Environment and Natural Resources Trust Fund
2020 Request for Proposals (RFP)

Project Title: **ENRTF ID: 229-F**

Predicting Pollen Dispersal: Impact on Habitat and Population

Category: F. Methods to Protect, Restore, and Enhance Land, Water, and Habitat

Sub-Category:

Total Project Budget: $ 325,918

Proposed Project Time Period for the Funding Requested: June 30, 2023 (3 yrs)

Summary:

We will conduct laboratory and field measurement of pollen dispersal by wind, and obtain a predictive model useful for both prairie conservation/restoration and for the evaluation of air quality.

Name: Filippo Coletti

Sponsoring Organization: U of MN

Job Title:

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Web Address:

Location:

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

The visual illustrates vast regions in Minnesota targeted by prairie protection efforts, and how we will measure pollen dispersal in wind tunnel and field experiments, to obtain useful prediction tools.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Predicting Pollen Dispersal: Impact on Habitat and Population

I. PROJECT STATEMENT

The **OBJECTIVE** of the present proposal is to provide measurements and predictions of **pollen dispersal by the wind**, which has crucial implications for both the **ecology** and the **population health**. Thus, our **GOALS** are:
(1) Predict the rate at which pollen is **picked up by the wind shearing** on the plant canopies
(2) Predict the time **pollen remains airborne** and how far it spreads
(3) Provide State agencies with an advanced **pollen forecasting tool** they can use in the decision-making process.

WHY? First, pollen dispersal is key for the movement of **native plant species** and for the **genetic diversity** of both fauna and flora. Since 1908, Minnesota has lost 99% of its 18 million acres of prairie, and is investing large amounts of money into **prairie habitat restoration** through the Minnesota Prairie Conservation Plan. But without accurate knowledge of the processes by which pollen is emitted and dispersed, the success of such projects is at risk.
Second, severe ecological risks are associated with the commercial release of **genetically modified crops**. It is important to know at what distance to place fields with unmodified crops downwind of fields with modified crops, in order to prevent cross-fertilization. Again, this relies on knowledge of pollen dispersion processes.
Third, from an **air quality** perspective, pollens also cause unwanted side effects such as **allergies**. Ragweed pollen season in Minnesota is now 18 to 21 days longer than it was in the mid-1990s, and the incidence of asthma and other respiratory diseases (exacerbated by poor air quality) are on the rise in the State.

The **OUTCOMES** of this project will be clear and measurable:
(1) First-ever measurements of **pollen emission** in laboratory experiments reproducing wind-plant interaction.
(2) First-ever measurements of **pollen settling** rate in a laboratory facility reproducing atmospheric conditions.
(3) Easy-to-use models of pollen **traveling distance** and **residence time** in air, depending on weather conditions.

IMPACT: This project responds to two LCCMR funding priorities (**Habitat Protection/Restoration** and **Air Quality**), thus it will deliver **multiple benefits** to the Minnesota environment and natural resources. It will contribute to the **knowledge base** and **disseminate information** that will benefit, among others, the MN Department of Natural Resources, Department of Agriculture, and Department of Health.

SCIENCE & INNOVATION: We will leverage cutting edge techniques drawn from Aerospace Engineering. We will carry out experiments with **unique facilities and methodologies** developed at the **St. Anthony Falls Laboratory:**
(a) the largest academic **wind tunnel** in Minnesota, where air moves up to 70 mph in a 20 feet long test section, and where nocturnal and diurnal conditions can be mimicked by independently heating/cooling both air and floor.
(b) the world largest "**turbulence chamber"**, where one cubic meter of turbulent air is generated by firing hundreds of computer-controlled jets, creating conditions equivalent to arbitrary altitudes in the atmosphere.
(c) ***in-situ* imaging** of pollen transport, by deploying illumination systems and high-speed cameras in the outdoor field. We recently pioneered this technique for the *in-situ* observation of snow settling and saltation.
These will be coupled with **high-speed imaging** to track the dispersion of pollen. Using these tools, **we recently demonstrated that natural air turbulence can cause a multifold increase in fallspeed** of microscopic particles similar to pollen. The environmental implications of these findings will now be explored.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Collect laboratory data on pollen emission, traveling speed, and settling rate for common species **Budget: $190,500**

