

Environment and Natural Resources Trust Fund

2023 Request for Proposal

General Information

Proposal ID: 2023-152

Proposal Title: Lichens as Low-Cost Air Quality Monitors in Minnesota

Project Manager Information

Name: Natalia Mossmann Koch Organization: U of MN - College of Biological Sciences Office Telephone: (612) 512-4646 Email: nkoch@umn.edu

Project Basic Information

Project Summary: The proposed project aims to develop protocols for using lichens as indicators of air quality data across Minnesota and through time.

Funds Requested: \$344,000

Proposed Project Completion: June 30, 2026

LCCMR Funding Category: Air Quality, Climate Change, and Renewable Energy (E)

Project Location

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

Air quality is an important issue worldwide especially given its negative effects on human health. Although atmospheric pollution has been discussed for a long time, according to the World Health Organization, 4.2 million deaths occur around the globe every year as a result of outdoor air pollution. The latest data from the US shows that in 2016 more than 77,000 deaths can be attributed to respiratory infections, lung cancer, stroke and heart diseases related to air contaminants. And it is due to this serious health impact that the constant monitoring of air pollutants needs to be a major concern. One cost-effective way to do so is using ecological indicators, which can be crucial to measure and map the impacts of pollution over space with high spatial resolution. Lichens are known to be very good air quality indicators, due to their sensitivity to even slight changes. They absorb humidity and their nutrients directly from the atmosphere, and by doing that, they also absorb a great amount of pollutants, for example heavy metals and particulate matter, when those are present in the environment. This makes lichens low-cost, natural, air quality monitors that can be applied to Minnesota.

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 lichens to monitor present and past air quality conditions in communities across Minnesota. We will use a combination of lichen transplants (which accumulate contamination, showing us pollution over a few months), lichen surveys (what is able to grow, reflecting pollution in recent years) and archival specimens (what grew in the past, tracking changing air quality over the past century). The aim is to both provide measurements that can complement current efforts by the Minnesota Pollution Control Agency and other entities using other methods, but also to develop lichen-based air-quality indices that can be used by citizen naturalists without extensive training.

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 project outcome will be to generate data of a more detailed distribution of air pollutants along Minnesota, including areas where no detailed information on air quality is currently available. As a next step, the information generated will be worked through collaborator contacts at relevant government agencies to share the information and correlate with existing data, aiming to improve and direct efforts on public health and the conservation of natural resources. Lastly, by developing and testing user-friendly protocols for citizen scientists, we will empower Minnesotans across the state to make observations of air quality in their communities.

Activities and Milestones

Activity 1: Mapping air-pollution in city/town parks using lichen transplants

Activity Budget: \$118,000

Activity Description:

Monitoring air quality is important for public health policy, but often costly and complex. It is important to find low-cost and time-efficient ways to expand our monitoring network beyond point locations, mostly around the metro area. Lichen transplants can be a useful approach, and have been applied successfully in other parts of the world, but never in MN. Some lichens, such as Common Greenshield (Flavoparmelia caperata) and Hammered Shield (Parmelia sulcata) are abundant and good at taking up heavy metals, sulfur dioxide and other pollutants, which makes them good "natural air quality monitoring stations". We will develop a lichen transplant protocol that will be easy to assemble and deploy in urban and suburban sites across MN, to provide standardized measures of air quality. In addition to measuring air quality by analyzing the lichens for pollutants, we will use non-invasive physiological monitoring approaches (chlorophyll fluorescence) to identify non-destructive predictors of air quality and stress.

