# Environment and Natural Resources Trust Fund

2024 Request for Proposal

## General Information

**Proposal ID:** 2024-199

**Proposal Title:** Real-Time Monitoring of Statewide Pollen in Minnesota

## Project Manager Information

**Name:** Jiarong Hong

**Organization:** U of MN - St. Anthony Falls Laboratory

**Office Telephone:** (612) 624-5102

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## Project Basic Information

**Project Summary:** Develop a smartphone-based, real-time pollen monitoring system using digital inline holography to track plant biodiversity, pollinator health, and invasive species, informing conservation efforts and aiding allergy sufferers.

**Funds Requested:** $229,000

**Proposed Project Completion:** June 30, 2026

**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?**

Statewide

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

Statewide

**When will the work impact occur?**

During the Project

## Narrative

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

Minnesota faces urgent challenges in preserving its diverse ecosystems, safeguarding native plant populations, and maintaining pollinator health, all of which are exacerbated by climate change, habitat loss, and invasive species. Pollen is vital for plant reproduction, ecosystem health, and survival, while also having direct implications on public health due to allergenic pollen. Reliable and timely pollen monitoring offers invaluable insights into plant diversity, population dynamics, and pollinator welfare. It enables early detection and tracking of invasive species, facilitating swift, targeted interventions to minimize ecological harm. Additionally, pollen monitoring plays a crucial role in evaluating restoration and reforestation projects, informing the selection of species that promote long-term success and ecological resilience. Despite its critical importance, current pollen monitoring methods are hindered by significant limitations. These methods involve collecting pollen samples with an air sampler and manually analyzing them under a microscope by skilled technicians. This labor-intensive and time-consuming process restricts monitoring efforts to a few stations, rendering large-scale and real-time pollen level assessments unfeasible, especially given substantial variation in pollen concentration across small areas and brief timeframes. It is vital to address these limitations and enhance pollen monitoring capabilities in order to protect and preserve Minnesota's natural resources and public health.

**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.**

Our proposal aims to revolutionize pollen monitoring by developing a cost-effective, compact module transforming smartphones into real-time pollen sensors. This innovative technology comprises a small phone attachment designed for in situ recording of airborne pollen images using digital inline holography (DIH). A user-friendly mobile app, employing a machine-learning-based algorithm, will automatically identify and quantify various pollen types. By engaging citizen scientists, this approach enables real-time pollen monitoring across an extended geographic scale in Minnesota. The equipment will be deployed to 10 sites, including the University of Minnesota Research and Outreach centers and State Parks. A spatial database of pollen levels will be created from shared pollen analysis and locations from smartphone users, enabling long-term tracking of individual pollen types across the state. This public database will be accessible to citizens, government agencies, health professionals, and researchers. The extensive and accurate pollen data will enhance understanding of plant biodiversity, pollinator population dynamics, and the spread of invasive species, informing targeted conservation and preservation efforts. Additionally, real-time allergen information will assist allergy sufferers in managing their symptoms more effectively.

**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?**

Our system's long-term, extensive pollen data will yield valuable insights into Minnesota's ecosystems. By tracking plant biodiversity and revealing population trends, we can identify vulnerable species and habitats, enabling targeted conservation and resource management to maintain ecosystem health and resilience. The data also informs pollinator population dynamics, including their foraging patterns and habitat preferences, which will aid their preservation and enhancement. Additionally, monitoring invasive species' spread enables early detection and proactive management, minimizing ecological damage.

## Activities and Milestones

### Activity 1: Perform lab measurements of common pollen in Minnesota using DIH

**Activity Budget:** $51,000

**Activity Description:**
This activity will involve the development of basic methodology for how to image and categorize different types of pollen grains using DIH, which has been broadly used for 3D imaging and live tracking particles yet thoroughly tested in analyzing pollen. The activity will take place at PI Hong's lab using the existing DIH setup, which consists of a laser source, a digital camera and a customized sampling device. This setup captures distinct marks made by the pollen grains floating in the air within the laser beam path on the camera sensor, called holograms (example shown in Figure 1). The holograms are then processed using a computer program developed in Hong's lab to reconstruct the in-focused images of individual pollen grains and their 3D spatial distribution in the air column, and successively derive the size, morphology and other optical properties of each grain. A machine-learning algorithm will be implemented to automatically categorize different types of pollen and measure the pollen counts.

