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

Project Title: **ENRTF ID:** **027-A**

Decision Support Tool for Prioritizing Shallow Lake Management

Category: A. Foundational Natural Resource Data and Information

Total Project Budget: $ 110,347

Proposed Project Time Period for the Funding Requested: 2 years, July 2017 – June 2019

Summary:

To confront deteriorating water quality, we will develop a decision-support tool to prioritize shallow lakes for management: lakes to protect, actively manage, and lakes where restoration will be costly.

Name: John   Fieberg

Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Schematic showing how results of recently developed statistical models will be used to assign lakes to one of three management categories: a) protect (highly resilient clear lakes); b) actively manage (clear lakes that are vulnerable to state shifts and "opportunistic" turbid lakes that can be restored to clear conditions with appropriate management actions); and c) high cost (turbid lakes that are highly resilient and require costly, drastic to restore them to clear conditions). Lakes are then prioritized based on their management category, factors that influence their likelihood of transitioning to or from desired states, and the chance of achieving clear conditions in the long term.

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

PROJECT TITLE: Decision Support Tool for Prioritizing Shallow Lake Management

I. PROJECT STATEMENT

In the face of deteriorating water quality and spread of invasive species, managers in Minnesota need user-friendly tools to help make difficult decisions regarding when and how to manage shallow lakes.

Shallow lakes exist in one of two states. Healthy lakes have clear water, abundant aquatic vegetation, and provide crucial habitat for waterfowl and other wildlife. By contrast, deteriorated lakes are turbid and prone to explosive, sometimes toxic, algal blooms, especially in lakes that have been subjected to high nutrient loading. There is also evidence that nitrate accumulates at higher rates in turbid lakes, reducing water quality. Fortunately, it is sometimes possible to manage these lakes (e.g., by killing fish, implementing temporary drawdowns, reducing nutrient inputs) so that they shift from turbid to clear states. However, once lakes surpass certain thresholds for nutrient levels or water clarity, achieving a shift to the clear state can be nearly impossible, and successful transitions may be short-lived. Mathematical ecologists have developed theoretical models to explain why shallow lakes behave this way, but unfortunately, **managers still lack the ability to predict whether their efforts will maintain clear conditions in high quality lakes, whether these clear lakes are approaching thresholds and thus are likely to transition to turbid conditions, or if management will succeed in restoring highly deteriorated lakes.** Thus, lake managers often have to rely on prior experience, intuition, and guesswork when making costly, important management decisions.

Our group has been developing statistical models that use landscape-level characteristics and within-lake data to estimate critical nutrient thresholds that determine shallow lake dynamics, and to identify important factors that influence the likelihood that lakes will deteriorate, or conversely, that they can be managed for clear conditions (Figure 1, top panel). Our goal is to translate the results of this research (e.g., predictions based on multiple statistical models) into an interactive decision support tool that will allow lake managers to:

1. Assign shallow lakes to one of three *management categories*: a) **protect** (highly resilient clear lakes); b) **actively manage** (clear lakes that are vulnerable to state shifts and "opportunistic" turbid lakes that can be restored to clear conditions with appropriate management actions); and c) **high cost** (turbid lakes that are highly resilient and require costly, drastic actions (e.g., sediment removal) to restore them to clear conditions).
2. Prioritize lakes for management based on their current status, the likelihood of transitioning to or from desired states, and the chance of achieving clear conditions in the long term.
3. Explore appropriate management actions, taking into account a lake's current status, its connectivity to other lakes, and regional factors reflecting historical land-use legacies (e.g., long-term nutrient loading).
4. Help identify uncertainties resulting from data gaps for particular lakes, evaluate the benefits of collecting additional information, and prioritize lakes for future sampling.

This project will result in a product that can be used by a diverse audience (local and state governments, lake associations, natural resource agencies) to prioritize shallow lakes for management.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Develop decision support tool for shallow lake managers   **Budget: $55,000**
In the first phase of the project, we will develop an interactive tool, capable of using a variety of data sources, to assign lakes to one of three management classes (protect, actively manage, high cost), predict the likelihood that lakes will transition, and help prioritize lakes for management (Figure 1).

