Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-356

Proposal Title: Help MPCP by Understanding Seeds and Pollens Dispersion

Project Manager Information

Name: Lian Shen

Organization: U of MN - St. Anthony Falls Laboratory

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Project Basic Information

Project Summary: We will conduct computer simulations and laboratory experiments to understand seeds and pollen dispersion in canopy and use the knowledge to assist the planning of MPCP for environment/climate changes.

Funds Requested: $199,000

Proposed Project Completion: 2024-06-30

LCCMR Funding Category: Small Projects (H)

Secondary Category: Methods to Protect, Restore, and Enhance Land, Water, and Habitat (F)

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.

Minnesotan prairie is facing threats from habitat fragmentation, loss of plant and animal species, degradation of soil and water resources, and invasive species. Department of Nature Resources (DNR) has put forward the Minnesota Prairie Conservation Plan (MPCP), which will invest $2.5 billion before 2035 to retain the thriving and genetic diversity of the Minnesotan prairie. This plan designates 28 existing large-area prairie patches as “core areas”, and plans corridors to connect the “core areas” as gene flowing paths and the migration routes of species living in the prairie. Specific strategies and conservation goals are set for the core areas and corridors, respectively.

Because climate and environment factors impose complex influences on the conservation of the Minnesotan prairie and they are difficult to predict precisely, this long-term plan needs to be adjusted when the future deviates from our present prediction. For example, some studies have projected the global temperature to increase by 1.5 degrees by 2035, but the effect of climate change on the conservation of Minnesotan prairie is not fully understood. Therefore, a quantitative assessment of its future performance, or “the data from the future”, is essential for keeping MPCP on the right track to its ultimate success.

What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.

We have developed a numerical model that can simulate the influence of environment on the wind dispersal of seeds and pollen. It is known that the seeds and pollen of many Minnesota native prairie species, such as Sporobolus heterolepis, Andropogon gerardii and Liatris aspera, are dispersed by winds, and the threats of habitat fragmentation and degrading genetic diversity can be quantified by the seed and pollen dispersal inside and among prairie patches. The expansion rate of invasive species can also be evaluated by the dispersal of their seeds and pollen in the native prairie. We plan to approach this problem by systematically conducting simulations at different scales. First, we will conduct simulations whose scales range from several stalks to a prairie patch to understand the dispersion of seeds and pollen inside the prairie. To verify our simulation results, we will conduct experiments with the cutting-edge instruments in the Saint Anthony Falls Laboratory. Then, based on the results from the first step, we will conduct simulations including the whole Minnesota to understand the development of native prairie and other plants across the state. At this step we will incorporate weather and climate data, including the data considering the climate change effect.

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 outcome of our simulation work will be a quantitative long-term assessment of the influence of environment and climate change on the MPCP. Based on this assessment, the policymakers can adjust and refine the MPCP for the benefits to the Minnesotan prairie in the long term. Our simulation can also identify the locations of the hot spots where the prairie is more fragile and volatile prone to climate and environment changes. Besides the benefits to Minnesota prairie, this study will also benefit other environmental topics such as air pollution dispersion, and water pollution dispersion in the aquatic plants.

Activities and Milestones

Activity 1: Conduct field investigation and laboratory experiments for the baseline data to validate our numerical model

Activity Budget: $60,000

Activity Description:
The Saint Anthony Falls Laboratory is renowned in environmental fluid flow studies. The lab possesses a state-of-the-art atmospheric wind tunnel equipped with cutting-edge instruments for flow measurement and particle tracking under realistic atmospheric environmental conditions. With these instruments, we will measure the temperature, wind speed, and humidity for canopy models representative of the native Minnesotan prairie. We will release the pollen and seeds of representative Minnesotan native and invasive species inside the wind tunnel and measure their dispersion within the canopy. The statistics of dispersion distance and time will be used for validating the results obtained from our simulation in Activity 2. Before the experiments, field investigation will be conducted to collect the information about the structure characteristics of the Minnesotan prairie to construct realistic canopy models in our wind tunnel.

Activity Milestones:

Description	Completion Date
Data of structure characterization of canopies in Minnesotan prairie.	2022-06-30
Experiment data of pollen and seeds dispersion distance and time for canopy models in SAFL wind tunnel.	2022-12-31
Experiment data of wind speed, temperature, and humidity for canopy models in SAFL wind tunnel.	2022-12-31

Activity 2: Run local-scale simulations to understand the dispersion of seeds and pollen inside prairie

Activity Budget: $69,000

Activity Description:
We have developed an advanced numerical model that can simulate the dispersion of pollen and seeds in natural prairie environment whose scales range from several stalks to a prairie patch. For high simulation accuracy, our model considers many microscale effects that influence the dispersion of pollen and seeds, such as the grass waving motions and the collision between the particles and plants. The simulations will be run on the high-performance supercomputers in the Minnesota Supercomputing Institute. We will first set up the same simulation cases as the experiments in Activity 1, and compare our simulation results with the experiment results to validate the model. Then, more cases will be run to systematically study the dispersion of particles and pollen in the canopy under different temperature, wind, and humidity conditions. The results will be used in the statewide simulations of Minnesota in Activity 3.