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| Perform 3D imaging and analysis of pollen grains using DIH | December 31, 2024 |
| Derive general relationship between pollen holograms and physical parameters | December 31, 2024 |
| Develop a machine-learning algorithm to automatically categorize and count pollen | December 31, 2024 |

### Activity 2: Develop the phone attachment and a mobile app

**Activity Budget:** $120,000

**Activity Description:**
This activity entails developing a smartphone hardware attachment, including a low-power laser, miniature lens piece, small fan and sampling channel for the phone camera, transforming it into a digital microscope (Figure 1). A mobile app will be created, incorporating hologram analysis codes and machine-learning algorithms from Activity 1. We will collect field data from three Twin Cities sites and compare the results to Clinical Research Institute (CRI) pollen counts (the only pollen collection site in south Minneapolis) and website forecasts for cross-validation. The hardware design and app will be optimized for compatibility with smartphone computing power, ensuring accuracy and speed.

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| Identify locations of test sites and collect field data | January 31, 2025 |
| Develop a phone attachment and mobile app for pollen monitoring | March 31, 2025 |
| Analyze field data and improve hardware and app design according to the outcomes | December 31, 2025 |

### Activity 3: Engage citizen-scientists and build a spatial database for long-term pollen monitoring

**Activity Budget:** $58,000

**Activity Description:**
Using the finalized hardware design from Activity 2, we will assemble 20 mobile phone attachments for volunteers at 10 statewide sites within the 4G network coverage area including the University of Minnesota Research and Outreach Centers and State Parks. A remote server at St. Anthony Falls Laboratory (SAFL) will collect and store pollen data, which

will be displayed on a user-friendly website with daily updates. This data will be shared with the Minnesota Department of Health via the Minnesota Environmental Public Health Tracking Program (MN Tracking) and made publicly accessible through a web server at the University of Minnesota.

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| Engage citizen-scientists by distributing phone attachments and mobile app | February 28, 2026 |
| Create a spatial map of pollen counts daily and build the long-term spatial database | June 30, 2026 |
| Finish a website to report pollen counts and to provide open access to the database | June 30, 2026 |

## 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?**

To secure the project's long-term success, we will pursue funding from agencies such as the Department of Natural Resources (DNR), the United States Department of Agriculture (USDA), the United States Forest Service (USFS), or other relevant agencies to expand nationwide pollen monitoring and enhance the mobile app. By collaborating closely with these agencies, we will build a comprehensive database benefiting natural resource management and protection. The developed tools, including the phone attachment and app, can be integrated into educational initiatives like SAFL's middle school outreach program, raising public awareness about pollen monitoring's significance and its impact on natural resources.

## Other ENRTF Appropriations Awarded in the Last Six Years

| Name | Appropriation | Amount Awarded |
|---|---|---|
| Remote Sensing And Super-Resolution Imaging Of Microplastics | M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 08j | $309,000 |

## Project Manager and Organization Qualifications

**Project Manager Name:** Jiarong Hong

**Job Title:** Professor

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

Dr. Jiarong Hong, a full professor in Mechanical Engineering at the University of Minnesota, brings extensive expertise in environmental fluid dynamics, particle diagnostics, and optical instrumentation to his role as Project Manager. With affiliations in the Saint Anthony Falls Laboratory (SAFL), Minnesota Robotics Institute, and the Electrical & Computer Engineering Department, Dr. Hong's interdisciplinary approach is well-suited for managing complex projects. As an expert in digital inline holography technology, Hong has amassed 18 years of experience and secured six patents in the field. He has led or co-led many grants from federal agencies including NSF, Navy, Army, NIH, and industrial grants from Land O'Lakes, Ford, Astrin Biosciences, and Baxter. In particular, Hong, as the leading Principal Investigator, spearheads a $1.5 million NSF Major Research Instrument project involving 12 international institutions, two national labs, and industry partners. This cutting-edge endeavor focuses on the development of the Grand-scale Atmospheric Imaging Apparatus (GAIA), a groundbreaking imaging-based field measurement system. GAIA accurately quantifies 2D/3D atmospheric turbulent flows and particle transport across vast sample regions, offering exceptional spatio-temporal resolution. Moreover, Hong's research on airborne aerosol transmission during the COVID-19 pandemic has garnered global media attention, influencing government policies and the development of mitigation strategies. The proposed project will substantially benefit from Dr. Hong's experience and the resources provided by his existing grants, ensuring effective leadership and successful execution.

