Environment and Natural Resources Trust Fund
2018 Request for Proposals (RFP)

Project Title: **ENRTF ID: 150-D**

Development of Predictive Tools for AIS Management

Category: D. Aquatic and Terrestrial Invasive Species

Total Project Budget: $ 331,644

Proposed Project Time Period for the Funding Requested: 3 years, July 2018 to June 2021

Summary:

We will develop predictive modeling on which lakes are most susceptible to zebra mussel spread, which invasive species are most likely to arrive in Minnesota lakes and through which pathways.

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Sponsoring Organization: Concordia College

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Diagram of proposed activities: Modeling zebra mussel spread, predicting new invaders and assessing invasion pathways

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

I. PROJECT STATEMENT

In Minnesota (MN), no scientific tools have been developed to predict future spread of Zebra Mussel or the establishment of many other aquatic invasive species (AIS). Recently, Starry Stonewort, an invasive plant, established in several MN lakes, and Red Swamp Crayfish were collected in one MN lake. Those introductions surprised many agency and academic professionals within MN, but both species were predicted by one of our team (Hoff) to continue to spread in the Midwest. The purpose of our three proposed activities is to provide MN resource managers with innovative mathematical tools to characterize risk, within MN, of: 1) spread of Zebra Mussel, and 2) initial invasion by AIS not known to be established in MN. Those tools and their predictions will be developed, and then input from natural resource managers will be invited to enable us to improve those tools. Natural resource managers can use final versions of those tools and their predictions to: 1) interdict invasional pathways (i.e., prevent invasions), by identifying opportunities to develop and improve strategic risk management actions (i.e., policies, laws, rules, and best management practices), and 2) inform early detection programs to identify species, pathways, and locations (locations may be either specific locations, or classifications of waters) to be prioritized for agency and citizen science monitoring. Examples of high-risk pathways include live organism legal trade (internet, and brick-and-mortar retail and wholesale; includes live food, live bait, aquarium, water garden, and biological supply), and boating. Integrating species and pathway management is the foundation of future AIS risk reduction in MN. **The outcome of this work will reduce ecological, social, and economic damages from AIS to public surface waters within MN.**

II. PROJECT ACTIVITIES AND OUTCOMES

Budget: $120,627

Activity 1: *Characterizing risk of Zebra Mussel establishment in all uninvaded Minnesota Lakes >100 Acres*

The best predictors of invasion include habitat match and propagule pressure (number of organisms introduced into the ecosystem). We will develop analytics for habitat match (water quality) and propagule pressure (boater use) for Zebra Mussel-infested waters. Those analytics will be used by us to develop one or more mathematical models that predict risk of additional invasions. This mathematical modeling to predict invasion differs from MAISRC approaches in that it predicts which lakes are at high risk of future invasion rather than Zebra Mussel genotype movement. The outcome of our modeled risk characterizations can be used by resource managers to improve programs designed to prevent invasions.

Outcome	Completion Date
1. Merge existing databases, including data for boater use and lake water quality, and then use those data to develop analytical metrics needed for mathematical modeling.	*January 30, 2021*
2. Develop mathematical models, from the metrics developed in number 1 above, that characterize risk of Zebra Mussel in all Minnesota lakes >100 acres that have not yet been invaded.	*December 30, 2020*
3. Provide resource managers and the public with Zebra Mussel risk characterizations for Minnesota Lakes. Those characterizations of risk can be used to improve programs designed to prevent future invasions.	*December 30, 2020*

Activity 2: *Identify new aquatic invasive species that threaten MN waters*

Budget: $108,665

This project will identify aquatic invaders, not currently in MN waters, but with the potential to cause damage. We will use and improve existing AIS risk assessments for plants, fish, and mollusks, tailored for MN environmental and management conditions. Currently only national or regional risk assessments exist and the risk assessments need modification to be relevant for MN resource managers. Dr. Jerde built the U.S. and regional plant risk assessments and will efficiently tailor the models for MN. The goal of this activity is to provide a list of likely next invaders to MN resource managers so there are no surprises like the recently discovered Starry Stonewort or Red Swamp Crayfish.

Outcome	Completion Date
1. Application of Aquatic Weed Risk Assessment for MN waters that identifies greatest threats to MN	*January 2019*
2. Refinement of risk assessments to increase efficiency for MN waters	*June 2020*
3. Application of risk assessment approaches for fish and mollusks for MN waters	*December 2020*

Activity 3: *Evaluate and characterize AIS pathways in MN* **Budget: $** $102,351

The most effective way to reduce AIS impacts is to prevent their arrival. We will evaluate known AIS introduction pathways and identify previously unidentified pathways, characterize and prioritize those posing the most risk to MN. Evaluating the relative importance of each pathway in historic as well as recent introductions will focus containment efforts and identify the weak points in prevention. Focused assessment of the invasion threat from the aquarium trade will measure the relative threat each pathway provides. Surveys will be conducted by two high school students and one high school teacher to build K-12 Enrichment and to demonstrate the role of mathematical modeling in the prevention and spread of AIS. The goal of this activity is to identify pathways that pose the greatest risk of AIS introduction to MN waters.

