Environment and Natural Resources Trust Fund
2016 Request for Proposals (RFP)

Project Title: **ENRTF ID:** **080-B**

Mitigating Nitrogen to Protect Aquatic and Human Life

Category: B. Water Resources

Total Project Budget: $ 461,000

Proposed Project Time Period for the Funding Requested: 3 years, July 2016 to June 2019

Summary:

We will determine if nitrogen in water can be reduced by increasing plant abundance in shallow lakes, and assess whether nitrate-nitrogen is an endocrine disruptor for aquatic organisms.

Name: Kyle Zimmer

Sponsoring Organization: University of St Thomas

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Conceptual model illustrating our hypothesis that high abundance of submerged plants in shallow lakes reduces N in water via denitrification.

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

PROJECT TITLE: Mitigating nitrogen to protect aquatic and human life

I. PROJECT STATEMENT

Why this project needs to be done: High levels of nitrogen (N) in surface and subsurface water in Minnesota impacts eutrophication, drinking water safety, and downstream dead zones. Additionally, recent evidence suggests that nitrate-N may be an endocrine disruptor that reduces survival and reproduction of aquatic organisms.

Goal 1: **Reduce N in water by managing shallow lakes for high abundance of submerged plants**
Our preliminary evidence indicates N levels in water decrease by 68% as shallow lakes shift from algal-dominance to submerged plant dominance. We hypothesize that high plant abundance reduces N by increasing rates of denitrification, a natural process that moves N from water to the air where it innocuous (Fig 1).

The **outcomes** will be:

1) to determine if high plant abundance causes elevated denitrification rates and reduced N in water
2) to provide state-wide guidelines for increasing rates of denitrification in shallow lakes
3) to develop models that predict lakes at risk of high nitrogen levels.

We will **achieve** this goal by:

1) intensively sampling N concentrations and denitrification rates in 12 shallow lakes, with some lakes dominated by algae and others by submerged plants
2) conducting a survey of denitrification rates in 100 shallow lakes across Minnesota
3) developing statewide models that identify lakes at risk of elevated nitrogen levels.

Goal 2: Determine if nitrate-N is an endocrine disruptor for aquatic organisms
Our preliminary evidence indicates nitrate-N influences the endocrine (hormonal) system in fish, and may reduce survival and reproduction. However, effects of nitrate-N on fish and other aquatic organisms have not been explicitly examined.

The **outcomes** will be:

1) to determine if nitrate-N is an endocrine disruptor for fish and aquatic invertebrates
2) to develop guidelines for safe levels of nitrate-N for aquatic organisms
3) to identify lakes with nitrates exceeding levels safe for aquatic organisms, and to provide useful mitigation recommendations.

We will **achieve** this goal by:

1) testing effects of several concentrations of nitrate-N on endocrine function, survival, and reproduction of fish and aquatic invertebrates
2) identifying lakes with nitrate-N levels that are unsafe for aquatic organisms using our model developed in Goal 1.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Determine whether shallow lakes can be managed to remove N from surface water by studying 112 Minnesota lakes **Budget: $ 391,000**

We will intensively study 12 shallow lakes in western Minnesota to determine whether rates of denitrification are higher in lakes with high plant abundance compared to lakes dominated by algae. We will also conduct a survey of denitrification rates in 100 shallow lakes across the state. Lastly, we will use results from the 12-lake intensive study and 100-lake survey to develop a model that identifies lakes at high N-risk statewide.

