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

**Project Title:** **ENRTF ID: 063-B**

Benefits of Lake Plant Diversity for Water Quality

**Category:** B. Water Resources

**Total Project Budget: $** 463,113

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

**Summary:**

We predict that aquatic plant diversity will benefit water quality in lakes. We will test this in shallow lakes throughout Minnesota, leveraging the Sentinel Lakes program for this research.

**Name:** Daniel Larkin

**Sponsoring Organization:** U of MN

**Address:** 135 SKOK HALL, 2003 Upper Buford Circle
St Paul MN 55108

**Telephone Number:** (612) 625-6350

**Email** dilarkin@umn.edu

**Web Address**

**Location**

**Region:** Statewide

**County Name:** Statewide

**City / Township:**

**Alternate Text for Visual:**

Our visual is an underwater illustration of areas with and without a diverse aquatic plant community and the statement, "We predict that areas with higher plant diversity will support better water quality."

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

**Benefits of lake plant diversity for water quality**

## I. PROJECT STATEMENT

***We predict that rates of key water quality functions in lakes will be higher where there is greater plant diversity.*** This prediction is based on research in Minnesota prairies that has revolutionized our understanding of how humans benefit from plant diversity. These relationships have not been adequately tested in aquatic habitats, despite the incredible importance of clean waters for Minnesota's citizens and economy. This project will evaluate key traits of abundant aquatic plants in the state, relate them to water quality functions, and provide tools to use them to identify targets for restoration and management.

**Background:** Vegetation is a critical component of healthy lakes. Plants provide food and habitat for fish, stabilize sediments, and support biodiversity. Plants also drive key processes that increase water quality. Aquatic plants and associated organisms remove nutrients, increase oxygenation, and stabilize sediments, which provide clear, clean water and improve habitat quality for fish and other wildlife. But does water quality depend on *how many* plant species are found in a lake and the biology of those plant species? Or is just the presence of enough vegetation—regardless of its diversity—sufficient for lakes to naturally process nutrients? This is the focus of our proposed research. Minnesota has been a global leader in demonstrating the relationship between plant biodiversity and ecosystem function in terrestrial habitats, showing that diversity is critical for ensuring ecosystem services people depend on. Similarly, communities of aquatic plants that are more diverse may be more effective at maintaining water quality. But research is needed to test this prediction.

**Need:** Lakes in Minnesota are changing in response to a variety of stresses. Our recent analyses of over 1,000 Minnesota shallow lakes show striking changes in plant communities over just 13 years, including loss of diversity and ecological uniqueness. The Sentinel Lakes Program has established a statewide framework to monitor changes in lake conditions and biodiversity. By testing how plant communities influence water quality, we will leverage the efforts of the Sentinel Lakes program to predict effects of vegetation change on water quality and apply our findings to help resource professionals manage lakes.

**Strategy:** We propose to investigate lake plant communities and associated water-quality functions (denitrification, phosphorus retention, and oxygen dynamics) in Sentinel Lakes. We will focus on shallow Sentinel Lakes because of their large vegetated zones and our previous work documenting change in these systems. We hypothesize that greater diversity will increase water quality functions; specifically that more diverse communities will have greater trait diversity (plant physical, structural, and chemical characteristics), which in turn will increase productivity and sedimentary nutrient storage and removal. Our work will quantify the effect of plant communities on water quality, provide data on aquatic plant traits for other researchers, leverage existing LCCMR-supported monitoring programs, and be applied to help manage Minnesota lakes.

## II. PROJECT ACTIVITIES AND OUTCOMES

**Activity 1: Analyze large plant community datasets and measure plant functional traits Budget: $182,392**

We will use 9 years of vegetation data collected by the Sentinel Lakes Program to characterize and map plant communities across the state. We will perform intensive sampling in a subset of shallow Sentinel lakes (≥2 from each of the 3 major ecoregions), taking 1000s of measurements of plant traits in the field and lab. Functional trait work has transformed terrestrial plant ecology, but the necessary data are not available for aquatic plants. We will contribute our data to the TRY plant traits database (https://www.try-db.org), making them available for any researchers who want to study Minnesota lake plants, e.g., their role in fish or food web support.

| Outcome | Completion Date |
|---|---|
| *1. Publish GIS-based maps of plant communities in Sentinel Lakes across the state* | *December 2018* |
| *2. Collect functional trait data for all aquatic plant species found in experimental plots* | *September 2020* |
| *3. Make functional trait data for Minnesota aquatic plants publically available* | *May 2021* |

