Environment and Natural Resources Trust Fund
2017 Request for Proposals (RFP)

Project Title: **ENRTF ID: 166-F**

Modeling/Measurement of Wetland Processes for Habitat Protection

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

Total Project Budget: $ 298,504

Proposed Project Time Period for the Funding Requested: 3 years, July 2017 - June 2020

Summary:

We will measure/model water and sediment/nutrients motions in wetlands for accurate description of habitat environment, and will develop predictive tools for vegetation landscape evolution for wetland restoration and habitat protection.

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Sponsoring Organization: U of MN

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Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

There are three panels provided as visual to help illustrate this proposal. The top panel illustrates the motivation: Wetlands have enormous ecologic and environmental benefits, but currently we have insufficient knowledge on the habit environment inside wetlands and insufficient practice guidance on wetland restoration. The middle panel shows the approaches that will be used in this project, including lab experiment, field measurement, and data collection. The bottom panel shows the expected outcomes of this project, including valuable measurement data of wetlands and accurate and user-friendly predictive tools for MN DNR, MPCA, and MBWR.

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

PROJECT TITLE: Modeling/Measurement of Wetland Processes for Habitat Protection

I. PROJECT STATEMENT

What: This project will perform **measurements of wetland processes** including water velocity and sediment/nutrients motions to create an accurate **model for habitat environment**, and will develop a **predictive tool for vegetation landscape evolution** to be used by wetland and habitat restoration/protection programs.

Why: Wetlands have enormous **ecologic and environmental benefits**. The aquatic plants form the foundation of healthy ecosystems by providing habitat for microorganisms, insects and other invertebrates, fish, and wildlife, including many endangered species. They produce oxygen and absorb excessive nutrients that would otherwise be used by algae, and their roots stabilize sediments to protect shorelines and riverbanks. Wetlands absorb storm flows, and filter out pollutants and sediments before runoff enters lakes and rivers.

While the benefits of wetlands are now widely recognized, challenges remain in wetland conservation and habitat protection. Our knowledge and modeling capability of the habit environment inside wetlands is far from satisfactory, and practice guidance on wetland restoration is insufficient due to the lack of information on how the landscape of vegetation patches evolves. This project aims at **closing these knowledge gaps** and providing useful **prediction tools for the design of conservation and restoration schemes.**

How: We will collect valuable data through **observations and measurements in field and at the St. Anthony Falls Lab** (SAFL) at University of Minnesota, which has state-of-the-art data acquisition systems and facilities including flumes, channels, and a one-of-a-kind Outdoor StreamLab. Systematic experiments will be performed for a variety of wetland conditions. Based on the valuable measurement data, **practical models will be developed for the description of habitat environment inside wetlands and for the prediction of landscape evolution of vegetation patches** critically important for wetland protection and restoration.

Goals: This project is expected to have the following **four deliverables**:

- Valuable measurement data on the velocity of water flows and motions of suspended sediments, organic matters, and nutrients in wetlands. The data will be shared with state agencies and interested groups.
- A publicly-accessible, user-friendly model for the prediction of habitat environment in wetlands.
- Important information on the processes at the edges of vegetation patches, including water flows and deposition of fine sediments with nutrients and organic matter contents.
- A useful, easy-to-use predictive model of landscape evolution of vegetation patches to provide best management practices in wetland restoration.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Measure and model habitat environment inside wetland **Budget:** $104,476

The object of this activity is to establish a solid foundation of wetland study, via **collecting data for water flow motions and the movements of sediments and nutrients among the vegetation stems inside wetlands**, and develop a realistic prediction **model for the habitat environment** in wetlands. The measurements will be performed at SAFL in a flume and the Outdoor StreamLab, and will be validated via field observations in several lakes and rivers. The prediction model will be built upon a computational program developed at SAFL, using parameterizations obtained from the measurements in this study.

Outcome	Completion Date
1. Design and build physical models in a flume and the Outdoor StreamLab	June 30, 2018
2. Collect and analyze data on flows and environmental quantities in laboratory and in field	August 31, 2019
3. Develop and validate a numerical model for predicting habitat environment in wetlands	March 31, 2020

Activity 2: Measure/model processes around vegetation patches for wetland restoration **Budget:** $149,253

This activity aims at answering the important questions of **what happens at the edge of vegetation patches** and **how to use this knowledge for wetland protection and restoration**. Very recently, studies have shown that in

some regions (e.g., on the sides of vegetation patches) the water flow is more turbulent, sediment erosion and nutrients depletion are enhanced, and vegetation growth is limited; meanwhile, in some other regions (e.g., in the wake of vegetation patches) the flow is less turbulent, and there are more fine sediments with enhanced organic and nutrient contents to stimulate the vegetation to grow. The underlying mechanism is unclear, and there is a lack of guidance on what is the best strategy for wetland restoration. We will perform experiments in the SAFL main channel and the Outdoor StreamLab to collect data on the interactions among water, vegetation, and sediment, based on which we will use a computational tool for their modeling.