Outcome	Completion Date

1. Determine whether managing shallow lakes for high plant abundance can reduce N in surface waters by increasing rates of denitrification. If so, provide recommendations for how shallow lakes can be managed to reduce N statewide.	June 2019
2. Using results from outcome 1, produce a model that identifies lakes at risk of high N levels statewide. It will also identify lake specific (depth, etc.) and watershed-scale factors (land use, etc.) associated with high denitrification rates.	June 2019

Activity 2: Determine whether nitrate-N affects the endocrine system, survival, and growth of aquatic organisms, and provide guidelines for safe levels if it does **Budget: $70,000**

We will examine the influence of multiple concentrations of nitrate-N on endocrine function, growth, and survival of fathead minnows and *Daphnia* (the 'water flea'), two model organisms that work well for predicting effects of nitrate-N on other aquatic organisms. We will conduct laboratory experiments and expose these model organisms to nitrate-N levels that span the range of values we observe across the state in our Activity 1 above.

Outcome	Completion Date
1. Determine whether nitrate-N influences endocrine function, growth, and survival of the fathead minnow and *Daphnia*. If nitrate-N is an endocrine disruptor, we will develop guidelines for safe levels of nitrate-N to protect aquatic life in Minnesota.	June 2019
2. Use the model developed in Activity 1 above to identify lakes with nitrate-N levels high enough to threaten aquatic life, and make recommendations for how the threat could be mitigated through management efforts.	June 2019

III. PROJECT STRATEGY

A. Project Team/Partners

Our team consists of scientists with diverse skills from both universities and state agencies:
- Kyle Zimmer (University of St Thomas, UST) is a shallow lake ecologist and will serve as the overall projector coordinator.
- Gaston Small (UST) is an ecosystem ecologist and will be lead on lake modeling.
- Dalma Martinovic-Weigelt (UST) is an aquatic toxicologist and will be lead on testing influences of nitrate-N on aquatic organisms.
- Jim Cotner (University of Minnesota) is a microbial ecologist and will be lead on the 12 lake intensive study.
- Brian Herwig and Mark Hanson are ecologists with the Minnesota Department of Natural Resources, and they will assist with the 100 lake survey.

All collaborators will receive support from LCCMR, excluding Hanson and Herwig. Zimmer will contribute non-state support via funds provided by UST for supplies and student research assistants. Hanson and Herwig will contribute state support for the project via their time and support for travel for field work.

B. Project Impact and Long-Term Strategy

Our long-term goal is to reduce levels of N in surface and subsurface waters by managing shallow lakes and potentially other aquatic systems for high levels of submerged plants that promote denitrification. High plant abundance has the additional benefit of reducing phosphorus in water and providing excellent habitat for waterfowl, fish, amphibians, and aquatic invertebrates. We will also develop water quality standards for nitrate-N to protect aquatic organisms.

C. Timeline Requirements

We request funding July 2016 through June 2019, with no costs beyond this time frame.

