**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) Predictthe rateat 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**.