Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-056

Proposal Title: Healthy Forests: Wildlife as Dispersers of Beneficial Fungi

Project Manager Information

Name: Michael Joyce

Organization: U of MN - Duluth - NRRI

Office Telephone: (218) 788-2656

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Project Basic Information

Project Summary: We will determine the contribution of wildlife to increasing forest health and resilience through dispersal of beneficial fungi and how we can manage for valuable ecosystem services provided by wildlife.

Funds Requested: $290,000

Proposed Project Completion: 2023-06-30

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): Central, NE, NW,

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

Region(s): Central, NE, NW,

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.

Forests cover most of northern Minnesota and provide important economic revenue and essential ecosystem services. Maintaining forest health and resilience in the face of climate change will be critical so forests can provide important ecological, economic, and recreational services to Minnesotans into the future.

Mycorrhizal fungi are a type of beneficial fungus that colonizes roots and allows trees to better access water and soil nutrients. They associate with all trees in Minnesota and are required for the establishment and growth of many species. Further, they can make trees more resistant to drought, insect pests, and diseases.

However, most mycorrhizal fungi have limited dispersal on their own and many require wildlife such as small mammals to eat their fruiting bodies (mushrooms) and disperse their spores. The absence of small mammal spore dispersal in northern Minnesota has been linked to failed spruce regeneration. Small mammal spore dispersal occurs over relatively short distances, but with climate change spore dispersal must take place at large spatial scales so that more southerly adapted fungi can migrate north. Mammal carnivores, that consume small mammals, may play a key role in long-distance dispersal because they have large home ranges and occupy both mature and regenerating forests.

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.

Our study will focus on the role of five carnivore species (bobcat, fisher, coyote, marten, and red fox) and their prey as dispersers of mycorrhizal fungi. These species represent the most abundant carnivores living in Minnesota and because they commonly eat small mammals that consume mushrooms, we expect that these carnivores are important secondary disperses of mycorrhizal spores. However, differences in diet, habitat selection, and spatial movements may influence their relative importance.

We will integrate species-specific diet and habitat selection with measurements of mycorrhizal spore abundance in scats to determine carnivore spore dispersal ability. Additionally, we will conduct greenhouse and field experiments to determine how fungal spores in small mammal and carnivore scats influence tree establishment, survival, and growth. With these data, our objectives are to:

1. Identify the relative importance of different mammal species in dispersing fungal spores among habitats.
2. Determine how within- and between-species differences in diet selection and spatial movement influences spore dispersal.
3. Measure the effect of mammal-dispersed mycorrhizal fungi on the establishment of trees.

Understanding the role of different mammal species in dispersing mycorrhizal fungi can better inform management practices that maximize regeneration potential and maintain healthy and resilient forests.

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?

This project will allow us to identify which mammals play the biggest role in forest health through dispersal of beneficial mycorrhizal fungi. By determining how mycorrhizal spores dispersed in wildlife scat influence establishment and growth of tree seedlings, we will link directly wildlife interactions with forest regeneration. This knowledge can guide development of harvest strategies that will attract mammals that disperse fungi to recently harvested forests thereby increasing mycorrhizal diversity. This project is a first step toward understanding the underappreciated benefits that maintaining healthy wildlife populations have on forest health by contributing to forest regeneration and resilience.

Activities and Milestones

Activity 1: Determine the role of carnivores and their prey at dispersing mycorrhizal fungal spores and how this influences forest regeneration

Activity Budget: $290,000

Activity Description:
Using scat-detection dogs, we will collect scats from five carnivores in dominant forest types in northeastern and northcentral Minnesota during summer and fall. We will also measure small mammal prey abundance and collect prey scats from these areas. Using a combination of microscopy and genetics, we will determine the types and number of fungal spores that the different carnivore and prey species are carrying. By linking data on spore abundance in scat with prey selection and habitat occupancy of carnivores, we will determine the relative role of different carnivores at dispersing spores across forest types. Focusing on two carnivores (bobcats and fishers) we will determine how variable spore dispersal is both within and between species depending on their diet selection and spatial movements. Data for this comparison will come from samples and data collected as part of a project recommended for funding by LCCMR (2020 Bobcat and fisher habitat use and interactions), allowing us to meet this objective with minimal additional funding. Finally, we will conduct a greenhouse and field experiment in recently harvested forests to determine whether fungal spores deposited in carnivore scats can effectively inoculate tree seedlings with mycorrhizal fungi and how this influences seedling growth and survival.