2016 Detailed Project Budget

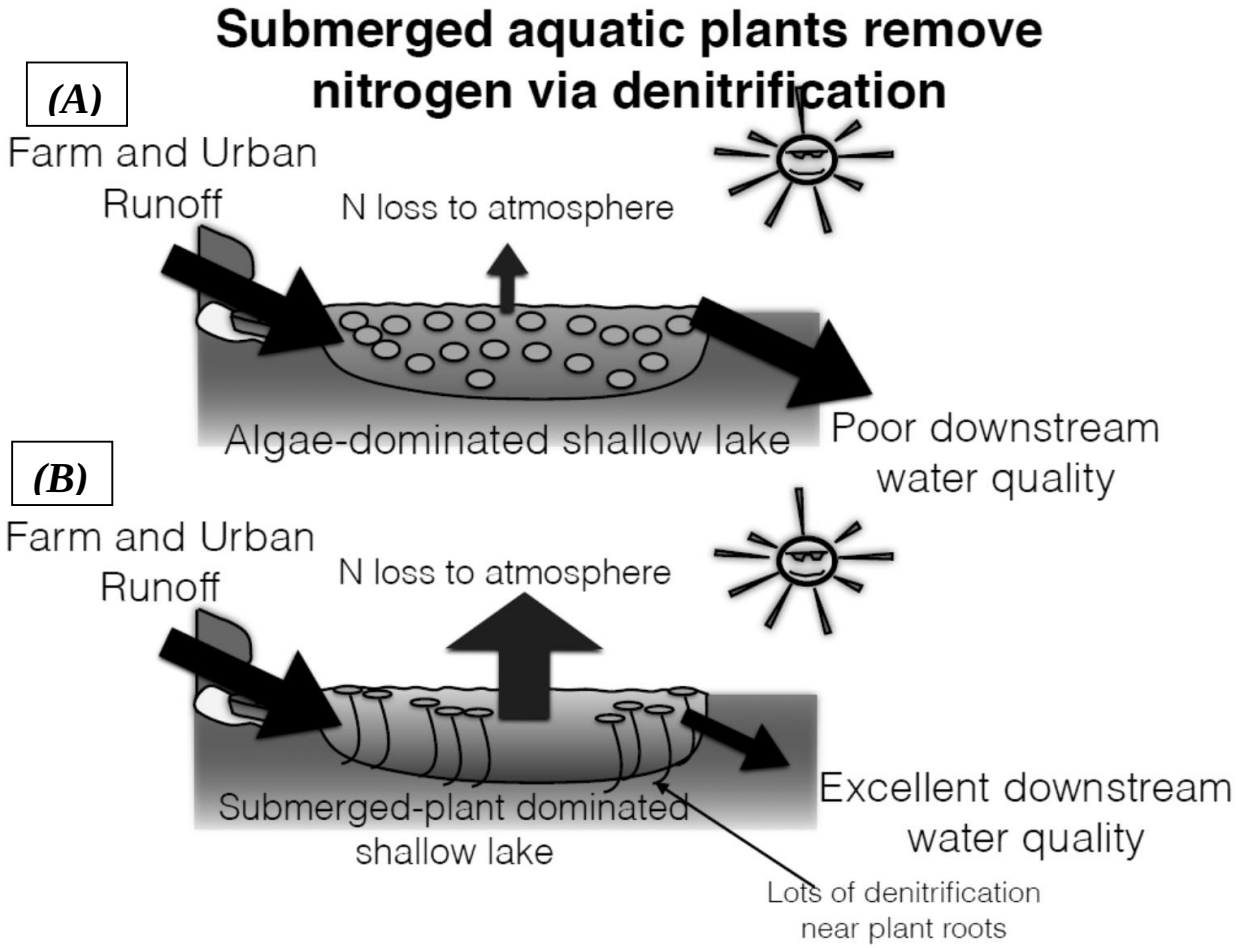
Project Title: Mitigating nitrogen to protect aquatic and human life