Dr. Hong will oversee the entire project and directly supervise postdoctoral researchers and engineers, ensuring that the project stays on track and meets its objectives. His interdisciplinary expertise will guide the team through technical challenges, while his mentorship fosters a collaborative environment. Dr. Hong will leverage his extensive network of industry and academic connections to source additional resources, collaborate with external experts, and foster partnerships, ultimately driving innovation and advancing the field.

**Organization:** U of MN - St. Anthony Falls Laboratory

**Organization Description:**
Dr. Hong is affiliated with SAFL (http://www.safl.umn.edu), a world-renown research laboratory in environmental engineering and fluid mechanics. The lab has a large number of faculty and research engineers who have contributed to projects related to environmental research and management across the state. Instrumentation development is a significant part of the lab. In the past, the lab has developed automated data collection, sampling protocols, wireless data transfer, and storage for several state agencies. SAFL provides a number of cutting-edge facilities for the proposed research including an atmospheric boundary layer wind tunnel (https://www.safl.umn.edu/facilities/wind-tunnel) that can be used for testing the performance of our device under different wind and temperature conditions, and distributed data servers (https://www.safl.umn.edu/facilities/computational).

## Budget Summary

| Category / Name | Subcategory or Type | Description | Purpose | Gen. Ineligible | % Benefits | # FTE | Classified Staff? | $ Amount |
|---|---|---|---|---|---|---|---|---|
| **Personnel** | | | | | | | | |
| Dr. Jiarong Hong | | Principal Investigator | | | 36.8% | 1 | | $19,900 |
| Researcher | | Postdoctoral Associate | | | 25.7% | 2 | | $145,100 |
| Ben Erickson | | Civil Service Engineer | | | 32% | 38 | | $34,000 |
| | | | | | | | **Sub Total** | **$199,000** |
| **Contracts and Services** | | | | | | | | |
| | | | | | | | **Sub Total** | - |
| **Equipment, Tools, and Supplies** | | | | | | | | |
| | Tools and Supplies | Fabrication supplies and measurement | Supplies for developing mobile app and phone attachment, as well as equipment for air sample collections | | | | | $22,000 |
| | | | | | | | **Sub Total** | **$22,000** |
| **Capital Expenditures** | | | | | | | | |
| | | | | | | | **Sub Total** | - |
| **Acquisitions and Stewardship** | | | | | | | | |
| | | | | | | | **Sub Total** | - |
| **Travel In Minnesota** | | | | | | | | |
| | Miles/ Meals/ Lodging | Field trips to collect daily pollen samples | For research purposes | | | | | $8,000 |
| | | | | | | | **Sub Total** | **$8,000** |
| **Travel Outside Minnesota** | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | **Sub Total** | **-** |
| **Printing and Publication** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Other Expenses** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| | | | | | | | **Grand Total** | **$229,000** |

## 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** | | | | |
| | | | **Non State Sub Total** | **-** |
| | | | **Funds Total** | **-** |

## Attachments

### Required Attachments

*Visual Component*

File: 91f586a4-a3c.doc

*Alternate Text for Visual Component*

Figure 1, The schematic illustration of imaging and analyzing pollen grains using smartphones with a customized hardware attachment and app; Figure 2, 4G coverage map of Verizon in Minnesota in 2023 and the proposed ten sample sites within Minnesota: Crookston, Ely, Grand Rapids, Cloquet, Morris, Becker, Chaska, Rosemount, Lamberton, Waseca....

### Optional Attachments

*Support Letter, Photos, Media, Other*

| Title | File |
|---|---|
| SPA support letter | ec0b92e5-12a.doc |

## 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?**

No

**Does the organization have a fiscal agent for this project?**

Yes, Sponsored Projects Administration

**Does your project include the design, construction, or renovation of a building, trail, campground, or other capital asset costing $10,000 or more?**

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?**

No