Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-406

Proposal Title: Roadside Mosses as Biological Filters for Mitigating Microplastics

Project Manager Information

Name: Natalia Mossmann Koch

Organization: U of MN - College of Biological Sciences

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Project Basic Information

Project Summary: This project will test the use of mosses as biological filters to mitigate microplastic pollution and prevent them from reaching waterways in Minnesota.

ENRTF Funds Requested: $509,000

Proposed Project Completion: June 30, 2030

LCCMR Funding Category: Water (B)

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.

Small plastic particles, commonly known as microplastics, are a long-lasting form of pollution, able to reach rivers and lakes and contaminate the whole food chain. These particles can be small enough that not only they are carried out through our waterways, but also through the air. And this is what explains microplastics to be so widely distributed - being even found in pristine environments. Recently, studies have identified disturbing amounts of microplastics in human bodies (including our brains!), and health impacts including diseases related to the digestive, reproductive and respiratory systems, as well higher risks of strokes and heart attacks, and possible links to colon and lung cancer. So monitoring and mitigating them is an urgent need. Mosses have proven to be successful monitors of environmental pollution, due to their close relation to the environment - they have extremely thin leaves, and have also shown to hold different types of microplastics particles, suggesting they may also act as effective filters.

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 propose to use mosses to monitor and mitigate microplastic pollution along roadsides in Minnesota. Roadsides have elevated concentrations of microplastics, which is mainly a result of high amount of tire wear. These tire wear particles also shed chemicals that negatively affect fish health (e.g., 6PPD-Q). This makes high-traffic roadsides an important intervention site to keep microplastics from reaching Minnesota waters. We propose to test the use of mosses as biological filters on roadside edges. Mosses are known for their ability to filter nutrients and pollutants from air and water, but their ability to capture microplastics is less well known. We will apply a combination of laboratory experiments (develop better protocols for assessing microplastics in mosses), transplants of mosses from clean areas (measure microplastic pollutant loads), moss sampling along roadsides, and the installation of moss-innoculated biochar plaster. Biochar plasters are a sustainable option for urban interventions: they are made from waste material, absorb pollutants themselves and can be applied at scale (spraying or cement mixer). Our aim is to propose a solution to mitigate the microplastic pollution resulting from tire wear before it reaches water bodies, protecting rivers and lakes, as well as the health of Minnesotans.

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?

The main outcome will be to have a solution to help mitigate microplastics from reaching Minnesotans waterways. The application of mosses on biochar plaster, could be a scalable option to filter microplastics using a waste product with known pollutant-binding abilities. This solution could be used to improve management and protection of Minnesota natural resources. We will share our findings through partnerships with MnDoT, MPCA, BWSR, and others, as well as in peer-reviewed journals to make this a viable and applied solution if we have successful results. We believe that mosses could be a great tool for microplastic mitigation.

Activities and Milestones

Activity 1: Measuring microplastic retention in mosses

Activity Budget: $121,000

Activity Description:
Most mosses derive their nutrition from dust and rain, making them excellent filters for capturing particles from deposition and runoff, such as microplastics and metals. However, there have been no studies testing the presence of microplastics on natural growing mosses in the U.S., despite the potential of using these organisms for that goal. The aim of this activity is to evaluate the amount of microplastics that can be trapped by mosses and what is the impact of water runoff on this ability. We will do that, by testing existing protocols in lab and greenhouse experiments with project partners (UMN Chemistry). We will add and evaluate the filtering capability of particles of different sizes (<50 microns, between 51 and 100, between 101 and 200 and >201 microns) through chemical and microscopical analyses. Extracts will be done by digesting the moss with H2O2, filtering the particles and counting under a microscope confirming a subset of particles with Fourier-Transform Infrared Spectroscopy (FTIR) and Scanning Electron Microscopy (SEM). Fire moss (Ceratodon purpureus), a fast-growing and pollution-tolerant Minnesota native plant, will be our target species.