Activity Milestones:

Description	Completion Date
Validation of simulation data in the canopy models of the SAFL atmospheric wind tunnel.	2023-03-31
Simulation results of pollen and seeds dispersion at the stalk-scale.	2023-06-30
Simulation results of pollen and seeds dispersion at the prairie-scale.	2023-09-30

Activity 3: Conduct statewide simulations to model the evolution of Minnesotan prairie and help assess MPCP.

Activity Budget: $70,000

Activity Description:

In this activity, we will conduct statewide simulations for Minnesota. The results from the stalk-scale and prairie-scale simulations in Activity 2 will be applied here. Various factors threatening the conservation of Minnesota prairie will be examined. For example, the effect of climate change will be examined by varying the atmospheric conditions, and the effect of invasive species will be examined by randomly placing the invasive species existing in North America and observe their development in the simulation. Based on our statewide simulation results, we will produce a report to assess these threats and provide suggestions to the MPCP to adapt to the environment and clime changes.

Activity Milestones:

Description	Completion Date
Results of statewide simulation of the evolution of Minnesota prairie.	2023-12-31
Assessment of environment and climate change impacts on Minnesota prairie.	2024-03-31
Recommendations of strategies on how cope with the above threats to protect Minnesota prairie.	2024-06-30

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 be funded?

Our study will provide recommendations to the MPCP for its long-term effectiveness. The outcomes of this project can be implemented in the MPCP framework in a cost-effective way. Moreover, if other environment or climate factors emerge in the future, our model can rerun on computers with relative ease. In the future, with the advancement of computer technologies, simulation will be an indispensable tool to assist decision making. The proposed research will provide an accurate and efficient computer simulation tool that can be used for many years.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Assess and Develop Strategies to Remove Microscopic Plastic-Particle Pollution from Minnesota Water Bodies	M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 04b	$300,000
Extraction of Solar Thermal Energy in Minnesota	M.L. 2017, Chp. 96, Sec. 2, Subd. 07a	$250,000

Project Manager and Organization Qualifications

Project Manager Name: Lian Shen

Job Title: Professor and Director

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

Dr. Lian Shen is the Director of the St. Anthony Falls Laboratory and a Professor in the Department of Mechanical Engineering at University of Minnesota, Twin Cities. He earned his Doctor of Science degree from Massachusetts Institute of Technology in 2001. After three years of postdoctoral training at MIT, he joined the faculty of Johns Hopkins University in 2004. In 2012, he was recruited by University of Minnesota to join its faculty. Dr. Shen is a world expert on the study of environmental fluid flows and renewable energy. He is currently serving on the national committee of ASCE Environmental & Water Resources Institute on CFD Applications in Water and Wastewater Treatment. Dr. Shen is serving as the Co-Chair of the Advisory Group of the National Offshore Wind Energy Research and Development Consortium, which has 40 organizations nationwide. He is also on the editorial boards of four internal academic journals. Dr. Shen has organized several national and international conferences and symposiums, and has participated in a large number of research projects funded by federal and state agencies, including the Minnesota Environment and Natural Resources Trust Fund.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:

This project will be performed at the St. Anthony Falls Laboratory (SAFL, http://www.safl.umn.edu) at University of Minnesota. SAFL is an interdisciplinary fluid mechanics research and educational institution. It has 22 faculty members and 35 research and administrative staff members. SAFL is a world-renowned research laboratory specialized in environmental and engineering fluid mechanics. SAFL researchers have been performing many innovative environmental studies for the state of Minnesota. Some of the projects were/are funded by the Minnesota Environment and Natural Resources Trust Fund. The proposed research leverages on the unique and advanced capability of simulating and measuring environmental flows at SAFL, which has 16,000 ft2 of research space dedicated to

research. The facility, which has recently been upgraded with a $16M renovation, has a wind tunnel and 15 general purpose flumes, tanks, and channels readily configurable to the needs of the projects.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Project Manager		Oversee the whole project and lead the research planning and reporting			27%	0.12		$36,508
Postdoctoral Associate		Design and establish computational model and carry out computer simulations			20.2%	1.5		$96,898
Graduate Student Research Assistant		Perform experiments to validate the computational model			16.6%	0.75		$26,299
Undergraduate Student Assistant		Assist experiment data analysis and model validation			0%	0.75		$7,200
IT Staff		Assist computational model development			24%	0.3		$24,442
							Sub Total	**$191,347**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Equipment	Cost of two anemometers ($1,000 each), and data acquisition system ($2,000)	To conduct laboratory and field measurements for validating simulation results.					$4,000
	Tools and Supplies	Cost of materials for fabricating models to be tested in experiments.	To conduct laboratory and field measurements for validating simulation results.					$2,903
							Sub Total	**$6,903**
Capital Expenditures								
							Sub Total	**-**

Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Field experiment	Miles and meals to conduct field experiments					$750
							Sub Total	**$750**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$199,000**

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				
In-Kind	Unrecovered F&A	Support of SAFL facilities where research will be conducted.	Secured	$109,450
			Non State Sub Total	**$109,450**
			Funds Total	**$109,450**

Attachments

Required Attachments

Visual Component

File: f6d823f1-8ee.pdf

Alternate Text for Visual Component

This project aims to help the Minnesota Prairie Conservation Plan (MPCP), with the specific goal of understanding seeds and pollen dispersion in the canopy. Laboratory experiments using wind tunnel and simulations on supercomputers will be conducted. The main outcome of this project will be a quantitative long-term assessment of the influences of environment and climate change and invasive species on Minnesota prairie and recommendation of adaptive strategies for MPCP.

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

No

Does your project include research?

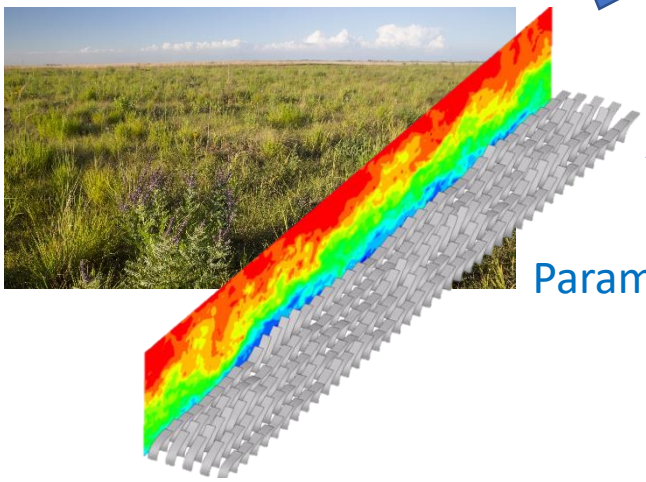
Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Help MPCP by Understanding Seeds and Pollens Dispersion

Small-scale simulations

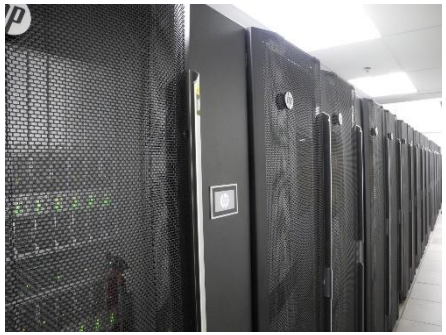


Validate

Parameterize

Run

Cutting-edge wind tunnel in SAFL

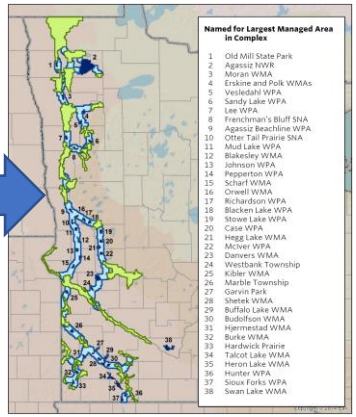


MSI supercomputers

Run by

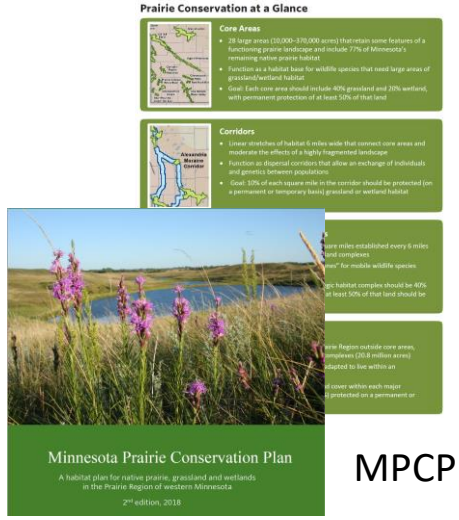
Run

Climate change
Wind variation
Invasive species
...



Large-scale simulations

Assess



MPCP