IV. TOTAL ENRTF REQUEST BUDGET: $461,000 **YEARS:** 3

BUDGET ITEM	AMOUNT
Personnel: (UST) Co-PI Kyle Zimmer: He will supervise overall project. One month of summer salary each year, benefits 7.62% of total.	$ 29,000
(UST) Co-PI Dalma Martinovic-Weigelt: She will be lead on Activity 2. One month of summer salary each year, benefits 7.62% of total.	$ 27,000
(UST) Co-PI Gaston Small: He will be lead on Activity 1, outcome 2. One month of summer salary each year, benefits 7.62% of total.	$ 24,000
(UST) Undergraduate research assistants: Four undergraduates working full time during summer and part time during school year who will assist with sample collection and analysis for both Activities. Fringe is 7.65% during summer and 0% during school year.	$ 76,000
Professional/Technical/Service Contracts: (UMN) Co-PI Jim Cotner, (75% salary, 25% benefits): One month summer salary is requested each year. He will be lead on Activity 1, outcome 1.	$ 47,000
(UMN) Lab technician (78% salary, 22% benefits): Six months salary is requested each year. Technician will perform chemical analyses for both Activities.	$ 96,000
(UMN) Undergraduate research assistant (100% salary, 0% benefits): One undergraduate working full time during summer and part time during school year who will assist with sample collection and analysis for both Activities.	$ 19,000
(UMN) Graduate student (85% salary, 15% benefits): Three months summer salary is requested each year at 50% time. Graduate student will assist with lab and field sampling for both Activities.	$ 24,000
(UMN) Supplies: Laboratory supplies include analytical standards, reagents, solvents, disposable labware, filters, fluorescent probes, maintenance costs, fluorometer, microplates, etc. These funds will also be used for sample analysis costs such as particulate nutrients (CHN), phosphorus, etc.	$ 23,000
(UMN) Travel: In-state travel for Activity 1 (sampling the 12 intensive lakes 5x/year for 3 years and sampling the 100 lakes state-wide once). PIs, graduate student, and undergraduates will be traveling. Request is for vehicle rental, while UST travel funds requested below will cover hotel rooms and per diem expenses while traveling. An additional $15,000 for renting field vehicles will be provided by the DNR (see below).	$ 8,000
University of California-Davis: Perform stable 15N isotope analysis for 596 nitrate-N samples at $25/sample, and 832 solid samples at $9/sample.	$ 22,000
Equipment/Tools/Supplies: UST field and lab supplies for both activities: lab reagents (hydrochloric acid, persulfate, etc.), 300 sample jars, 1000 glass sample vials, glassware, 1440 glass-fiber filters, field sampling equipment, sample disks and consumable supplies for 720 CN samples, supplies for assaying 600 organisms in our lab endocrine experiments.	$ 49,000
Travel: In-state travel for Activity 1 (sampling the 12 intensive lakes 5x/year for 3 years and sampling the 100 lakes state-wide once). PIs, graduate student, and undergraduates will be traveling. Request is for 88 hotel rooms (2 people/room) at $120/room/night, 244 days of per diem at $25/day/person while traveling for field work. The UMN will cover vehicle rental costs with their request above, and the DNR will provide an additional $15,000 for vehicle rental (see below).	$ 17,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 461,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: Funds from the University of St Thomas to hire research students and purchase lab supplies across the three years.	$ 12,000	secured
Other State $ To Be Applied To Project During Project Period: PI Hanson salary of $6,333 for each of the three years (DNR source).	$ 19,000	secured
PI Herwig salary of $5,400 for each of three years (DNR source).	$16,200	secured
DNR funds for travel support for field vehicles ($7,500 for each of two years).	$ 15,000	secured
Funding History: Quantifying Carbon Burial in Wetlands (PI Cotner) (M.L. 2010, Chp. 362, Sec. 2, Subd. 3g).	$ 144,000	
Assessment of Shallow Lake Management (PI Hanson) (M.L. 2010, Chap. 362, Sec. 2, Subd. 5g).	$ 262,000	



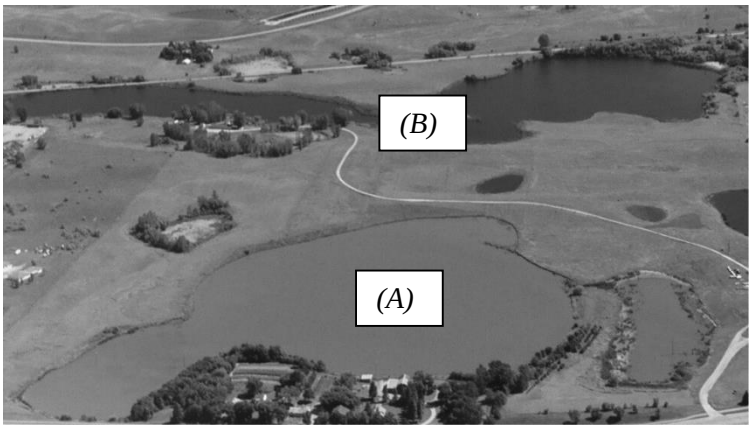


Figure 1. Conceptual model illustrating our hypothesis that high abundance of submerged plants in shallow lakes reduces N in water via denitrification. In algae-dominated shallow lakes (*A* above, at right), denitrification rates are low causing large amounts of N to be exported downstream. In submerged-plant dominated shallow lakes (*B* above, at right), roots of submerged plants facilitate high denitrification rates in lake sediment. High denitrification rates result in more N being lost from water to the air, and less N exported downstream.