**Activity 2: Test effects of plants on water quality** **Budget: $226,177**

Using the same lakes and sampling locations as Activity 1, we will test how plant diversity and traits influence sedimentary denitrification, phosphorus burial/release, and oxygen dynamics. This will include both *in situ* measurements in lakes and *ex situ* (lab-based) measures of water and sediments collected from the field. This will involve making 1000s of measurements of water and sediment physical and chemical properties and biogeochemical processes (microbially driven nutrient transformations).

| Outcome | Completion Date |
|---|---|
| *1. Measure key functions that support water quality* | *September 2020* |
| *2. Test the influence of plant communities on water quality functions* | *November 2020* |
| *2. Identify mechanisms through which plant diversity affects water quality* | *January 2021* |

**Activity 3: Predict water quality services and apply findings to support management** **Budget: $54,544**

Using data from our plant community (Activity 1) and water quality analyses (Activity 2), we will develop statistical models relating plant community characteristics to water quality services. We will then use vegetation, environmental, and landscape data from the Sentinel Lakes Program, MnDNR, MPCA, and other sources to predict water quality services in >1,000 shallow lakes across Minnesota. Predictions will be used to generate maps that highlight "hotspots" of water quality services. We will integrate findings from all three activities and translate findings into action by working with agency staff and lake managers across the state.

| Outcome | Completion Date |
|---|---|
| *1. Relate water quality services to vegetation, environmental, and landscape factors* | *March 2021* |
| *2. Estimate water quality benefits of vegetation in shallow lakes across the state* | *June 2021* |

## III. PROJECT STRATEGY

### A. Project Team/Partners

- Dr. Daniel Larkin (FWCB, UMTC) will oversee all aspects of the project and lead efforts related to sampling/analysis of plant communities and functional traits (Activity 1). He will receive summer salary.
- Dr. Jacques Finlay (EEB, UMTC) will lead efforts related to sampling and analysis of water/sediment chemistry and biogeochemical processes (Activity 2). He will receive summer salary.
- Dr. Ranjan Muthukrishnan (FWCB, UMTC) will co-lead plant community/trait analyses (Activity 1) and lead statewide prediction of water-quality services in shallow lakes (Activity 3). He will receive salary.
- Sentinel Lakes program leads Jeff Reed and Casey Schoenebeck (MnDNR) will provide in-kind support for the project, including sharing of data and technical consultation. No salary received.

### B. Project Impact and Long-Term Strategy

Our long-term goal is to work with resource professionals and lake managers to help conserve diverse aquatic plant communities and the benefits they provide to people and nature. By testing relationships between aquatic plant communities and water quality, we will advance scientific understanding and help identify priorities for protection, conservation, and management of Minnesota lakes. This is a critical area of research as our lakes face multiple stressors and—in many cases—are changing before our eyes. Understanding how these changes could influence water quality is critical for supporting science-based resource management. The impact of this project will be amplified by leveraging ongoing LCCMR-supported work by state agencies (MnDNR, MPCA) and making new data resources available for other users (vegetation and water quality maps, plant trait data).

### C. Timeline Requirements

Three years are needed to complete the project. In Year 1, we will synthesize and analyze existing data from the Sentinel Lakes program and conduct preliminary fieldwork. In Years 2 and 3 we will perform extensive field and lab work to quantify plant functional traits and biogeochemical processing rates in multiple lakes. During the remainder of Year 3 we will analyze data and translate findings into predicting and helping to protect water quality services provided by shallow lakes across the state.

