar Creek's land, staff, and budgets; and supervises Cedar Creek's Education and Community Engagement programs. Isbell has conducted field research at Cedar Creek for the past decade.

Isbell has been the lead principle investigator (PI) on five projects, which together total more than $2,000,000, funded by the US National Science Foundation, the US Department of Agriculture, and the LCCMR. He has also been a co-PI on five more projects, which together total more than $14,000,000, funded by the US National Science Foundation.

Isbell is a global expert on biodiversity and ecosystem functioning, ecosystem stability, and ecosystem services. He was nominated by the US government to serve as a Lead Author on multiple assessments by the United Nations Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services. Isbell has published 78 peer-reviewed journal articles, including 13 publications in the world's top journals (4 in Nature, 3 in Science, 6 in PNAS). Isbell

is an Editor at Ecology Letters, the top disciplinary journal for the publication of original ecological research. For the past two years, Isbell has been recognized by the Web of Science as one of the most highly cited researchers worldwide in the area of Ecology/Environment.

As Project Manager, Isbell will coordinate all proposed project activities and supervise all personnel. Isbell has extensive experience designing and conducting experiments; sampling plants, soils, and wildlife at Cedar Creek; accounting for the monetary value of ecosystem services; supervising teams of researchers; and disseminating results to both the scientific community and the public. The proposed work builds on two previous LCCMR projects that Isbell led at Cedar Creek, and leverages additional effort from personnel supported by Isbell's NSF CAREER award.

Organization: U of MN - Cedar Creek Ecosystem Science Reserve

Organization Description:
Cedar Creek Ecosystem Science Reserve is a University of Minnesota biological field station that is world renowned for its long-term ecological research. Its 5,300 acres includes many ecosystems and species found throughout the forests, grasslands, and wetlands of Minnesota and North America. Faculty, staff and students who work at Cedar Creek are dedicated to discovering sustainable solutions to environmental challenges. We do this by: (1) investigating the fundamental processes that govern the dynamics and functioning of ecological communities and ecosystems, and how human activities are changing ecosystems; (2) sharing knowledge gained at Cedar Creek with citizens of the state, the nation, and the world; and (3) conserving natural ecosystems as platforms for study and as examples of intact ecosystems.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Postdoctoral researcher		Conduct research and disseminate results			20.3%	2.5		$174,368
Graduate student researcher		Conduct research and disseminate results			48.19%	0.3		$43,367
Undergraduate students		Assist with research			0%	0.78		$21,923
Temporary casual interns		Assist with research			7.4%	1.04		$31,318
Research technician		Supervise summer research assistants and engage citizen scientists			24.13%	1.88		$97,024
							Sub Total	**$368,000**
Contracts and Services								
TBD	Professional or Technical Service Contract	Lab sample analysis fees will be paid for environmental DNA analyses to generate species lists for each plot in both experiments. DNA is extracted and universal primers are used to produce lists of species (or OTUs) for five taxonomic groups: soil fungi, soil bacteria, plants, arthropods, and vertebrates.				0.5		$45,000
TBD	Professional or Technical Service Contract	Lab sample analysis fees will be paid to determine the total carbon and nitrogen content of soil samples for each plot in both experiments.				0.05		$2,000
TBD	Professional or Technical Service Contract	Experimental fences to exclude bison will be welded, delivered, and installed. This will allow us to double the number of experimental plots in the bison grazing study.				0.4		$25,000
							Sub Total	**$72,000**
Equipment, Tools, and Supplies								