Activity Milestones:

Description	Completion Date
Determine effect of wildlife-dispersed fungal spores on colonization, growth, and survival of tree seedlings	2022-10-31
Collect carnivore and small mammal scats over two seasons	2022-10-31
Analyze scat samples for fungal spore abundance	2023-04-30
Analyze carnivore spore dispersal and seedling data and submit final reports	2023-06-30

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Dr. Michael Joyce	UMD-NRRI	Project manager and Principal investigator, overseeing all aspects of this project and coordinating field scat collection.	Yes
Dr. Alexis Grinde	UMD-NRRI	Co-principal investigator who will provide input and support on all aspects of this project and will help coordinate field work.	Yes
Dr. Ryan Stephens	UMD-NRRI	Postdoctoral researcher who will provide input and contribute to all aspects of this project. Will conduct and coordinate all scat analyses and field/greenhouse experiments.	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 be funded?

This proposal is part of a larger effort to examine interactions between wildlife and forestry in Minnesota. This project builds on recent ENRTF-funded projects focused on understanding the effects of forestry on wildlife (e.g., 2016 Evaluation of Tree Retention Guidelines Pertaining to Wildlife, 2019 Den boxes for fishers and other cavity-nesting wildlife) to understand the effects of wildlife on forest health and resilience. One novel aspect of this project is that we seek to understand how wildlife activities affect growth and survival of seedlings, allowing us to determine direct effects of wildlife populations on forest health and regeneration.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Den Boxes for Fishers and other Nesting Wildlife	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 03i	$190,000

Project Manager and Organization Qualifications

Project Manager Name: Michael Joyce

Job Title: Wildlife Ecologist/Researcher 5

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

Dr. Joyce is a Wildlife Ecologist at the Natural Resources Research Institute, University of Minnesota Duluth. He has over 9 years of wildlife research experience on telemetry and habitat analyses using LiDAR and other spatial data. Michael is working on, and managing, one current ENRTF-funded project (2019 Den boxes for fishers and other cavity-nesting wildlife) and is the project manager on a project that has been recommended for ENRTF funding focused on carnivore ecology (2020 Bobcat and fisher habitat use and interactions). He has worked extensively on wildlife research projects in northern Minnesota over the last 9 years.

EDUCATION:
PhD, 2018. University of Minnesota, Integrated Biological Sciences.
MS, 2013. University of Minnesota, Integrated Biological Sciences.
BS, 2008. University of Wisconsin-Madison, Molecular Biology.

RECENT PUBLICATIONS (Directly related to research on carnivore habitat selection and movement):

Joyce, M., J. Erb, P. Coy, B. Sampson, R. Moen. (in revision). Age- and sex-specific dispersal in a harvested population of American martens. Submitted to Journal of Mammalogy.

Joyce, M., J. Erb, B. Sampson, R. Moen. 2019. Detection of coarse woody debris using airborne light detection and ranging (LiDAR). Forest Ecology and Management 433 (pp 678-689).

Joyce, M. 2018. Evaluating American marten habitat quality using airborne light detection and ranging (LiDAR) data. PhD Dissertation, University of Minnesota.

Joyce, M., A. Zalewski, J. Erb, R. Moen. (2017). Use of resting microsites by members of the Martes Complex: the role of thermal stress across species and regions. The Martes complex in the 21st Century: Ecology and Conservation (pp. 181-220).

Green, R., M. Joyce, S. Matthews, K. Purcell, J. Higley, A. Zalewski. (2017). Guidelines and techniques for studying the reproductive ecology of wild fishers, American martens, and other members of the Martes complex. The Martes complex in the 21st Century: Ecology and Conservation (pp. 313-358).

Organization: University of Minnesota Duluth - NRRI
Organization Description:
The Natural Resources Research Institute (NRRI) is an applied research and economic development engine for the University of Minnesota research enterprise. NRRI employs over 130 scientists, engineers and technicians to deliver on its mission to provide research solutions to balance our economy, resources and environment for resilient communities. NRRI collaborates broadly across the University system, the state and the region to address the challenges of a natural resource based economy.