Outcome	Completion Date
1. Develop the decision support tool	June 1, 2018

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Activity 2: Illustrate the use of the tool in a series of "case study" lakes   **Budget: $55,347**
In the second phase of the project, we will organize three regional workshops (in southwestern MN, north central MN, and east central MN), inviting representatives from the MNDNR, Minnesota Pollution Control Agency (MPCA), US Fish and Wildlife Service (USFWS), Ducks Unlimited, and local lake associations. We will use the workshops to illustrate the tool in a series of "case study" lakes. Specifically, we will explore how the tool may be used to prioritize lakes for management attention and to evaluate the likelihood of successful lake manipulations (Figure 1, bottom panel).

Outcome	Completion Date
1. Workshops illustrating the use of the tool to make decisions for specific lakes	June 1, 2019

III. PROJECT STRATEGY
A. Project Team/Partners
We have assembled a diverse team of project partners from the University of Minnesota (UMN), MNDNR, and the University of St. Thomas. Funds received from this Environmental and Natural Resources Trust Fund request will be received by the University of Minnesota in an agreement with Dr. Fieberg as Principal Investigator.

Project partners receiving funds:
- Dr. John Fieberg, UMN: Project manager.
- Kelsey Vitense, UMN: Ph.D. student responsible for model and tool development.

Project partners not receiving funds:
- Dr. Anthony Starfield, UMN professor emeritus
- Dr. Mark Hanson, MN DNR: Limnologist.
- Nicole Hansel-Welch, MN DNR: Shallow Lake Program Supervisor.
- Brian Herwig, MN DNR: Fisheries Research Biologist.
- Dr. Kyle Zimmer, University of St. Thomas: Limnologist.

B. Project Impact and Long-Term Strategy
We expect to be able to meet project objectives during the proposed project period (July 2017 – June 2019) with requested funds, and we do not anticipate making additional requests to the Environmental and Natural Resources Trust Fund to support this project. This work will leverage research being conducted by the PI and project collaborators and will utilize a wealth of data on shallow lakes in Minnesota collected from previously funded LCCMR research, efforts of the Minnesota Department of Natural Resources (MNDNR) Shallow Lakes Program, and additional regional research. Results of this project will provide information to help inform shallow lake management in Minnesota and will be disseminated to state and federal management agencies, published in the peer-reviewed literature, and made available to the general public via a website and popular articles. Representatives from the MNDNR, MPCA, USFWS, Ducks Unlimited, and local lake associations will have an opportunity to become familiar with the tool at one or more workshops.

C. Timeline Requirements
The project will last 2 years. During the first year, we will build an interactive tool to help aid in the management of shallow lakes. In the second year, we will conduct a series of 3 workshops to introduce the tool to a diverse audience interested in the management of shallow lakes.

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2017 Detailed Project Budget

**Project Title:** Decision Support Tool for Prioritizing Shallow Lake Management

IV. TOTAL ENRTF REQUEST BUDGET 2 years

BUDGET ITEM	AMOUNT
Personnel:	
Ph.D. Graduate Research Assistant (50% Research Assistantship, 50% FTE for 2 years, 55.6% stipend, 7.2% benefits, 37.2% tuition)	$84,239
John Fieberg, quantitative ecologist (9% FTE for 2 years, 66.3% salary, 33.7% fringe)	$19,448
Travel: all costs are associated with in-state travel for the PI and graduate assistant to meet with lake managers when developing the decision support tool and to participate in associated workshops)	
Lodging (15 nights x 2 rooms x $100/night)	$3,000
Mileage (4000 miles x .54/mile)	$2,160
Per diem (15 days x 2 people x $50/day)	$1,500
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST	$ 110,347

