Environment and Natural Resources Trust Fund
2019 Request for Proposals (RFP)

Project Title: **ENRTF ID: 241-FH**

Shoreline Erosion Control Using Aquatic Plants

Category: H. Proposals seeking $200,000 or less in funding

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

Total Project Budget: $ 199,019

Proposed Project Time Period for the Funding Requested: June 30, 2022 (3 yrs)

Summary:

We will conduct experiments to monitor shoreline evolution corresponding to various aquatic plants, streams, and wave conditions, develop prediction model, and provide guidelines on using aquatic plants for shoreline protection.

Name: Zixuan Yang

Sponsoring Organization: U of MN

Title: Researcher

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Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Shoreline erosion contaminates water, kills fish, and cases economic losses. We will study the efficiency of different aquatic plants in shoreline protection, and engage the public for long-term implementation.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%
____ If under $200,000, waive presentation?			

PROJECT TITLE: Shoreline erosion control using aquatic plants

I. PROJECT STATEMENT

The goal of this project is to provide guidance on how to effectively use aquatic plants to protect shorelines. The specific objectives of this project include: (1) **building a database of the sediment deposition rate** corresponding to various environmental conditions, such as aquatic plant species, stream speed, and wave conditions; (2) developing a model to **predict the evolution of shorelines** of different rivers and lakes; (3) providing **comprehensive guidelines** on how to use aquatic plants effectively for shoreline protection.

Due to human activities, **shoreline erosion** in rivers and lakes of Minnesota is becoming increasingly serious, and is endangering the ecosystems and residents' properties. According to Minnesota DNR, **half of the streams in Minnesota are altered for agriculture and urbanization purposes**. These streams often suffer from shoreline erosion due to increased water flow and lack of protection. Many lakes also suffer from bank erosion. For example, the bank of Little Bass Lake in north Minnesota retreats 6 inches per year because of the **loss of aquatic plants along the shoreline**, **which makes the bank more vulnerable to the fluvial erosion caused by waves and currents.**

Re-vegetation with aquatic plants along the shoreline is an environment-friendly way to protect the shoreline. Plants can reduce the erosion by **damping waves** and **slowing currents**. They also help the **trapping of sediment**, which is a key process for the restoration of shoreline. Compared with the artificial engineering structures that are currently overused in shoreline protection, such as riprap and gabions, aquatic plants provide a better solution because they are part of the nature.

Unfortunately, in many practices, the effectiveness of planting vegetation for shoreline protection is far from satisfactory, mainly because of the lack of a **comprehensive guideline on what, where, and how to plant the vegetation**. The optimal plant species and densities highly depend on the specific environmental conditions. For example, flexible plants such as Northern watermilfoil are good at damping waves, while stiff plants such as cattails are suitable for suppressing turbulence in water currents. It is necessary to establish a database and develop prediction models of shoreline evolution to guide the use of aquatic plants in the shoreline protection.

By utilizing the unique experimental resources at the St. Anthony Falls Laboratory (SAFL), we will study the interactions among plants, water, and sediment. Patches of various aquatic plants will be deployed in the **Outdoor StreamLab** at SAFL. The sediment deposition rate will be recorded as we vary the stream speed conditions. Meanwhile, we will perform systematic numerical experiments in a **virtual stream** to collect data complementary to the field measurement. Based on the massive data obtained from field and numerical experiments, we will develop a model to **predict the sediment deposition rate and shoreline evolution**. Meanwhile, we will **monitor the environmental conditions** of representative lakes and rivers with severe shoreline erosion. We will import the near-shore topography and water flow conditions into the model to **develop an executable plan** for planting aquatic vegetation at the shoreline of these rivers and lakes.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Collect data for the interactions among plants, water flow, and sediment.

We will use the unique experimental capability at SAFL to study the interactions among plants, water flow, and sediment. We will conduct laboratory experiments in the water channel, where the plants, soil condition, currents, and waves can be measured precisely. More experiments will be performed in the Outdoor StreamLab to better match the environment of Minnesota. We will also build a virtual stream, which will be validated against the measurement data, and will then be used to simulate the evolution of shorelines. The data collected in laboratory, field, and virtual experiments will be compiled to establish a comprehensive database.

ENRTF BUDGET: $ 98,171

Outcome	Completion Date

1. Conduct laboratory experiments and collect data in SAFL water channel.	June 30, 2020
2. Conduct measurements and collect data in SAFL Outdoor StreamLab.	June 30, 2021
2. Conduct virtual experiments and collect data on SAFL supercomputer.	Sept 30, 2021

Activity 2: Develop a model on shoreline erosion and restoration prediction and apply the model to monitor selected rivers and lakes in Minnesota.