NRRI researchers have extensive experience in managing large, interdisciplinary projects. NRRI's role is as an impartial, science-based resource that develops and translates knowledge. Projects include characterizing and defining resource opportunities, minimizing waste and environmental impact, maximizing value from natural resources and maintaining/restoring ecosystem function.

The Wildlife Ecology Team at NRRI is focused on the ecology, conservation, and management of wildlife populations in Minnesota and beyond. Our research focuses on identifying and addressing current and emerging issues for wildlife populations in Minnesota, with an emphasis on mammals. Our research aims to provide the knowledge needed to develop solutions that balance wildlife needs with societal needs.

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Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Michael Joyce, Researcher 5		Project Manager. Will help oversee and coordinate all aspects of the project.			26.7%	0.1		$8,670
Ryan Stephens, Postdoctoral researcher		Conduct and oversee all aspects of project. Will lead laboratory analysis of wildlife samples and greenhouse experiment.			20.2%	2		$148,533
Alexis Grinde, Researcher 6		Co-Investigator. Will help oversee and coordinate all aspects of the project.			26.7%	0.1		$12,317
Technician, Researcher 3		Assist with field and lab work to collect and analyze wildlife samples.			24.1%	0.3		$21,287
Undergraduate research assistant		Assist with field and lab work to collect and analyze wildlife samples.			0%	1		$27,193
							Sub Total	**$218,000**
Contracts and Services								
TBD	Professional or Technical Service Contract	Genetic analysis of carnivore scats to confirm species identity. 800 samples at $25/sample				0.26		$20,000
TBD	Professional or Technical Service Contract	Scat detection dog company will use dogs to search for and collect carnivore scats in our study areas.				0.14		$20,000
TBD	Professional or Technical Service Contract	Genetic identification of fungal samples using Illumina next-generation sequencing.				0.28		$9,000
							Sub Total	**$49,000**
Equipment, Tools, and Supplies								

	Tools and Supplies	Tools and supplies for greenhouse and field experiments including soil, pots, trays, and seeds.	Determine how wildlife-dispersed fungal spores effect seedling establishment, growth, and survival.					$500
	Tools and Supplies	Supplies and equipment for analyzing wildlife scat samples.	Supplies to identify fungal spores in scats of carnivores and small mammals. Supplies to process 900 samples (300 carnivore samples and 600 small mammal samples).					$4,000
	Tools and Supplies	Supplies for genetic analysis of fungal diversity	Supplies to extract DNA from fungal samples for a sub-set of all wildlife scats and fungal samples from the greenhouse experiment.					$3,500
	Tools and Supplies	Field supplies and equipment for wildlife scat sample collection (sample bags, desiccant, trapping bait, gloves, batteries for GPS, etc.)	Materials to conduct field surveys to collect wildlife scat samples and store samples for laboratory analysis.					$3,000
							Sub Total	**$11,000**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Travel for fieldwork including mileage (75%) and lodging (25%) for technician, PI, postdoc, and undergraduate field assistant. Mileage will be reimbursed at $0.575/mile. Lodging is estimated between $80 and $90 per night, less if camping is possible.	Field work to collect carnivore scats and survey prey populations					$11,800
							Sub Total	**$11,800**
Travel Outside Minnesota								
							Sub Total	**-**

Printing and Publication								
							Sub Total	**-**
Other Expenses								
		Shipping	Shipping genetic samples to a service lab for testing.					$200
							Sub Total	**$200**
							Grand Total	**$290,000**

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 55% 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	$159,500
			Non State Sub Total	**$159,500**
			Funds Total	**$159,500**

Attachments

Required Attachments

Visual Component

File: 19022700-bed.pdf

Alternate Text for Visual Component

Forest cover in Minnesota and the general locations of northeastern and north-central study areas for this project (left); conceptual diagram of the role of fungi and wildlife in tree growth and health (right); and text highlighting the over-arching goal of the study (bottom).