Activity Milestones:

Description	Approximate Completion Date
Develop a protocol to measure microplastics using mosses	January 31, 2028
Test the protocol in the laboratory with experiments	April 30, 2028
Analyze data for protocol publication	October 31, 2028
Completion of final products of research, such as peer-reviewed journal articles	March 31, 2029

Activity 2: Monitoring microplastic pollution along Minnesota roadsides using mosses

Activity Budget: $169,000

Activity Description:
After testing how much and what sizes of microplastics are mostly filtered by mosses (Activity 1), we will sample roadsides in Minnesota using two approaches: 1) Sample existing populations of the target moss species, Ceratodon purpureus - assess maximum load tolerance of living mosses in the field; 2) Transplant moss patches from less polluted environments - evaluate the load of microplastics per period. Transplants will be left for one year (starting during the spring for better moss establishment) and a subsample will be collected after 6 months. Microplastics in the mosses will be measured using the protocol tested as described in Activity 1. For the one year samples, metal contents will be measured as well. Every three months, the vitality of transplants will be evaluated with a portable Photosynthesis Yield Analyzer. Three sampling sites will be selected and different sets of transplants and interventions with biochar plaster (see Activity 3) will be placed closer and further from the roads. For site selection, we will prioritize roads with higher traffic (more than 2 thousand cars/day). The exact sites will be chosen based on the presence of native populations of our target moss species.

Activity Milestones:

Description	Approximate Completion Date
Select areas and request permits (MnDOT)	August 31, 2027
Sample mosses in roadsides in the Twin Cities metro area	October 31, 2027
Sample mosses in a less polluted environment for transplants	March 31, 2028
Measure microplastic accumulation in the existing population of mosses sampled along the roadsides	March 31, 2028
Deploy moss transplants along roadsides in the Twin Cities metro area	May 31, 2028

Measure microplastic accumulation and vitality of the transplanted mosses after 6 months	November 30, 2028
Measure microplastic accumulation, heavy metals and vitality of the transplanted mosses after 12 months	May 31, 2029
Analyze data	December 31, 2029
Completion of final products of research, such as final reports and peer-reviewed journal articles	June 30, 2030

Activity 3: Test the effectiveness of mosses growing on biochar plaster to mitigate microplastic pollution

Activity Budget: $219,000

Activity Description:
Our third activity aims to test the feasibility of "planting" fire moss (Cerotodon purpureus) to mitigate microplastic pollution. We will do that by testing scalable moss-based interventions using biochar plaster (made from organic waste material) inoculated with living mosses at the sites described in Activity 2. We will first test different biochar mixtures (both as slurry, for easy application to soil, and tiles, for easy installation) with project partners (UMN Design) to find the best ones for moss growth, microplastic retention, as well as being scalable and cost-efficient. The target moss species has been shown to grow well in biochar plaster mixtures (tested as a pilot in our lab). Moss-innoculated plaster will be applied to roadside soil surface as a slurry and to sound walls as 3-D printed tiles to compare effectiveness of different approaches. Every 3 months, we will evaluate the vitality and growth of these mosses by taking pictures and measuring photosynthetic activity the same way we will do with the transplants, and collect a sample to measure microplastics after 6 and 12 months of deployment. We foresee that, in a few months, this intervention will be successfully able to capture microplastics before these pollutants reach water bodies.

Activity Milestones:

Description	Approximate Completion Date
Test moss growth on different compositions of biochar plaster in the lab	March 31, 2028
Install biochar plaster with moss along roadsides in the Twin Cities metro area	May 31, 2028
Evaluate moss growth and vitality at every 3 months for 1 year	May 31, 2029
Measure microplastic retention by the mosses planted on the biochar plasters	November 30, 2029
Analyze data	December 31, 2029
Completion of final products of research, such as final reports and peer-reviewed journal articles	June 30, 2030
Dissemination and discussion of results with MnDoT, BWSR and other organizations - starting mid Y2	June 30, 2030

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Daniel Stanton	University of Minnesota - College of Biological Sciences	Co-lead, in particular providing expertise on mosses and moss biology, as well as equipment and expertise for moss growth, vitality/physiological measurements, and helping in the project design and outcomes.	No
Emilie Snell-Rood	University of Minnesota - College of Biological Sciences	Collaborator, in particular providing expertise on the effects of pollutants (microplastics and metals) in the environment, expertise on biochar interventions and helping in the project design.	No
Lee Penn	University of Minnesota - College of Science & Engineering	Collaborator, in particular providing expertise on the analyses of microplastics.	Yes
Malini Srivastava	University of Minnesota - College of Design	Collaborator, in particular providing expertise on developing and testing biochar plasters and tiles.	Yes

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
The design and findings will be shared and discussed with MnDoT through our collaborator Dr Emilie Snell-Rood and her active MnDoT/LRRB grant on biochar in roadside soil. Results will be also published in peer-reviewed academic journals, as well as written up and shared in public outreach formats. We will be further discussing results with BWSR to plan on future possible applications. The data generated will be incorporated and made publicly available into the databases managed and curated by the Urban Long-Term Ecological Research program at UMN, led by Dr Sarah Hobbie and Dr Emilie Snell-Rood.