Using the database established in Activity 1, we will develop a model that can provide accurate prediction on sediment deposition rate and shoreline evolution, with respect to various current speeds, wave conditions, vegetation statuses (species, density, and distribution), and soil categories. A monitoring and predicting system based on the model will be built to track and forecast the evolution of shorelines of rivers and lakes in Minnesota. The system will collect and analyze the data, make predictions of the shoreline evolution, and provide guidance on shoreline protection practices. We will build a data sharing platform to inform the public of the predictive shoreline evolution.

ENRTF BUDGET: $ 67,232

Outcome	Completion Date
1. Develop a model for predicting shoreline evolution.	Dec 31, 2021
2. Build a monitoring and forecasting system of shoreline evolution of rivers and lakes.	Dec 31, 2021
3. Build a data sharing platform.	March 31, 2022

Activity 3: Provide executable plan for shoreline protection and develop public-engagement platforms.

With the assistance of the prediction model developed in Activity 2, we will make an executable plan on how to use aquatic plants to protect shorelines of specific rivers and lakes that are suffering from shoreline erosion. The plan will offer detailed information such as the selection of species, growing density, and distance from the bank. We will develop a mobile app, which provides graphical interfaces to guide shoreline protection using aquatic plants. The mobile app can also receive reports from the public on shoreline erosion events for long-term monitoring purpose.

ENRTF BUDGET: $ 33,616

Outcome	Completion Date
1. Make an executable plan for planting aquatic plants on shoreline.	March 31, 2022
2. Develop a mobile app for public engagement.	June 30, 2022

III. PROJECT PARTNERS:

IV. LONG-TERM-IMPLEMENTATION AND FUNDING:

Aquatic plants, once they are grown, can often be self-maintained, and less human intervention is expected. The results from this project can serve as a long-term guidance on shoreline erosion control, and the shoreline prediction model developed in this project can be further expanded continuously as more data come in from various sources in the future. **Public engagement** is important for the long-term shoreline protection. The data-sharing platform will be used to integrate the shoreline evolution status obtained from our monitoring system and public reports. The mobile app will engage the public to shoreline protection. To enhance the awareness of the public on the threats faced by our aquatic environment and provide guidance to the public on how to protect the environment, we will also organize public tours to our field experiment site.

V. TIME LINE REQUIREMENTS:

This project is planned for 3 years starting from July 1, 2019 and ending on Jun 30, 2022.

VI. SEE ADDITIONAL PROPOSAL COMPONENTS:

A. Proposal Budget Spreadsheet
B. Visual Component or Map
F. Project Manager Qualifications and Organization Description

2019 Proposal Budget Spreadsheet

Project Title: Shoreline erosion control using aquatic plants

IV. TOTAL ENRTF REQUEST BUDGET: 3 years

BUDGET ITEM	AMOUNT
Personnel:	$ 187,019
Dr. Zixuan Yang, PI, 50% FTE for each of 3 years, 75% salary, 25% benefit. ($115,537)	
Postdoctoral Associate, experiment and modeling research, 21% FTE for each of 3 years, 82% salary, 18% benefit. ($39,864)	
IT Research Staff, facility maintainance and data management, 10% FTE for each of 3 years, 75% salary, 25% benefit. ($26,818)	
Undergraduate Assistant, data collection and process; 1 months for each of 3 years, 100% salary. ($4,800)	
Professional/Technical/Service Contracts: N/A	$ -
Equipment/Tools/Supplies:	$ 10,500
Cost of setting up of plant models to test in the lab ($1,500), plant aquatic vegetation in the field ($2,500), and the purchasing of wave sensors ($2,500) and velocimetry ($4,000) for the water flow measurement in this project.	
Acquisition (Fee Title or Permanent Easements): N/A	$ -
Travel:	$ 1,500
Tranportation within Minnesota state for data collection and research meetings with other researchers in the state. Estimation of cost for 3 years: Mileage $0.545/mile x 1000 miles =$545; Incidental expense during travel $200; Lodging $755.	
Additional Budget Items: N/A	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 199,019

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

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 does not charge the State of Minnesota its typical overhead rate of 54% of the total modified direct costs (graduate tuition and equipment are excluded).	$ 107,470	Secured
Past and Current ENRTF Appropriation:	$ -	N/A
Other Funding History: N/A	$ -	N/A