We will consider five species commonly found in Minnesota, e.g., prairie dropseed (*Sporobolus heterolepis*) and big bluestem (*Andropogon gerardii*), that use wind as moving mechanism. We will first carry out a survey to identify the atmospheric conditions most commonly associated to those species. We will then conduct experiments in which plants are placed in the wind tunnel, with various wind speeds and nocturnal/diurnal conditions. The plants will be placed in pots lodged within the movable floor of the test section. Finally, we will measure the settling rate of pollen grains from the same species, released in our turbulence chamber. While the

wind tunnel measurements will be representative of pollen dispersal near the ground, the turbulence chamber measurements will be representative of atmospheric dispersal. High-speed, high-resolution cameras will be used to image and track the pollen grains, along with laser illumination for maximum precision.

Outcome	Completion Date
1. Identify species that move by airborne pollen and associated atmospheric conditions	January 2021
2. Conduct wind tunnel measurements of emission and traveling speed at relevant wind/temperature conditions	January 2022
3. Conduct turbulence chamber measurements of settling rate in conditions relative to different atmospheric altitudes	January 2023

Activity 2: Collect outdoor field data on pollen emission, traveling speed, and settling rate **Budget: $120,418**

Two field sites will be selected, both featuring large swaths of remnant prairie: one flat and one hilly, to provide broad information on different wind-ground configurations. The measurements will be carried out at night, to facilitate illumination and imaging. Similarly to the snow saltation measurements we recently conducted, we will use a search light along high-speed cameras, while a portable anemometer will characterize the wind speed conditions. These measurements will provide the ground truth to validate the findings in Activity 1.

Outcome	Completion Date
1. Identify suitable sites for outdoor measurements based on prairie and land type	January 2021
2. Conduct outdoor field imaging measurements of pollen traveling speed and settling	January 2023

Activity 3: Develop model of pollen dispersal and transmit them to agencies **Budget: $15,000**

We will create open-source, user-friendly model that federal and state agency members can use to determine pollen movement by wind in a wide range of conditions. For this purpose, we will extrapolate dispersal distance and settling rate measured to species similar to those in Activity 1 and 2. This information will be shared with relevant MN Departments and conservation agencies. We will then hold virtual workshops to help agency members learn how to use this tool.

Outcome	Completion Date
1. Develop models of pollen dispersal based on land and atmospheric conditions	January 2023
2. Hold virtual workshops to train federal and state agency members how to use model	June 2023

III. PROJECT PARTNERS AND COLLABORATORS

The project will be managed by Filippo Coletti, McKnight Land-Grant Assistant Professor of Aerospace Engineering & Mechanics and member of the St. Anthony Falls Laboratory (SAFL). He will advise a senior graduate student who will lead the laboratory experiments. Research staff members at SAFL will support the field measurements. After first positive contacts, we will leverage assistance from **The Nature Conservancy** (TNC) for the field sites selection. We will engage agencies in Minnesota, including the MN **Department of Natural Resources** (DNR), where we have long-time collaborators. We will engage expert at the U of M **School of Public Health** and pulmonologist in the **Medical School** (e.g., Dr. Christine Went, world expert in Chronic Obstructive Pulmonary Disease and already collaborator of Coletti), in order to maximize the usefulness of our findings from the air quality standpoint.