Shallow lakes can be managed for high abundance of submerged plants. Abundance of submerged plants in Minnesota shallow lakes is less than historic levels due to habitat degradation. However, plant abundance can be increased by manipulating water levels or by controlling undesirable fish like carp.

Project Manager Qualifications and Organization Description

Project Title: Mitigating nitrogen to protect aquatic and human life

Project Manager: Kyle Zimmer, Ph.D., Department of Biology, University of St. Thomas, kdzimmer@stthomas.edu, ph. 651-962-5244

Project Manager Qualifications: My field of expertise is aquatic ecosystem ecology, and I have studied shallow lake ecosystems in Minnesota for 20 years. My research is focused on clarifying influences of fish and nutrients on shallow lakes, and in developing management strategies for improving water and habitat quality. I have published 31 peer-reviewed papers on the ecology and management of shallow lakes (several examples are given below), and I have supervised dozens of undergraduate research assistants and three postdoctoral associates. I have also served as overall project manager for multiple research grants, and I have supervised several large-scale research projects similar to the work we describe in this proposal to the LCCMR. Lastly, I have collaborated previously with all of the other co-PIs on this proposal.

Selected related publications:

Nolby, L.E., K.D. Zimmer, M.A. Hanson, and B.R. Herwig. 2015. Is the island biogeography model a poor predictor of biodiversity patterns in shallow lakes? Freshwater Biology 60: 870-880.

Gorman, M.W., K.D. Zimmer, B.R. Herwig, M.A. Hanson, R.G. Wright, S.R. Vaughn, and J.A. Younk. 2014. Phosphorus, fish biomass, and watersheds as drivers of phytoplankton abundance in shallow lakes. Science of the Total Environment 466–467:849–855.

Hobbs, W.O., K.M. Theissen, S.M. Hagen, C.W. Bruchu, B.C. Czeck, J.M. Ramstack Hobbs, K.D. Zimmer. 2014. The successful preservation of a healthy shallow lake ecosystem through landscape controls: the role of protected areas and stable aquatic food webs. Journal of Paleolimnology 51:405-420.

Friederichs, S.J., K.D. Zimmer, B.R. Herwig, M.A. Hanson, and J.R. Fieberg. 2011. Total phosphorus and piscivore mass as drivers of food web characteristics in shallow lakes. Oikos 120:756–765.

Zimmer, K.D., M.A. Hanson, B.R. Herwig, and M.L. Konsti. 2009. Thresholds and stability of alternative regimes in shallow prairie-parkland lakes of central North America. Ecosystems 12:843-852.

Zimmer, K.D., B.H. Herwig, and L.M. Laurich. 2006. Nutrient excretion by fish in wetland ecosystems and its potential to support algal production. Limnology and Oceanography 51:197-207.

Other related activities:

-Panelist to review proposals submitted to the National Science Foundation (2011, 2014).
-Co-organizer and moderator for the special session *Terrestrial-Aquatic Linkages II: Movement of Nutrients and Carbon* at the Ecological Society of America meeting (2013).
-Co-Chair of Student Activities Committee for the National Meeting of the American Fisheries Society (2012).
-Co-organizer of the special session *Shallow Lake Ecology* at the 2010 Midwest Fish and Wildlife Conference.

Organization Description: The University of St. Thomas in St. Paul, Minnesota, emphasizes undergraduate education. It also recognizes the importance of research, and faculty in the Department of Biology are given course-release time and dedicated laboratory space to support active research programs. Faculty research labs are also well equipped with research equipment.