# 2018 Detailed Project Budget

**Project Title:** Benefits of lake plant diversity for water quality

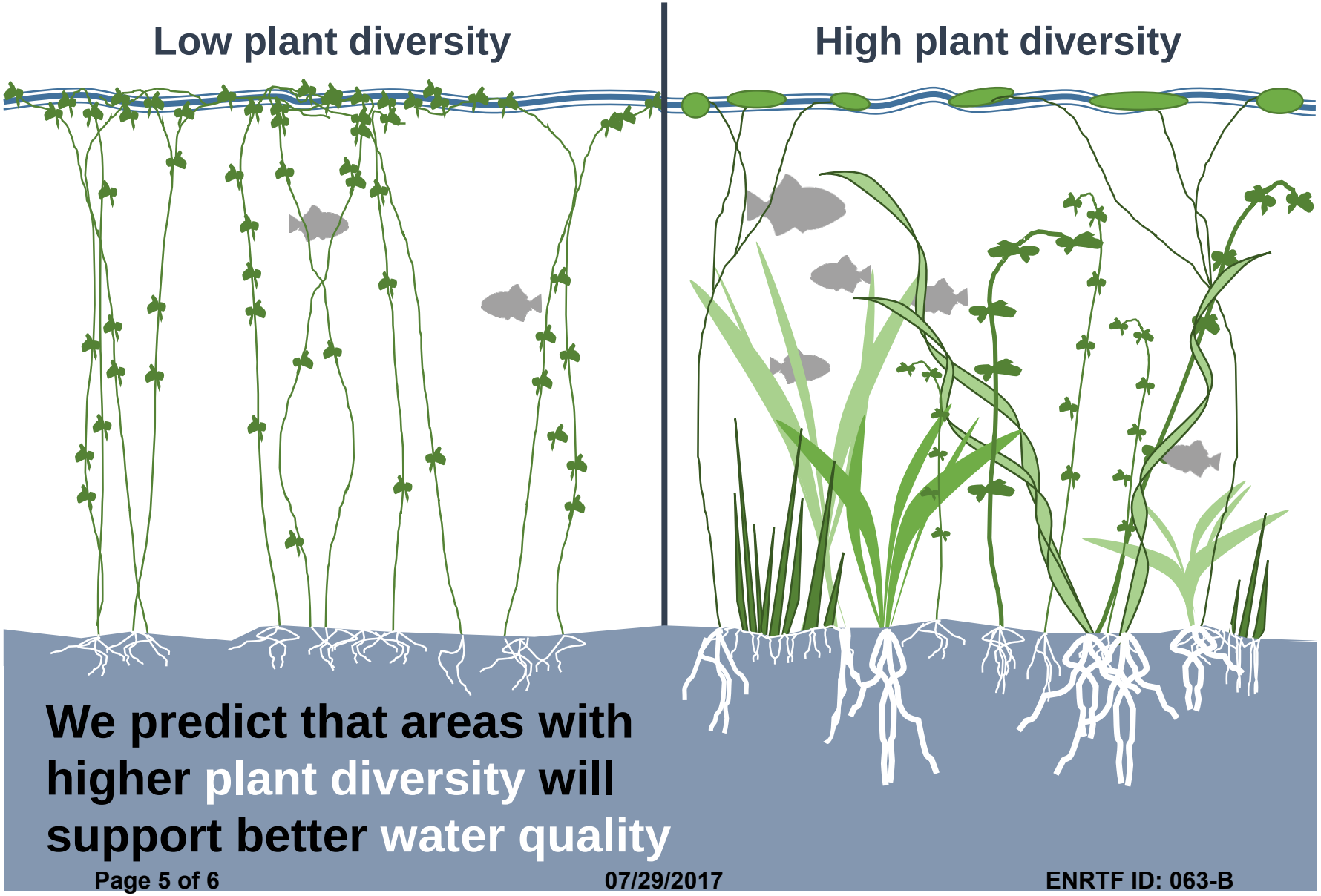
**IV. TOTAL ENRTF REQUEST BUDGET 3 years**

| BUDGET ITEM | AMOUNT |
|---|---|
| **Personnel:** | |
| Faculty: Summer salary plus fringe benefits (33.7% fringe rate, 75% salary, 25% benefits) for Assistant Professor Larkin (2 weeks each in 2018-2020, 3.8% FTE) and Professor Finlay (2 weeks each in 2019-2020, 3.8% FTE). 2 people. | $ 34,991 |
| Postdoc: Salary plus fringe benefits (20.1% fringe rate, 83% salary, 17% benefits) for postdoc Muthukrishnan (0.5 FTE per year 2018-2020) and additional postdoc TBD (1 FTE per year 2018-2019). 2 people | $ 208,791 |
| Laboratory staff: Salary plus fringe benefits (27.2% fringe rate, 79% salary, 21% benefits) for a staff member who will perform laboratory work on water and sediment chemistry and processes (33% FTE in 2018-2019 and 26% FTE in 2020). 1 person. | $ 53,424 |
| Graduate students: Salary plus tuition and fringe for a graduate research assistant who will perform field/lab work and analyses of aquatic plant communities and plant traits, fall 2017 - fall 2019. 54% of dollars are salary, 36% are tuition and benefits. 50% FTE, 1 person. | $ 100,933 |
| Undergraduate research assistants: Hourly wages for part-time undergraduate research assistants who will help with field and lab work. $12 per hour, 925 hours per year for two years. 100% of dollars are salary. 45% FTE total, 3 people (each 15% FTE). | $ 22,200 |
| **Equipment/Tools/Supplies:** Non-capital equipment, sampling devices, measuring tools, consumables, reagents, containers, identification guides, office supplies, computer software and peripherals, and other materials need to perform field and laboratory sampling of aquatic plant communities, plant functional traits, water and sediment chemical and physical properties, and chemical and nutrient transformations. | $ 23,500 |
| **Travel:** Vehicle rental/gas/mileage, fuel for boat, and lodging and food costs for research travel throughout Minnesota. These expenses are necessary for project investigators, staff, and students to be able to make multiple trips each year from the U of M's St. Paul campus to shallow lake field sites throughout Minnesota. Travel expenses will comply with U of M travel policies. | $ 19,274 |
| **TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =** | $ 463,113 |