Outcome	Completion Date
1. Metaanalysis of literature on invasion pathways	*July 2019*
2. Evaluate known modes of invasive species entry into Minnesota	*July 2020*
3. Survey aquaria throughout Minnesota and determine prevalence of invasive plants	*June 2021*
4. K-12 Educational Enrichment and Technology Transfer	*June 2021*

III. PROJECT STRATEGY

A. Project Team/Partners

- Dr. Michelle Marko, (Biology, Concordia College) has worked on the ecology of invasive species for 15 years.
- Dr. John Reber (Mathematics, Concordia College) is a consulting statistician.
- Dr. Nathan Axvig (Mathematics, Concordia College) specializes in coding theory and industrial mathematics.
- Mr. Michael Hoff (U.S. Fish and Wildlife Service, retired) has developed risk assessment tools for invasive species.
- Dr. Christopher Jerde (University of California, Santa Barbara) is an aquatic invasive species expert with over 40 publications on risk assessment and AIS modeling. His research program provides internationally recognized advancements in invasive species management, including successful applied risk assessments and early detection methods. His interdisciplinary expertise (mathematical biology) allows for effective communication between biologists and mathematicians, a central component of this project.

B. Project Impact and Long-Term Strategy

We will combine expertise in invasive species management with cutting edge mathematical modeling, computer science, and risk assessment tools to identify waters most at risk for invasive species. The outcome of this work will be proactive guidance that MN resource managers can use to reduce the spread of existing invasive species as well as to prevent the establishment of new species, thus mitigating the ecological, social, and economic damages from aquatic invasive species to MN waters.

C. Timeline Requirements

We are requesting three years of funding. Year 1 will focus on building databases. Year 2 will transition to modeling spread and risk assessment. Additionally, the current state of MN invasive species biology and management will be shared as part of a K-12 enrichment effort. In Year 3 we will focus on synthesis, testing of predications, and communication.

2018 Detailed Project Budget

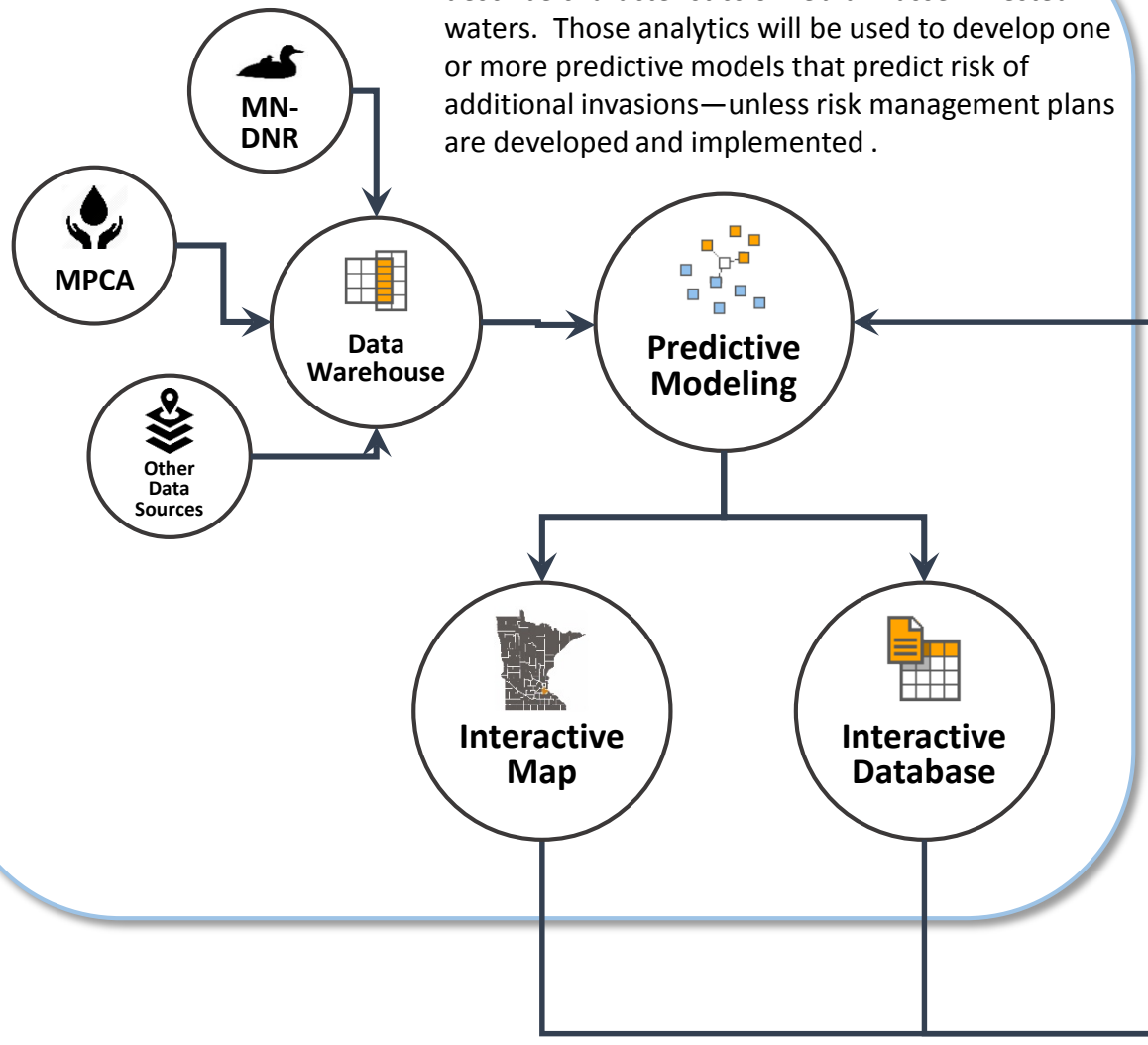
Project Title: *Development of predictive tools for AIS management*