Optional Attachments

Support Letter or Other

Title	File
Letter of Support from Dr. Tony D'Amato, Faculty and Forestry Program Director, University of Vermont	0da01753-c36.pdf
Sponsored Projects Authorization Letter	ee6d88ce-187.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

No

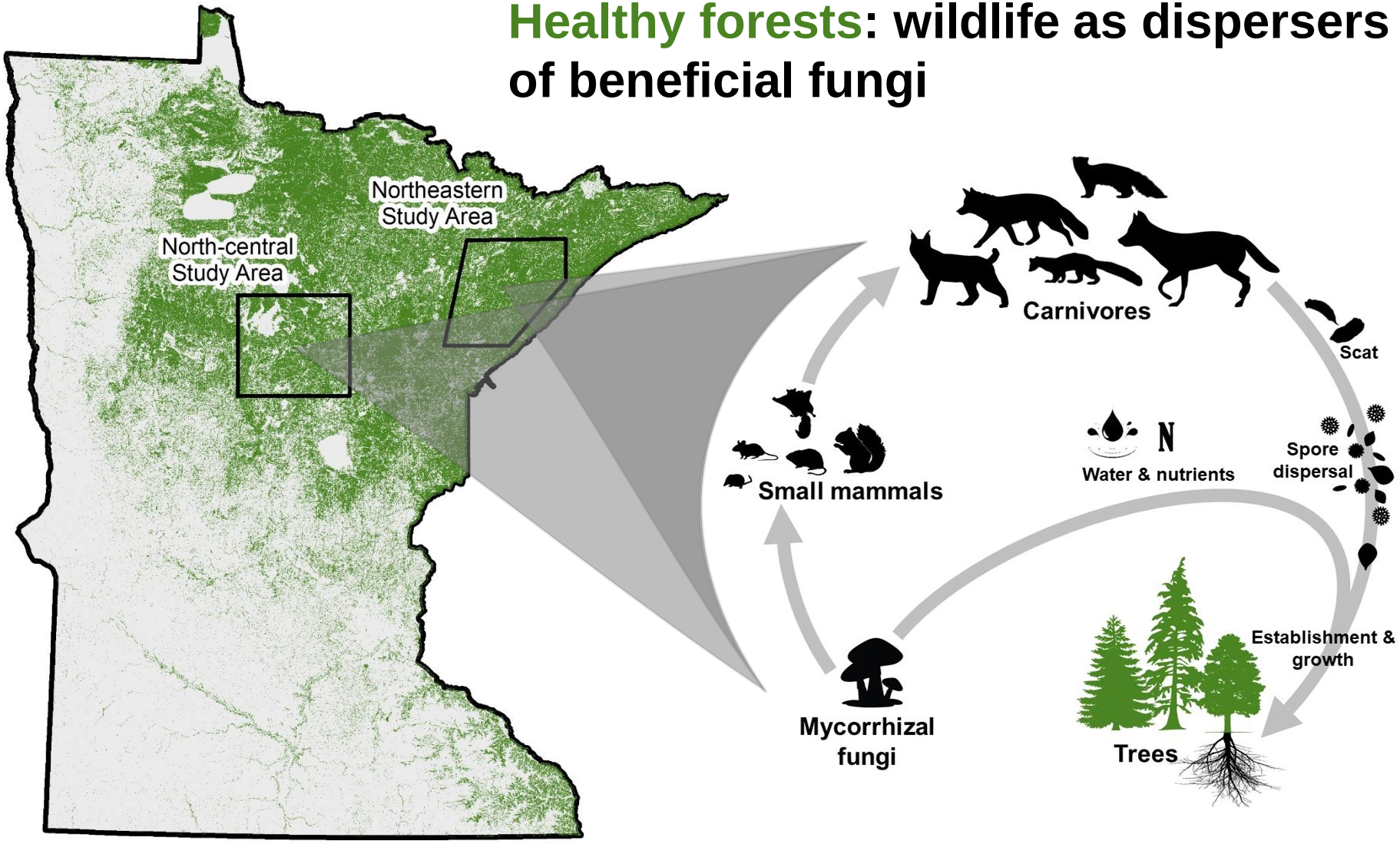
Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Healthy forests: wildlife as dispersers of beneficial fungi



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