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: *NA*	N/A	N/A
Other State $ To Be Applied To Project During Project Period: *NA*	N/A	N/A
In-kind Services To Be Applied To Project During Project Period: *NA*	N/A	N/A
Funding History:	N/A	N/A
Environment and Natural Resources Trust Fund (ENRTF), Sustainable, Cost-Effective Approaches to Management of Shallow Lakes (020-A3)	$262,000	project complete
Sections of Wildlife and Fisheries MDNR - Support for graduate assistant, GIS technician, CoPI summer salary, contract with ecological modeler, and DNR in-kind support	$263,960	support through FY2016
Remaining $ From Current ENRTF Appropriation *None*	N/A	N/A
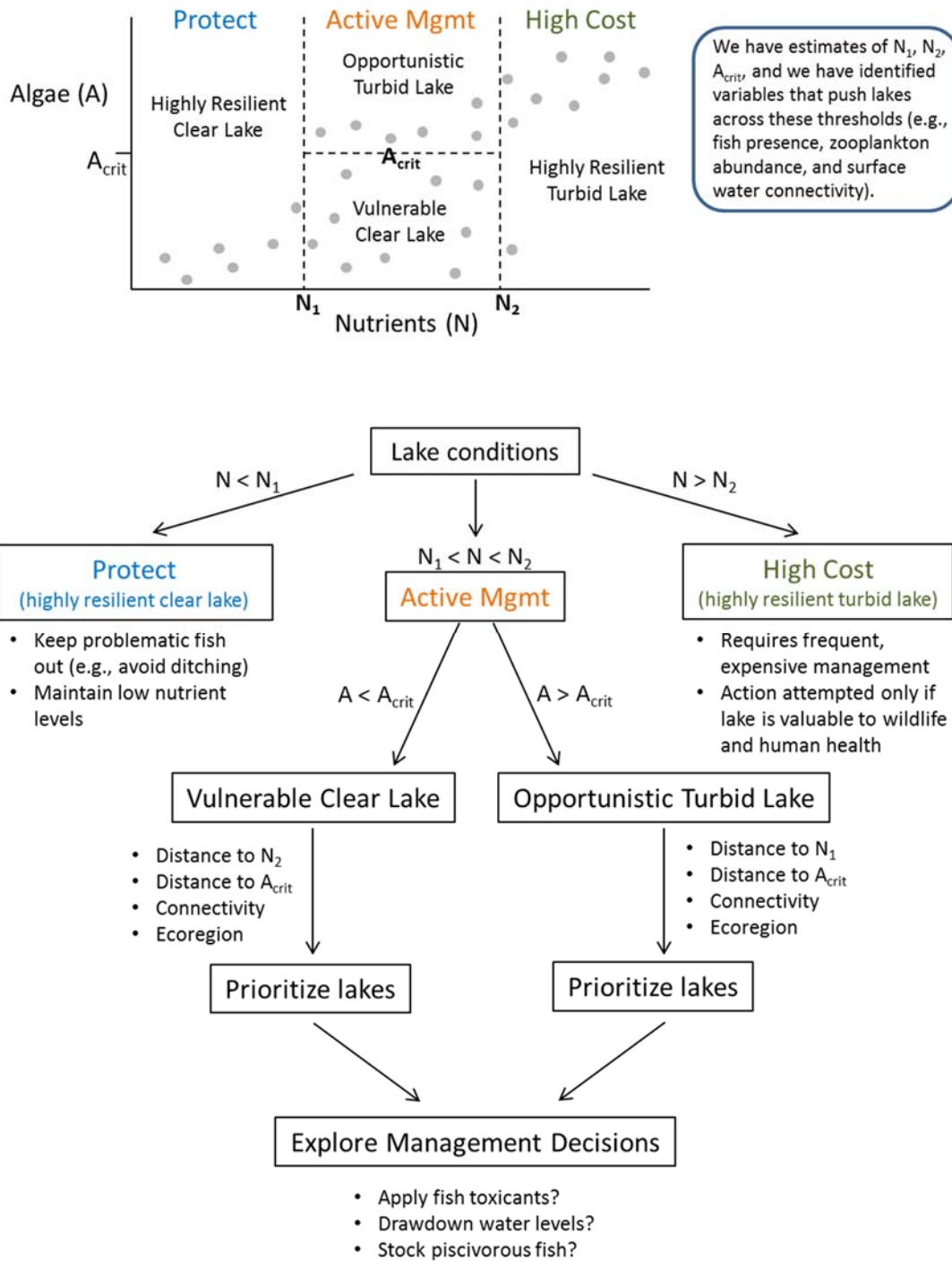
Figure 1. We will translate results of recently developed statistical models into an interactive tool that can be used to assign lakes to one of three management categories (top panel): a) **protect** (highly resilient clear lakes); b) **actively manage** (clear lakes that are vulnerable to state shifts and "opportunistic" turbid lakes that can be restored to clear conditions with appropriate management actions); and c) **high cost** (turbid lakes that are highly resilient and require costly, drastic to restore them to clear conditions). We will illustrate, using a series of workshops, how the tool can be used to prioritize lakes for management and explore appropriate management actions (bottom panel).