IV. TOTAL ENRTF REQUEST BUDGET: 3 years	
BUDGET ITEM	**AMOUNT**
Personnel:	**$ 174,524**
Michelle Marko, co-PI, ecologist (90% salary, 10% benefits): 50% summer FTE for each of 3 years: $33,910	
John Reber, co-PI, data acquisition and management (90% salary, 10% benefits): 50% summer FTE for each of 3 years: $36,786	
Nathan Axvig, co-PI, data management and analysis (90% salary, 10% benefits): 50% summer FTE for first 2 years, 12.5% summer for year 3: $31,488	
12 Concordia College Undergraduate Researchers, data acquistion, analysis, modeling and literature review (90% salary, 10% benefits): 4 summer FTEs for each of 3 years: $62,006	
2 High School-Student Researchers (90% salary, 10% benefits): 1 summer FTE for each of years 2 and 3: $10,334	
Professional/Technical/Service Contracts:	**$ 119,800**
Michael Hoff, private contactor, data acquisition and expertise, Activities 1-2: $48,000	
Chris Jerde, University of California- Santa Barbara, AIS data and mathematical modeling expertise, Activities 1-3: $52,000	
K-12 biology teacher, Activity 3: $19,800	
Equipment/Tools/Supplies:	**$ 23,745**
Computer server with 10TB data storage: $20,000	
Field equipment for Activity 3: (e.g. pathway assessment; 5 skimming nets @ $5, total: $25; plant identification (4 at $35) and mollusc identification manuals (4 at $35), total: $280: 150 gallon aquaria to raise plants and associated invertebrates to identification, 4 @ $700, total: $@800; aquarium filters and associated supplies 4 @ $160, $640). $3,745	
Travel:	**$ 11,075**
Mileage (~4000 miles), lodging, meals and per diem for in-state travel related to aquaria survey for Activity 3: $5,000	
Mileage (~1500 miles), lodging, meals and per diem for Michael Hoff's travel to Concordia for meeting with collaborators: $1,875	
Special Request for Chris Jerde's travel to Concordia for annual meeting with collaborators (3 round-trip flights, lodging, meals and per diem): $4,200	
Additional Budget Items:	**$ 2,500**
Publication costs: $2,500	
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	**$ 331,644**