IV. LONG-TERM IMPLEMENTATION AND FUNDING

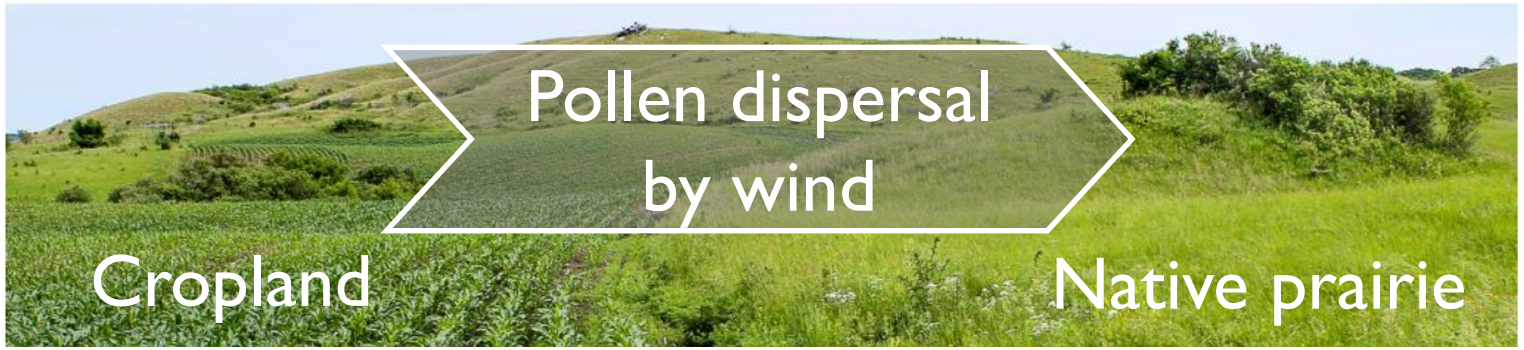
Because of our **changing climate** and the associated **shift in plant hardiness zones**, the project impact will be **long-term** and its significance **statewide**. Training **workshops** on the use of the dispersal model after the project completion will guarantee the **practical usefulness** of this research. Our findings will be also **disseminated** via local media outlets and leveraged in **educational efforts**, such as the SAFL outreach program towards middle school students from **Native American tribes** in northern Minnesota (for whom prairies are both a resource and an important heritage). Given our team's **track record securing funding from national agencies**, we will leverage the results of this project to expand our research through grants from the **US National Science Foundation**.

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Filippo Coletti
Project Title: Predicting Pollen Dispersal: Impact on Habitat and Population
Organization: Regents of the University of Minnesota
Project Budget: $325,918
Project Length and Completion Date: 3 years, June 30, 2023
Today's Date: 4/10/19