Outcome	Completion Date
1. Set up vegetation patch models in the SAFL main channel and the Outdoor StreamLab	May 31, 2019
2. Acquire and analyze measurement data on flow and fine sediments with nutrients	Sept. 31, 2019
3. Develop a predictive model for vegetation landscape evolution to provide practice guidance for wetland restoration	March 31, 2020

Activity 3: Dissimilation, outreach, and education **Budget:** $44,775

Substantial efforts have been planned for **sharing the results and predictive models** with state agencies including **MPCA, BWSR, and DNR, water quality managers, lake management associates, citizen scientists, students and teachers, and the public**.

Outcome	Completion Date
1. Create a user-friendly, publicly accessible web portal to share data	Dec. 31, 2019
2. Provide open-source, easy-to-use predictive models	March 31, 2020
3. Produce a comprehensive set of online tutorials and offer virtual workshops	June 30, 2020
4. Give on-site demonstrations to citizen scientists, students, teachers, and the public	June 30, 2020

III. PROJECT STRATEGY

A. Project Team/Partners

This work will be carried out by Prof. Lian Shen as Project Manager, with the assistance of a 50% postdoctoral associate, a 50% graduate student research assistant, and an undergraduate student assistant (2 summer months per year) for laboratory and field measurements and predictive model development. The project will be performed in close collaboration with state agencies and other researchers in Minnesota.

B. Project Impact and Long-Term Strategy

Minnesota has about 10.6 million acres of wetlands, which are an important part of Minnesota's natural ecosystem and water resources. In 1991, Minnesota passed the Wetlands Conservation Act, which states that there should be no loss in the quantity, quality, and biological diversity of the existing wetlands. This project aims at assisting conservation programs of wetland restoration and habitat protection.

The impact of this project will be significant. **It addresses two critical issues in the conservation of wetlands and habitat**, namely what is the habitat environment inside wetlands and how the landscape of vegetation patches evolves during wetland restoration and protection. The proposed work aligns with ENRTF's Six Year Strategic Plan. This proposal directly responds to the **RFP priority area F**, as well as **area B**.

The long term strategy of the project is to ensure that the data acquired and the models developed in this project will be accessible and useful to state agencies, including **Minnesota DNR, MPCA, and BWSR, water quality and lake/wetland managers, and concerned citizens**. We will make the predictive models living tools that keep evolving with new academic research results and new inputs from practitioners. We expect the measurement data and models of this project will be useful for **wetland restoration and habitat protection programs** in the decades to come.

C. Timeline Requirements

This project will be conducted over a 3-year period from July 1, 2017 to June 30, 2020.

2017 Detailed Project Budget

Project Title: Modeling/measurement of wetland processes for habitat protection

IV. TOTAL ENRTF REQUEST BUDGET: 3 years

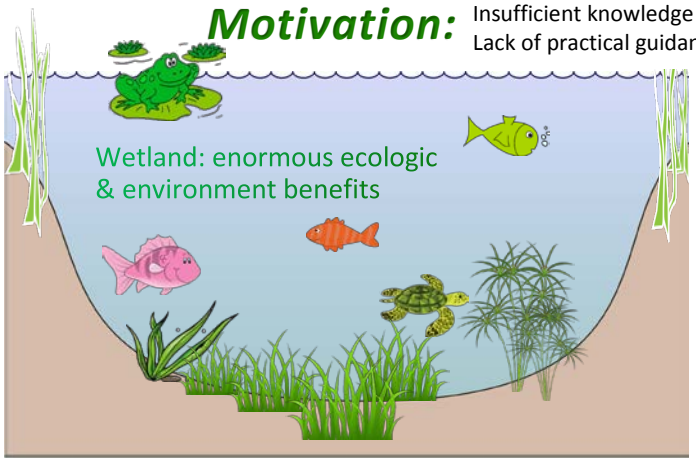
BUDGET ITEM	AMOUNT
Personnel:	
Prof. Lian Shen, project manager (75% salary, 25% benefit); 5.6% FTE (i.e., 0.5 months of summer salary) for each of 3 years	$ 25,668
Dr. Zuo Cui, Postdoctoral Associate, experiment and education/outreach activities (82% salary, 18% benefit); 50% FTE for each of 3 years	$ 92,674
Graduate Research Assistant, data analysis and model development (60% salary, 40% benefit including tuition); 50% FTE for each of 3 years	$ 145,062
Undergraduate Assistant, measurement and data analysis (100% salary); 2 summer months for each of 3 years	$ 9,600
Professional/Technical/Service Contracts: N/A	$ -
Equipment/Tools/Supplies: Cost of raw materials for setting up vegetation and sediment models in flume, channel, and Outdoor StreamLab ($4,000) and the purchasing of velocimetry for the water flow velocity and turbulence measurement in this project ($20,000).	$ 24,000
Acquisition (Fee Title or Permanent Easements): N/A	$ -
Travel: Tranportation within Minnesota state, to and from field sites, for observations and data collection in wetlands.	$ 1,500
Additional Budget Items: N/A	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 298,504