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?
The design and findings will be shared and discussed with MnDoT through our collaborator Dr Emilie Snell-Rood and her active MnDoT/LRRB grant on biochar in roadside soil. Results will be also published in peer-reviewed academic journals, as well as written up and shared in public outreach formats. We will be further discussing results with BWSR to plan on future possible applications. The data generated will be incorporated and made publicly available into the databases managed and curated by the Urban Long-Term Ecological Research program at UMN, led by Dr Sarah Hobbie and Dr Emilie Snell-Rood.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Lichens as Low-Cost Air Quality Monitors in Minnesota	M.L. 2023, , Chp. 60, Art. 2, Sec. 2, Subd. 07d	$341,000

Project Manager and Organization Qualifications

Project Manager Name: Natalia Mossmann Koch

Job Title: Research Associate

Provide description of the project manager's qualifications to manage the proposed project.
Dr Koch has extensive expertise (>18yrs) of work on ecology, including particular focus on biomonitoring and lichens. She has led studies in urban and natural environments in Minnesota and Brazil, including on biomonitoring using lichen biology and diversity. She also has expertise in the use of physiological measurements to provide a non-destructive means of assessing health and stress of plants and lichens. Currently she is the lead of a LCCMR funded project on Lichens as Low-Cost Air Quality Monitors across Minnesota (now in its final months), managing the project's budget, mentoring students, doing field work, identifying lichen species, leading outreach activities and preparing manuscripts and reports.

Organization: U of MN - College of Biological Sciences

Organization Description:
Department of Ecology, Evolution and Behavior in the College of Biological Sciences at the University of Minnesota.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Project Leader		Lead experiments in the lab and in the field, responsible for data collection, analysis and dissemination. Dr. Mossmann Koch is the project leader and the research associate of the project.			26.8%	3		$317,000
Academic Faculty		Dr Lee Penn will support by providing expertise and help with the protocols and tests for microplastic assessment.			26.8%	0.03		$9,500
Graduate Student (Semester)		Graduate students will help in lab experiments and design of protocols, as well as the design and test of biochar plasters and tiles.			50%	1		$83,400
Undergraduate Assistants (Semester)		Assisting research scientist and graduate students with laboratory and field work during school semesters.			0%	0.6		$27,600
Graduate Students (Summer)		Graduate student will help the PIs by coordinating laboratory work and contributing to the preparation of the resulting manuscripts.			20%	0.5		$12,000
Undergraduate Assistants (Summer)		Assisting research scientist with field work during the summer.			0%	0.25		$18,000
Academic Faculty		Providing expertise on developing, testing and producing biochar plasters and tiles.			26.8%	0.02		$4,500
							Sub Total	**$472,000**
Contracts and Services								
TDB	Service Contract	Lab services: Analyses of types of microplastics and heavy metals.				-		$18,000
							Sub Total	**$18,000**
Equipment, Tools, and Supplies								
	Tools and Supplies	Lab and fieldwork supplies	Collection bags, tools, reagents for microplastic analyses, biochar and other materials for the plasters, etc.					$10,000

							Sub Total	**$10,000**
Capital Equipment								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Car rental with the UMN Fleet Services for around 30 visits to the sites for each year.	Field sampling, monitoring of transplants and moss growth on biochar interventions, sampling of mosses for microplastic analyses.					$9,000
							Sub Total	**$9,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$509,000**

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				
In-Kind	Indirect costs	Indirect costs associated with this proposal	Potential	$257,000
			State Sub Total	**$257,000**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**$257,000**

Total Project Cost: $766,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 80771a50-a7e.pdf

Alternate Text for Visual Component

Activities and outcomes. Activity 1 is represented by the laboratory tests of microplastics in the moss. Activity 2 is shown with transplants and sampling of native moss populations on the roadside. Activity 3 is represented by the biochar covered in moss on the ground and a wall on the roadsides....

Supplemental Attachments

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

Title	File
Proposal Approval Letter	ff9ba6ab-16f.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?

Yes, I understand the UMN Policy on travel applies.

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

Yes

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

Yes

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

No

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:

Daniel Stanton, University of Minnesota

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

Yes, I understand