	Tools and Supplies	35 wildlife acoustic recording devices	These devices will provide continuous monitoring of animals that make sounds in experimental plots					$25,000
	Tools and Supplies	35 trail cameras with security boxes and locks	These trail cameras will continuously monitor animal use of experimental plots					$17,000
	Tools and Supplies	Supplies for trail cameras and acoustic recording	These supplies, which include batteries and SD cards, are needed for the operation of the trail cameras and acoustic recording devices					$5,000
	Tools and Supplies	Plant, arthropod, and soil sampling materials and supplies	These tools and supplies are needed to collect and grind samples of plants, arthropods, and soils, including for eDNA analyses					$3,000
	Tools and Supplies	25 lbs of high diversity (70 species) prairie plant seed mix	These seeds will be the diversity inputs for subplots in the bison experiment					$8,000
							Sub Total	**$58,000**
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	**$498,000**

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	Indirect costs associated with this proposal	Indirect costs	Potential	$264,000
			Non State Sub Total	**$264,000**
			Funds Total	**$264,000**

Attachments

Required Attachments

Visual Component

File: 1aff3577-f21.pdf

Alternate Text for Visual Component

In Activity 1 (left), the grassland habitat shown in the red areas will be experimentally destroyed, leaving behind the habitat fragments shown in purple. This is one of only eight similar habitat fragmentation experiments in the world. Uniquely, this study will test whether diversity inputs can prevent the losses of biodiversity and ecosystem services that are expected to otherwise occur in these habitat fragments. In Activity 2 (right), diversity inputs will be added to experimental plots (white rectangles) of an ongoing study to test whether bison grazing and fire management enhance the benefits provided by diversity inputs.