John Fieberg
Assistant Professor, Department of Fisheries, Wildlife, and Conservation Biology, University of Minnesota.

Ph.D., Biomathematics, 2000, North Carolina State University, Raleigh, NC
M.S., Biostatistics, 1996, University of North Carolina-Chapel Hill, Chapel Hill, NC
B.S., Mathematics (*summa cum laude*), Westminster College, Fulton MO

John Fieberg will be responsible for project coordination, mentoring the graduate research assistant, and providing analytical support. Prior to coming to the University of Minnesota, John worked for 10 years as a research statistician with the Minnesota Department of Natural Resources. He has considerable expertise in the application of statistical and mathematical models to natural resource problems.

Relevant Publications (*selected from a total of 65*)
Fieberg, J. and D. H. Johnson. 2015. MMI: Multimodel inference, or models with management implications? Journal of Wildlife Management 79(5):708-718.
Fieberg, J. 2012. Estimating Population Abundance Using Sightability Models: R SightabilityModel Package. Journal of Statistical Software 51:1-20.
Hanson, M., B. R. Herwig, K. D. Zimmer, J. Fieberg, S. R. Vaughn, R. G. Wright, and, J. A. Younk. 2012. Comparing effects of lake- and watershed-scale influences on communities of aquatic invertebrates in shallow lakes. PlosONE 7(9): e44644. doi:10.1371/journal.pone.0044644.
Friederichs, S. J., K.D. Zimmer, B. R. Herwig, M. A. Hanson, J. R. Fieberg. 2010. Total phosphorus and piscivore mass as drivers of food web characteristics in shallow lakes. Oikos 120:756-765.
Hanson, M. A., S. E. Bowe, F. G. Ossman, J. Fieberg, M. G. Butler, and R. Koch. 2009. Influences of adjacent forest harvest and environmental gradients on aquatic invertebrate communities of seasonal ponds in forested landscapes in Northern Minnesota. Wetlands 29:884-895.
Fieberg, J. and K. Jenkins. 2005. Assessing uncertainty in ecological systems using global sensitivity analysis: a case example of simulated wolf reintroduction effects on elk. Ecological Modeling, 187:259-280.

Recent Presentations (*on related work*)
Vitense, K., Hansel-Welch, N., Hanson, M.A., Herwig, B.R., Zimmer, K., and J. Fieberg. 2016. Predicting Total Phosphorus and Assessing State Transition Risk in Shallow Lakes. North American Duck Symposium, Washington DC.
Hanson, M.A., Herwig, B.R., Zimmer, K.D., Hansel-Welch, N., Vitense, K., and J. Fieberg. 2016.; Rehabilitating Turbid Shallow Lakes: Harder Than We Think? North American Duck Symposium, Washington DC.
Vitense, K ., Hansel-Welch, N., Hanson, M.A., Herwig, B.R., Zimmer, K., and J. Fieberg. 2015. Uncovering state-dependent relationships in shallow lakes using Bayesian latent variable regression models. The Wildlife Society Meeting, October 2015.

Organization Description
The University of Minnesota is Minnesota's flagship, land grant university. It has a strong tradition of excellence in education, research, and outreach.

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