Background

Shoreline erosion pollutes water…

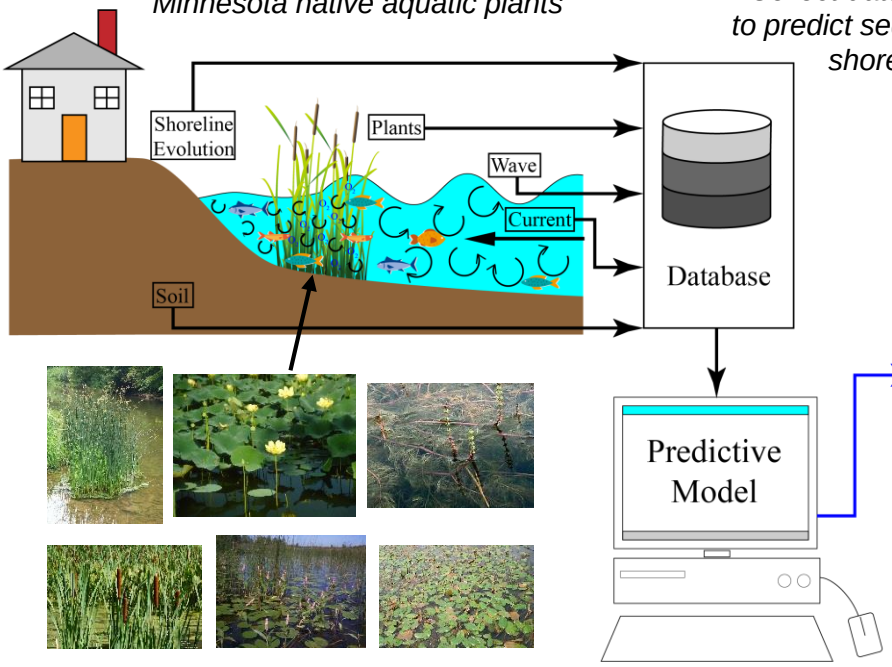
…kills fish…

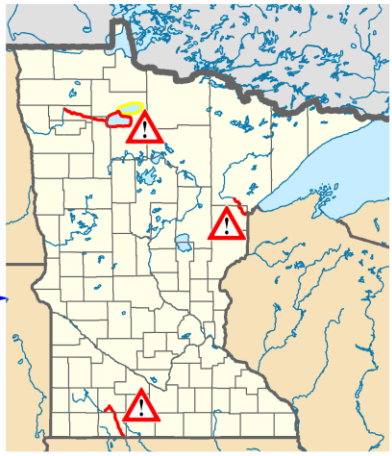
… and causes economic losses

Proposed Research

1. *Conduct experiments to study the interaction among water, sediment and different species of Minnesota native aquatic plants*

2. *Collect data, and develop a model to predict sediment deposition and shoreline evolution.*



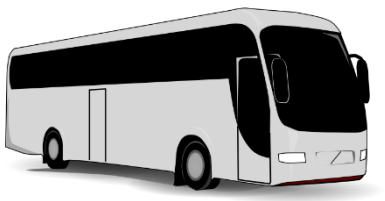


3. *Establish a monitoring and forecasting system for shoreline evolution.*

Public Engagement for Long-Term Implementation

Make an executable plan on how to use aquatic plants to control shoreline erosion.

Develop mobile app for public accessibility to report shoreline erosion.



Give public tours to our Experimental Sites for education purpose.

PROJECT MANAGER QUALIFICATIONS

The proposed research will be led by Dr. Zixuan Yang, Researcher at the St. Anthony Falls Laboratory (SAFL) at the University of Minnesota, Twin Cities. Dr. Yang earned his bachelor's and Ph. D. degrees from Tsinghua University (China) in 2007 and 2012, respectively. From 2013 to 2015, he was a postdoctoral fellow at the University of Manitoba (Canada). He joined the Department of Mechanical Engineering at the University of Minnesota in 2015, and is now a researcher at SAFL. Dr. Yang conducts research in environmental fluid mechanics, focusing on wave-structure interaction, wave dynamics, and sediment transport. He is an expert using advanced in-house-developed fluid simulation software WOW to simulate wave-structure interactions. He is part of the team that developed this software.

ORGANIZATION DESCRIPTION

This project will be performed at SAFL (http://www.safl.umn.edu) at University of Minnesota. SAFL is an interdisciplinary fluid mechanics research and educational institution. It has 21 faculty members and 37 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 uses 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 has recently been upgraded with a $16M renovation, has 15 general purpose flumes, tanks, and channels readily configurable to the needs of projects. 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 nearly 300 ft^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.

The proposed project 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.

The powerful supercomputer equipped at SAFL will be used for the simulation part. SAFL has two High Performance Computing (HPC) Beowulf-style computer clusters with execution and compute nodes connected by low-latency/high-throughput local interconnects (InfiniBand). We also have 240 cores of Paros-class interactive nodes provisioned via Openstack for interactive use. The storage associated with the clusters is a 262TB Lustre-based storage system with distributed metadata servers (MDS) and object storage servers (OSS), all connected via the IB network in order to handle high I/O needs of the programs. A secondary 400TB storage system based on Serial Attached SCSI (SAS-2) disks with redundant controllers serves the long-term storage and day-to-day needs of the cluster.