V. OTHER FUNDS

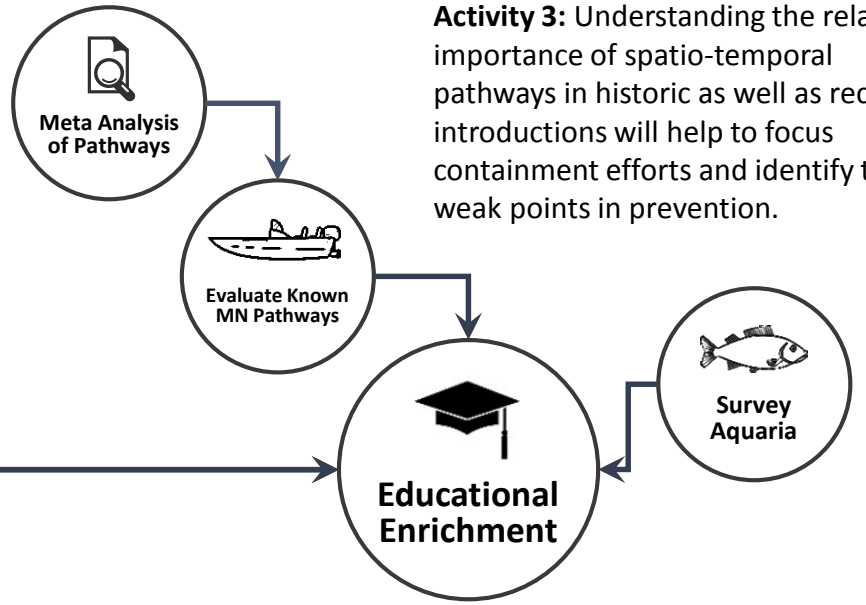
SOURCE OF FUNDS	**AMOUNT**	**Status**
Other Non-State $	N/A	
Unrecovered Facilities and Administration (Concordia College)	$ 70,737	*Secured*
Unrecovered Facilities and Administration (UC Santa Barbara)	$ 27,820	*Secured*
Other State $ To Be Applied To Project During Project Period:	N/A	
In-kind Services To Be Applied To Project During Project Period:	N/A	
Faculty time on Project during school year	$ 72,000	*Secured*
Past and Current ENRTF Appropriation:	N/A	
Other Funding History:	N/A	

Activity 1: Analytics will be developed that describe characteristics of Zebra Mussel-infested waters. Those analytics will be used to develop one or more predictive models that predict risk of additional invasions—unless risk management plans are developed and implemented .



Activity 2: This activity will use and improve existing AIS risk assessments and apply them to Minnesota.

Activity 3: Understanding the relative importance of spatio-temporal pathways in historic as well as recent introductions will help to focus containment efforts and identify the weak points in prevention.



PROJECT MANAGER QUALIFICATIONS AND ORGANIZATION DESCRIPTION

Project Manager: Michelle D. Marko
Associate Professor of Biology and Co-Director of Environmental Studies
Concordia College, 901 8th St. S., Moorhead, MN 56562
Office phone: 218-299-3745; email: marko@cord.edu; Fax: 218-299-4308

Professional Preparation and Experience

Postdoctoral Associate, The Connecticut Agricultural and Experimentation Station
Ph.D., University of Minnesota, St. Paul, Minnesota, 2006, Water Resources Science
Supporting Program: Science Education
M.S., Colorado State University, Fort Collins, Colorado, 1996, Zoology
B.S., University of Minnesota, St. Paul, Minnesota, 1993, Ecology, Evolution, and Behavior

Dr. Marko has worked with aquatic invasive species for over 15 years. She has been the project manager of several AIS projects and the recipient and collaborator of many more. She is currently a co-Principal Investigator of a National Science Foundation, S-STEM grant ($959,562). Marko previously received and managed as a co-PI, a Pelican River Watershed District ecology and management project on Flowering Rush ($149,983) and several biological control of Eurasian watermilfoil projects (ranging from $23K-$59K).

Dr. Marko's research is in the field of aquatic ecology, with specific projects on the ecology of invasive species, the chemical ecology of aquatic plants, and water quality assessments. She has worked with modeling and large datasets as part of teaching and scholarship activities. For several years, Dr. Marko has been working at the interface between basic and applied research. Recent studies have shown that natural resource managers rarely get the information they need from scientists, and scientists rarely include information that managers need in their manuscripts. By working at this interface, she can continue conducting research in the basic biology and ecology of invaders , while working with managers to solve true environmental problems.

Organizational Description

Concordia College, which was founded in 1891, is a four-year coeducational, liberal arts institution in Moorhead, Minnesota that enrolls over 2,100 students from 38 states and 26 countries. Students learn to become responsible citizens prepared to live out Concordia's mission *to influence the affairs of the world by sending into society thoughtful and informed men and women.*

Concordia offers STEM majors in biology, chemistry, computer science, environmental studies, mathematics, neuroscience, and physics, with minors in data analytics and vaccinology. Construction is underway on a $45 million renovation of our science facilities, with completion targeted for August of 2017. These facilities will allow us to realize a vision for science education that focuses on scholarship, integrative learning, and multidisciplinary education, while promoting an environment of "learning science by doing science."