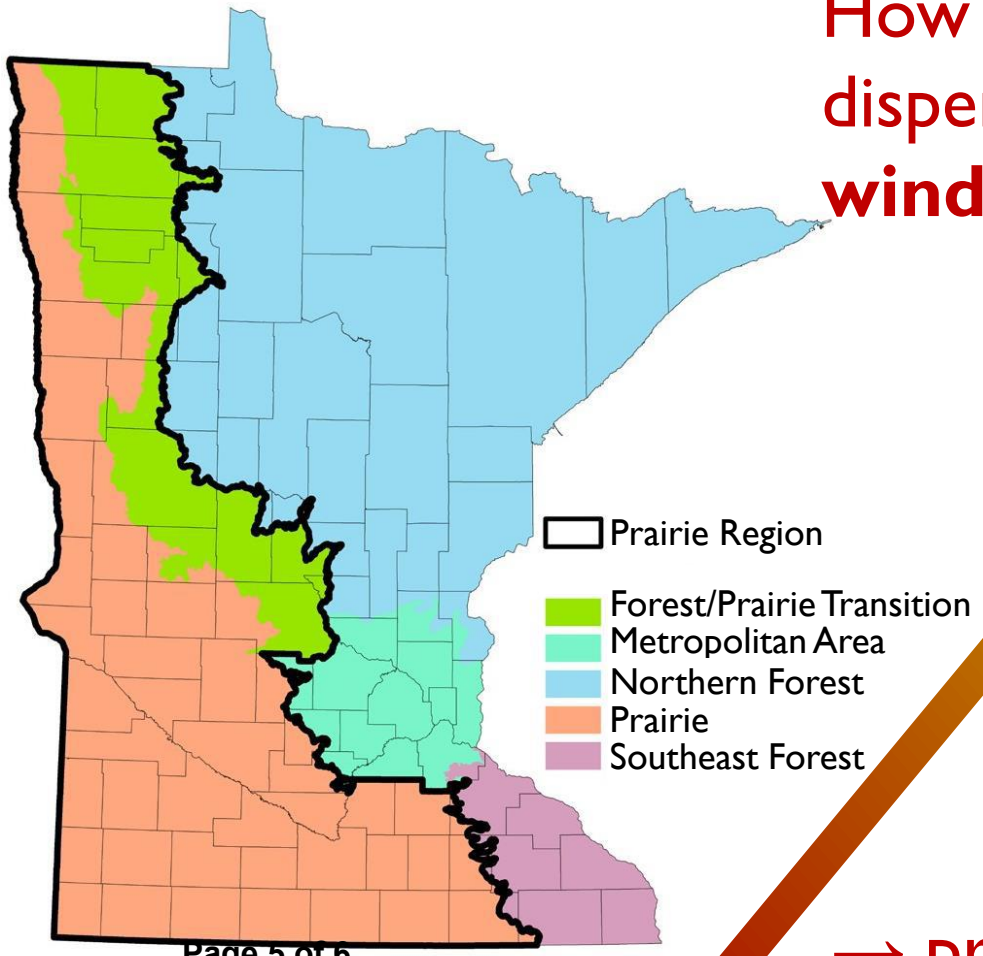
ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 250,918	$ -	$ 250,918
Filippo Coletti, Project Manager (74% salary, 26% fringe benefits) $51,914 Will manage the project, supervise the graduate student, co-write reports and present the work in workshops and conferences			
Graduate student Research assistant (58% salary, 42% fringe benefits) $153,921 Will carry out laboratory and field measurements, co-write reports and present the work in workshops and conferences			
Technical Support (77% salary, 23% fringe benefits) $45,083 Will support laboratory and field measurements, help the graduate student in manufacturing necessary contraptions			
Professional/Technical/Service Contracts			
	$ -	$ -	$ -
Equipment/Tools/Supplies			
Equipment for maintenance and upgrade of wind tunnel, turbulence chamber, laboratory imaging contramption, and field imaging contramption ($5000/year, for three years)	$ 15,000	$ -	$ 15,000
Capital Expenditures Over $5,000	$ 60,000		$ 60,000
High-resolution CCD camera for imaging of airborne pollen ($25,000)			
Nd:YAG laser for illumination of airborne pollen in lab ($35000)			
Fee Title Acquisition			
	$ -	$ -	$ -
Easement Acquisition			
	$ -	$ -	$ -
Professional Services for Acquisition			
	$ -	$ -	$ -
Printing			
	$ -	$ -	$ -
Travel expenses in Minnesota			
	$ -	$ -	$ -
Other			
	$ -	$ -	$ -
COLUMN TOTAL	$ 325,918	$ -	$ 325,918