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

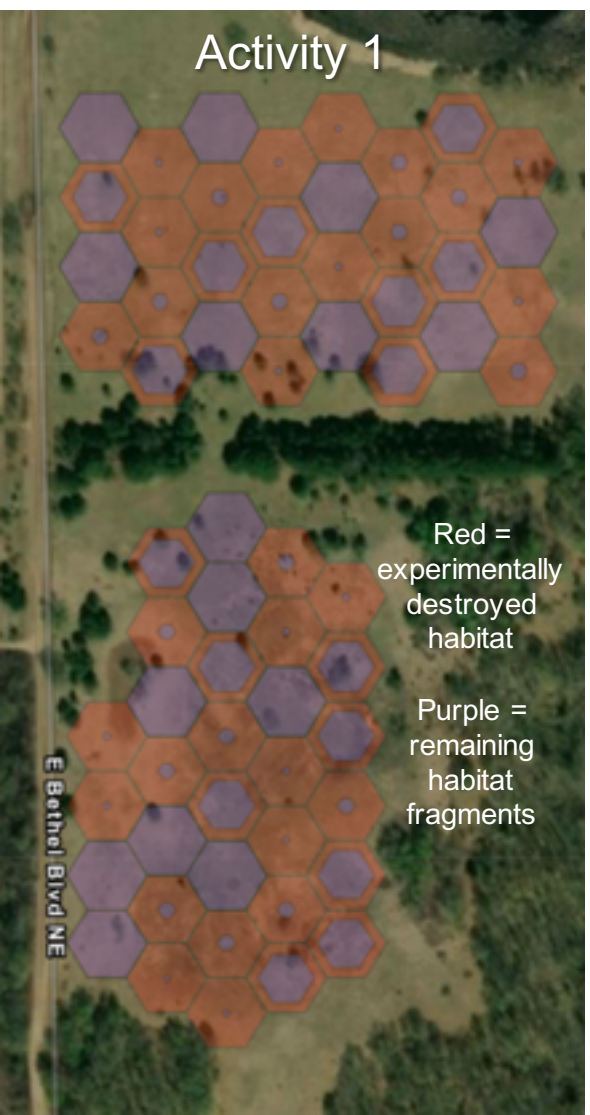
No

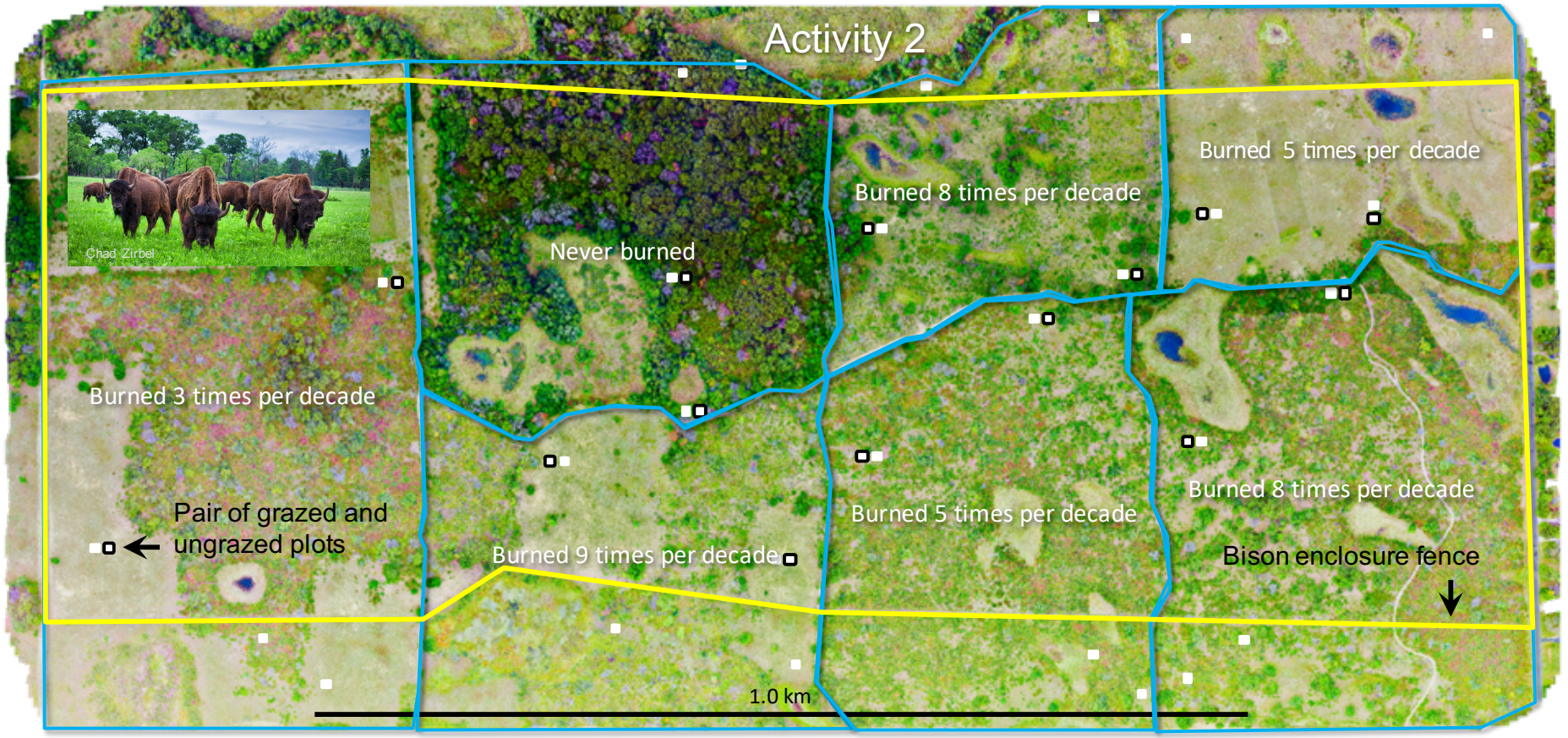
Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration


Activity 1
Red = experimentally destroyed habitat
Purple = remaining habitat fragments
E Bethel Blvd NE


Activity 2
Chad Zirbel
Never burned
Burned 3 times per decade
Burned 8 times per decade
Burned 5 times per decade
Pair of grazed and ungrazed plots
Burned 9 times per decade
Burned 5 times per decade
Burned 8 times per decade
Bison enclosure fence
1.0 km