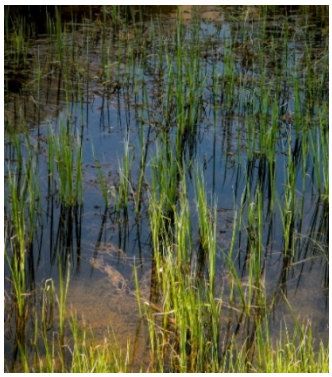
V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: N/A	$ -	N/A
Other State $ To Be Applied To Project During Project Period: N/A	$ -	N/A
In-kind Services To Be Applied To Project During Project Period: The University of Minnesota nomally charges overhead for Facilities and Administrative of the modified total direct cost (i.e., the total direct cost less graduate fringe, captipal equipment, subawards over $25,000 and on-site facilities rental). If F&A expenses would have been allowed on the project, the amount would be $117,198. There will not be F & A expenses charged on this project and the University will provide office space, IT services, and administrative/financial services in support of the project.	$ 117,198	Secured
Funding History: N/A	$ -	N/A
Remaining $ From Current ENRTF Appropriation: N/A	$ -	N/A

Motivation:

Insufficient knowledge on habitat environment inside wetlands.
Lack of practical guidance on best wetland restoration strategies.





How?

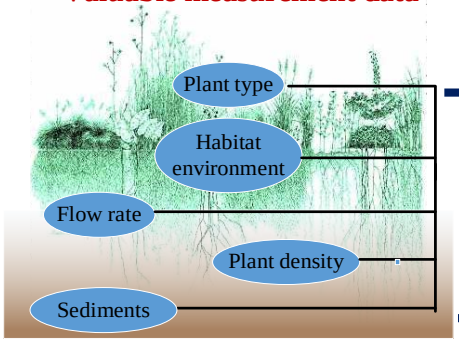
Main channel at St. Anthony Falls Lab

Outdoor Stream Lab at St. Anthony Falls

Outcomes

We can develop user-friendly tools for wetland restoration/protection

Valuable measurement data



Minnesota Pollution Control Agency

Minnesota Department of Natural Resources

Minnesota Board of Water & Soil Resources

Accurate and user-friendly prediction tools

Publically-accessible data online

Guidance for wetland restoration

PROJECT MANAGER QUALIFICATIONS

This project will be led by Professor Lian Shen as program manager. Prof. Shen currently holds the position of Benjamin Mayhugh Associate Professor in the St. Anthony Falls Laboratory and Department of Mechanical Engineering at University of Minnesota, Twin Cities. He earned his Doctor of Science degree from Massachusetts Institute of Technology (MIT) in 2001. After three years of postdoctoral training at MIT, he joined the faculty of Johns Hopkins University (JHU) in 2004. At JHU, he performed extensive research on environmental water and air flows. In 2012, he was recruited by University of Minnesota to join its faculty.

Prof. Shen is a world-expert in the study of environmental fluid flows. He is on the editorial boards of the International Journal of Computational Methods and the Ocean Systems Engineering journal. He has organized many national and international conferences and symposiums. Prof. Shen has also been active in professional societies, including American Society of Civil Engineers (ASCE), American Society of Mechanical Engineers (ASME), American Geophysical Union (AGU), and Association of Environmental Engineering and Science Professors (AEESP). He is currently serving on the ASCE Environmental & Water Resources Institute (EWRI) task committee on CFD Applications in Water and Wastewater Treatment.

ORGANIZATION DESCRIPTION

This project will be performed in 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 17 faculty members, 26 research staff, 8 administrative staff, and about 50 graduate students. Prof. Shen is the lab's Associate Director for Research overseeing the lab's research and academic activities. 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 builds on the unique and advanced capability of measuring environmental flows at SAFL, which has 16,000 ft^2 of research space dedicated to physical modeling and experimentation. The facility, which was just upgraded with a $16M renovation, has 15 general purpose flumes, tanks, and channels readily configurable to the needs of a project. The primary water source is the Mississippi River. SAFL's maximum flow capacity is 300 ft^3/s (8.5 m^3/s), which can be sustained indefinitely, allowing long-duration experiments. This project will utilize the main channel, SAFL's largest research channel, which is a straight, concrete channel capable of 300 ft^3/s (8.5 m^3/s) flow rates of river water. The channel is equipped with a wave generator, sediment flux monitoring and recirculation system, and a data acquisition carriage. The channel can be run in flow-through mode or as a ponded system.

We will also use the Outdoor StreamLab (OSL), which is a premier research facility developed at SAFL. The OSL is an experimental stream channel system designed to host experiments on the interactions between physical, chemical, and biological processes with water diverted from the Mississippi River. The OSL is equipped to: a) quantify environmental fluid flow processes from microscopic to reach scales with high-resolution laboratory-quality measurements; b) conduct hydrological and ecological field-scale experiments under controlled conditions; and c) impose and repeat steady and unsteady inlet hydrographs, including floods. Located across the Mississippi River from downtown Minneapolis, OSL is frequently visited by the public. The proposed project will provide an excellent opportunity for public education and outreach.