**V. OTHER FUNDS**

| SOURCE OF FUNDS | AMOUNT | Status |
|---|---|---|
| **Other Non-State $ To Be Applied To Project During Project Period:** | NA | NA |
| **Other State $ To Be Applied To Project During Project Period:** | NA | NA |
| **In-kind Services To Be Applied To Project During Project Period:** In kind support (20hrs/year for 2 years) from the Minnesota Department of Natural Resources Sentinel Lakes Program. | $ 4,115 | Secured |
| **Past and Current ENRTF Appropriation:** | NA | NA |
| **Other Funding History:** | NA | NA |

# *Benefits of lake plant diversity for water quality*




**We predict that areas with higher plant diversity will support better water quality**

**Project Manager Qualifications**

Daniel J. Larkin
Assistant Professor & Extension Specialist
Dept. of Fisheries, Wildlife, and Conservation Biology
University of Minnesota–Twin Cities
http://larkinlab.cfans.umn.edu/

B.A., Biology, with Honors, 1998. University of California, Santa Cruz
Ph.D., Botany, 2006. University of Wisconsin–Madison

Dr. Larkin will be responsible for coordinating the project, mentoring a graduate research assistant and postdoc, and leading activities focused on aquatic plant communities and plant traits. Dr. Larkin's research focuses on the role of plants in delivering key ecological functions and how we can better protect and conserve plant communities through ecological restoration, invasive species management, and other applications. His study systems include terrestrial, wetland, and aquatic habitats of the upper Midwest. Since joining U of M in 2015, he is particularly focused on ecology, management, and restoration of plants in Minnesota lakes and wetlands.

Examples of recent publications relevant to the proposed research include the following (mentored graduate or undergraduate students underlined):

Hartzog, P. E., M. Sladek, J. J. Kelly, and **D. J. Larkin**. 2017. Bottle effects alter taxonomic composition of wetland soil bacterial communities during the denitrification enzyme activity assay. Soil Biology & Biochemistry DOI 10.1016/j.soilbio.2017.03.006.

**Larkin, D. J.**, S. K. Jacobi, A. L. Hipp, and A. T. Kramer. 2016. Keeping all the PIECES: phylogenetically informed *ex situ* conservation of endangered species. PLoS ONE 11: e0156973.

**Larkin, D. J.**, A. L. Hipp, J. Kattge, W. Prescott, R. K. Tonietto, S. K. Jacobi, and M. L. Bowles. 2015. Phylogenetic measures of plant communities show long-term change and impacts of fire management in tallgrass prairie remnants. Journal of Applied Ecology 52:1638–1648.

Glisson, W. J., R. S. Brady, A. T. Paulios, S. K. Jacobi, and **D. J. Larkin**. 2015. Sensitivity of secretive marsh birds to vegetation condition in natural and restored wetlands in Wisconsin. Journal of Wildlife Management. 79:1101–1116.

**Larkin, D. J.**, J. F. Steffen, R. M. Gentile, and C. R. Zirbel. 2014. Ecosystem changes following restoration of a buckthorn-invaded woodland. Restoration Ecology 22:89–97.

**Organization Description**

The University of Minnesota is one of the largest, most comprehensive, and most productive public research universities in the country (https://twin-cities.umn.edu/about-us). This proposal brings together researchers from U of M's College of Food, Agricultural and Natural Resource Sciences (https://www.cfans.umn.edu/) and College of Biological Sciences (https://cbs.umn.edu/). The facilities of the project team and their students and staff are equipped with the space, equipment, and resources they need to carry out the proposed research.