Activity Milestones:

Description	Completion Date
Develop lichen transplant design, and deploy in 4 sites in the Twin Cities metro area	August 31, 2024
Measure physiology and accumulated pollutants after 6 months	March 31, 2025
Install lichen transplants in urban sites in 20 urban sites across MN	August 31, 2025
Measure physiology and accumulated pollutants after 6 months	September 30, 2025

Activity 2: Developing lichen indices of air quality from expert and citizen surveys

Activity Budget: \$127,000

Activity Description:

Transplants, although low-cost, require installation and maintenance, which limit really wide use. However, surveys of existing lichen communities can provide an insight into air quality as well. Air quality indices based on surveying lichens have been developed in other countries, but none exist for the Upper Midwest. One of the challenges is that some lichen identification can be challenging for non-experts, so for maximum applicability, we will develop an index to predict air quality that does not require expert-level identification. We will achieve this by first developing an index from expert surveys, and then designing a more user-friendly version. We will test the public protocol through collaborations with UMN outreach (Bell Museum) and Extension (Master Naturalists) to refine the protocol and make it easily shared and applied.

Activity Milestones:

Description	Completion Date
Expert surveys of lichen communities surrounding the transplant sites and other sites	August 31, 2025
Develop a predictive index of air quality from lichen communities	August 31, 2025
Develop and test a user-friendly protocol for identifying lichen communities	June 30, 2026

Activity 3: How has MN air quality changed through time?

Activity Budget: \$99,000

Activity Description:

Time scaled monitors of air pollution are lacking in the current literature and herbarium material could be a valuable tool for this purpose. At the University of Minnesota, the Herbarium has over 35,000 lichen specimens from Minnesota

representing over 120 years of collecting. Some of these have sufficient material for analysis of heavy metals and nitrogen content without losing its value as an archival sample. There is also considerable uncatalogued and duplicate material available for use. This is especially true for some areas that were visited repeatedly over the 20th century, giving us a record of changes in air quality through time. These same species, from the same sites, can then be revisited in the present day to document change of health related air pollutants.

Activity Milestones:

Description	Completion Date
Analyze historical samples from the Bell Herbarium and other historical collections	December 31, 2025
Resample those same species from the same locations for analysis of present day conditions	December 31, 2025
Analysis of changes in air quality through time	June 30, 2026

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Daniel Stanton	University of Minnesota- College of Biological Sciences	Co-lead, in particular providing equipment and expertise for physiological measurements (Activity 1), as well as access and expertise with historical and archival lichen collections at the Bell Museum (Activity 3)	No
Holly Menninger	Bell Museum	Citizen Science activity support	Yes
Andrea Lorek	Minnesota Master Naturalists	Citizen science component support	No
Emilie Snell- Rood	University of Minnesota- College of Biological Sciences	Collaborator	No
Sarah Hobbie	University of Minnesota- College of Biological Sciences	Collaborator	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 work be funded?

The findings and results will be published in peer-reviewed academic journals, as well as written up and shared in public outreach formats. The long term continuation of the citizen science activities will be incorporated into the Urban Long-Term Ecological Research program at the University of Minnesota, led by Dr Sarah Hobbie (a project collaborator), which will also provide a platform for data curation and publicly accessible data storage.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Assessing Natural Resource Benefits Provided by Lichens and Mosses	M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 03e	\$213,000

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 (>15yrs) of work with lichen ecology, including particular focus on urban lichen communities. She has led studies of lichens in urban and natural environments in Minnesota and Brazil, including on variation of lichen communities in parks from urban to suburban to rural contexts in Brazil. More recently she has been developing expertise in the use of physiological measurements of lichens that can provide a non-destrtucive means of assessing health and stress.

