

**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

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## **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 gible** | **% Bene fits** | **# FTE** | **Class ified Staff?** | **$ Amount** |
| **Personnel** |  |  |  |  |  |  |  |  |
| Project Leader |  | Lead data collection, analysis and outreach |  |  | 25% | 3 |  | $230,000 |
| Public Engagement Support |  | Consultation, planning and implementation support for public engagement component |  |  | 25% | 0.06 |  | $6,000 |
| Student worker-semester |  | Undergraduate student researcher |  |  | 0% | 0.51 |  | $20,000 |
| Student worker (summer) |  | Field support student researcher |  |  | 0% | 0.75 |  | $22,000 |
|  |  |  |  |  |  |  | **Sub Total** | **$278,000** |
| **Contracts and Services** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Equipment, Tools, and Supplies** |  |  |  |  |  |  |  |  |
|  | Tools and Supplies | Lab and fieldwork supplies (chemically clean collection bags, CO2 cartridges for physiological measurements, etc) | Miscelleaneous supplies for collecting and measuring lichen pollutant content and physiology |  |  |  |  | $6,000 |
|  | Tools and Supplies | Instructional materials (urban lichen book, handlens, grid, etc $50/kit for 100 kits) | Outreach kits for training citizen scientists |  |  |  |  | $5,000 |
|  | Tools and Supplies | Dataloggers (HOBO U23 Pro V2 or equivalent 50 units at $200/each) | Dataloggers to track local climate conditions at the transplant sites |  |  |  |  | $6,000 |
|  |  |  |  |  |  |  | **Sub Total** | **$17,000** |
| **Capital Expenditures** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Acquisitions and Stewardship** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  | **Sub Total** | **-** |
| **Travel In Minnesota** |  |  |  |  |  |  |  |  |
|  | Miles/ Meals/ Lodging |  | food and lodging (eg motel/hotel near study sites in Greater Minnesota) for research scientist and assistant during fieldwork |  |  |  |  | $15,000 |
|  | Miles/ Meals/ Lodging |  | Fleet vehicle rental for fieldwork across Minnesota |  |  |  |  | $15,000 |
|  |  |  |  |  |  |  | **Sub Total** | **$30,000** |
| **Travel Outside Minnesota** |  |  |  |  |  |  |  |  |
|  | Conference Registration Miles/ Meals/ Lodging | 1 trip to a week-long domestic conference for 1 person (project manager) | Travel for research scientist to present findings and methods at 1 domestic conference (Year 2) | X |  |  |  | $2,000 |
|  |  |  |  |  |  |  | **Sub Total** | **$2,000** |
| **Printing and Publication** |  |  |  |  |  |  |  |  |
|  | Printing | Outreach materials for citizen scientist kits (100) and other outreach brochures | Printing costs for outreach materials |  |  |  |  | $4,000 |
|  |  |  |  |  |  |  | **Sub Total** | **$4,000** |
| **Other Expenses** |  |  |  |  |  |  |  |  |
|  |  | Equipment servicing and re-calibration in Year 1 and Y3 | Ecophysiological equipment to be used requires regular servicing and recalibration |  |  |  |  | $4,000 |
|  |  | Lab services (analyses of pollutant content) | or analyses of carbon, nitrogen and heavy metal content of specimens of transplants (Activity 1), archival samples (Activity 3) and fresh samples (Activity 3) |  |  |  |  | $9,000 |
|  |  |  |  |  |  |  | **Sub Total** | **$13,000** |
|  |  |  |  |  |  |  | **Grand Total** | **$344,000** |

### **Classified Staff or Generally Ineligible Expenses**

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

### **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 Sub Total** | **$189,000** |
|  |  |  | **Funds Total** | **$189,000** |

## **Attachments**

### **Required Attachments**

#### ***Visual Component***

File: [5ce9e7fc-9aa.pdf](https://lccmrprojectmgmt.leg.mn/media/map/5ce9e7fc-9aa.pdf)

#### ***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](https://lccmrprojectmgmt.leg.mn/media/attachments/017570fe-918.pdf) |
| Letter of Support Master Naturalists | [2d6b86e8-524.pdf](https://lccmrprojectmgmt.leg.mn/media/attachments/2d6b86e8-524.pdf) |
| Letter of Support Sponsored Projects Administration | [e5821202-619.pdf](https://lccmrprojectmgmt.leg.mn/media/attachments/e5821202-619.pdf) |

## **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