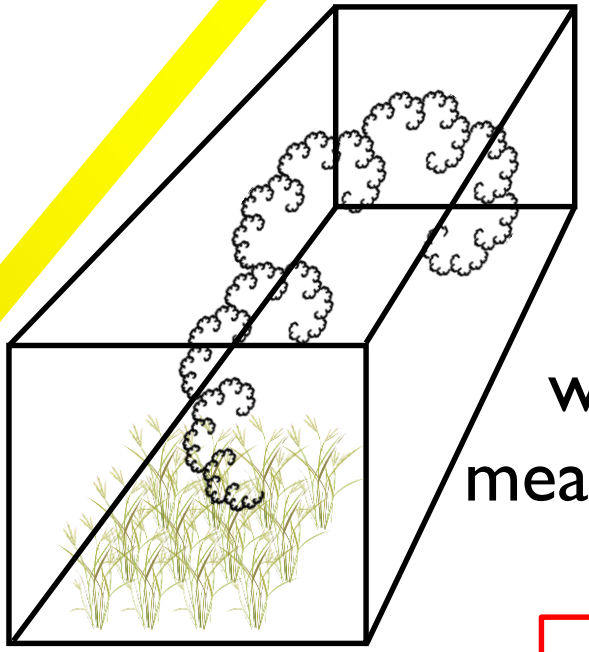
SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Because the project is overhead free, laboratory space, electricty, and other facilities/adminstrative costs (54% of direct costs excluding permanent equipment and graduate student tuition benefits) are provided in-kind.	secured	$ 116,907	$ -	$ 116,907

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Removing plastic particle pollution from Minnesota water bodies		$ 300,000	$ 42,269	$ 257,731
Enabling extraction of solar thermal energy in Minnesota		$ 250,000	$ 96,886	$ 153,114



How far does **pollen** disperse with the **wind**?





wind tunnel measurements

nocturnal field imaging of airborne pollen

→ predict pollen dispersal for ecosystem and air quality

PROJECT MANAGER QUALIFICATIONS

The proposed research will be led by Filippo Coletti, McKnight Land-Grant Assistant Professor of Aerospace Engineering and Mechanics at the University of Minnesota. Coletti obtained his bachelor's and master's degrees in Mechanical Engineering at the University of Perugia (Italy) in 2005, and a research master in Fluid Dynamics at the von Karman Institute (Belgium) in 2006. He performed his doctoral studies at the von Karman Institute and at the University of Stuttgart (Germany), where he obtained his Ph.D. in Aerospace Engineering in 2010. From 2011 to 2013 he was postdoctoral fellow at Stanford University, before joining the U of M in 2014. Shortly after he became a member of the St. Anthony Falls Laboratory (SAFL), where he conducts research in environmental fluid mechanics, focusing on the transport of solid particles in the environment. Coletti uses advanced imaging techniques both in the laboratory and in the field, where he is part of a team that investigates settling speed of hydrometeors. He also conducts research in health-related processes such as transport of contaminants in the human respiratory system, and he is a member of the graduate faculty in the Biomedical Engineering Department at the University of Minnesota. His research is funded by federal agencies including the National Science Foundation (NSF) and the National Institute of Health (NIH), the US Department of Defense, as well as by major companies including 3M, Boston Scientific, and Medtronic. Coletti has published 90 refereed journal articles and conference papers on transport phenomena and experimental fluid mechanics. A list of his recent honors includes the McKnight Land-Grant Professorship from the University of Minnesota (2018-2020), the CAREER Award from the National Science Foundation (2015-2019), the Non-Tenured Faculty Award from The 3M Company (2015-2018), and the Best Paper Award from the ASME Wind Energy Committee (2014).

ORGANIZATION DESCRIPTION

The proposed research will be conducted at the St. Anthony Falls Laboratory (SAFL), University of Minnesota. The laboratory is particularly experienced in conducting and analyzing laboratory and field measurements in environmental fluid dynamics. Permanent research staff at SAFL has vast expertise in laboratory and field measurements involving imaging, similar to what proposed in this project. Unique facilities are available for experimental research, including the large wind tunnel and turbulence chamber that will be used for this project. Large projects funded by the US National Science Foundation, Department of Energy and Department of Defense are conducted based on these unique experimental facilities. Automated data collection, sampling protocols, wireless data transfer and display over the Internet have been developed for several state and federal funding agencies at the laboratory. SAFL has also top-notch computing capabilities that allow for high performance parallel processing linked by high speed connections.