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. Ineli	% Bene	# FTE	Class ified	\$ Amount
				gible	fits		Staff?	
Personnel								
Project		Lead data collection, analysis and outreach			25%	3		\$230,000
Leader								
Public		Consultation, planning and implementation support			25%	0.06		\$6,000
Engagement		for public engagement component						
Support								
Student		Undergraduate student researcher			0%	0.51		\$20,000
worker-								
semester								
Student		Field support student researcher			0%	0.75		\$22,000
worker								
(summer)								
							Sub	\$278,000
							Total	
Contracts								
and Services								
							Sub	-
							Total	
Equipment,								
Tools, and								
Supplies								
	Tools and	Lab and fieldwork supplies (chemically clean	Miscelleaneous supplies for collecting					\$6,000
	Supplies	collection bags, CO2 cartridges for physiological	and measuring lichen pollutant content					
		measurements, etc)	and physiology					
	Tools and	Instructional materials (urban lichen book, handlens,	Outreach kits for training citizen					\$5,000
	Supplies	grid, etc \$50/kit for 100 kits)	scientists					
	Tools and	Dataloggers (HOBO U23 Pro V2 or equivalent 50	Dataloggers to track local climate					\$6,000
	Supplies	units at \$200/each)	conditions at the transplant sites					
							Sub	\$17,000
							Total	
Capital								
Expenditures								
							Sub	-
							Total	
Acquisitions								
and								
Stewardship								

					Sub	-
					Total	
Travel In						
Minnesota						
	Miles/ Meals/		food and lodging (eg motel/hotel near			\$15,000
	Lodging		study sites in Greater Minnesota) for			
			research scientist and assistant during			
			fieldwork			
	Miles/ Meals/		Fleet vehicle rental for fieldwork across			\$15,000
	Lodging		Minnesota			
					Sub	\$30,000
					Total	
Travel						
Outside						
Minnesota						
	Conference	1 trip to a week-long domestic conference for 1	Travel for research scientist to present	Х		\$2,000
	Registration	person (project manager)	findings and methods at 1 domestic			
	Miles/ Meals/		conference (Year 2)			
	Lodging					
					Sub	\$2,000
					Total	
Printing and						
Publication						
	Printing	Outreach materials for citizen scientist kits (100) and	Printing costs for outreach materials			\$4,000
		other outreach brochures				
					Sub	\$4,000
					Total	
Other						
Expenses						
		Equipment servicing and re-calibration in Year 1 and	Ecophysiological equipment to be used			\$4,000
		Y3	requires regular servicing and			
			recalibration			
		Lab services (analyses of pollutant content)	or analyses of carbon, nitrogen and			\$9,000
			heavy metal content of specimens of			
			transplants (Activity 1), archival			
			samples (Activity 3) and fresh samples			
			(Activity 3)			
					Sub	\$13,000
					Total	
					Grand	\$344,000
					Total	

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Travel Outside	Conference	1 trip to a week-long domestic	Formal presentation of results at a conference
Minnesota	Registration	conference for 1 person (project	
	Miles/Meals/Lodging	manager)	

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub	-
			Total	
Non-State				
In-Kind	Indirect costs	Indirect costs associated with this proposal	Potential	\$189,000
			Non State	\$189,000
			Sub Total	
			Funds	\$189,000
			Total	

Attachments

Required Attachments

Visual Component File: <u>5ce9e7fc-9aa.pdf</u>

Alternate Text for Visual Component

Activities and outcomes of this proposal: left, example of lichen transplants; middle, the sampling method to assess lichens on tree trunks and examples of those communities; right, specimens of lichens from Bell Museum that will be used to assess changes in air quality through time; bottom, summary of outcomes....

Optional Attachments

Support Letter or Other

Title	File
Letter of Support Urban LTER	017570fe-918.pdf
Letter of Support Master Naturalists	2d6b86e8-524.pdf
Letter of Support Sponsored Projects Administration	<u>e5821202-619.pdf</u>

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

Can we use lichens as low-cost air quality predictors in Minnesota?

Activities

1. Mapping air-pollution using lichen transplants

Example of a lichen transplant



Analyses of heavy metals and nitrogen

Physiological analyses

Pb Cr Cu N



2. Developing lichen indices of air quality from expert and citizen surveys

Lichen diversity sampling on tree trunks



"Healthy"

community

3. How has MN air quality changed through time?

Analyses of herbarium specimens



Main outcomes



Empower Minnesotans across the state to make observations of air quality in their communities.