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

Project Title: **ENRTF ID:**   077-B

Establishing Priorities for Restoring Minnesota's Nutrient-Impaired Lakes

Category: B. Water Resources

Total Project Budget: $ 375,000

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

Summary:

Over 350 Minnesota lakes are impaired with excess nutrients and noxious algae. This project will target restoration efforts toward the most imperiled and recoverable lakes to maximize resources and success.

Name: Mark   Edlund

Sponsoring Organization: Science Museum of Minnesota

Address: St. Croix Watershed Research Station

   Marine on St. Croix   MN   55047

Telephone Number: (651) 433-5953

Email medlund@smm.org

Web Address   https://www.smm.org/scwrs

Location

Region: Central, Metro

County Name: Anoka, Becker, Benton, Carver, Chisago, Clearwater, Dakota, Douglas, Grant, Hennepin, Isanti, Kanabec, Kandiyohi, Le Sueur, Mahnomen, McLeod, Mille Lacs, Morrison, Otter Tail, Pine, Pope, Ramsey, Rice, Scott, Sherburne, Stearns, Todd, Wadena, Washington,

City / Township:

Alternate Text for Visual:

aerial photo and lake types

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

PROJECT TITLE: Establishing priorities for restoring Minnesota's nutrient-impaired lakes

I. PROJECT STATEMENT

The water quality of more than 350 Minnesota lakes is currently impaired by excess nutrients (phosphorus) and associated degradation from abundant and noxious algae. Cleaning up all of these lakes presents an almost overwhelming task. Under the Clean Water Act (1972) the State is required to develop a plan to assess and restore impaired water bodies. However, given the magnitude of the problem and finite available resources, where should lake and watershed managers tasked with restoring impaired water bodies begin? How can we prioritize impaired lakes for restoration and what criteria should be used to make such decisions?

This project will provide two critical pieces of information needed to guide restoration efforts on a lake-by-lake basis: the urgency for protection from irreversible harm (**ecological risk**) and the likelihood that a lake can be restored (**recoverability**). High priority lakes for restoration are (1) those at an ecological 'tipping point' where continued nutrient stress could lead to a perpetually eutrophic state, and (2) lakes where restoration efforts will likely produce measurable and lasting improvements in water quality within a reasonable period of time. These criteria will be assessed using dated sediment cores, which are a chronological record of nutrient inputs and biological response in each lake. *The St. Croix Watershed Research Station is an international leader in this type of research.*

1. **Ecological risk** will be determined by measuring the amount of biological change that each impaired lake has experienced based on shifts in fossil algal (diatom) communities preserved in its sediment record. The biological history of a lake provides the critical bench-mark for understanding the present state of a lake and its future trajectory. Lakes with marked and recent biological shifts are high-risk protection targets.

2. **Recoverability** will be determined from the ability of a lake to bury excess phosphorus (P) in its sediments and keep it from recycling back into the water column. Sediment P burial is the primary way lakes rid themselves of phosphorus. Lakes that are good at it can recovery quickly once watershed P inputs are reduced and should be key restoration targets.

Ultimately the goal of restoration activities is the recovery of ecological health and beneficial uses of impaired water bodies. This study would aid that process using information from lake sediments to better target restoration activities toward the most imperiled <u>and</u> most recoverable lakes with the aim of maximizing implementation resources and success.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Collect sediment cores from 50 lakes to determine risk and restorability   **Budget: $121,100**

Fifty study sites will be selected from among the more than 200 impaired lakes in the North Central Hardwood Forest (NCHF) ecoregion of central Minnesota. The NCHF is a lake-rich region that contains lakes with forested, urban, and agricultural watersheds. Study lakes, chosen in consultation with MPCA staff, will cover two environmental gradients important to lake response and recovery: lake depth (deep vs. shallow) and watershed size (large vs. small). Cores will be dated with lead-210 methods and magnetic susceptibility (MS) to identify the timing of disturbances in each lake's watershed.

Outcome	Completion Date
1. Select 50 study lakes and collect sediment cores	*June 2019*
2. Date cores by lead-210 and paleo-magnetic methods	*Dec 2019*

Activity 2: Determine biological change and ecological risk for 50 impaired lakes   **Budget: $121,060**

Sediment cores will be analyzed for fossil diatom remains to reconstruct past changes in lake biology. Diatoms are often the most abundant algae in a lake, are well-preserved in sediments, and are reliable indicators of changes in lake health. Three key periods of lake history will be analyzed for diatoms: pre-

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settlement (1800-1850), near-recent (1970-1980), and modern (2008-2018). Based on these analyses, we will determine the **ecological risk** facing each lake – is the lake at a tipping point, has its biology changed, and by how much and when?

Outcome	Completion Date
1. Analyze fossil diatoms in sediment cores	*June 2020*
2. Complete statistical analysis of diatom community change	*Dec 2020*

Activity 3: Determine recoverability of 50 impaired Minnesota lakes   **Budget: $51,480**

How quickly a lake responds to restoration efforts is best determined by its ability to process and get rid of excess nutrients. We will determine recoverability for 50 lakes by quantifying the rate at which each lake buries phosphorus (P) in its sediment – the primary way lakes rid themselves of excess P. Lakes that most effectively bury P and keep it from recycling back into the lake to produce noxious algae blooms are most likely to respond quickly to restoration efforts.

Outcome	Completion Date
1. Measure sediment P concentrations and determine whole-lake P burial rates	*June 2020*
2. Construct phosphorus budgets for study lakes	*Dec 2020*

Activity 4: Rank risk and restorability of lakes and guide restoration efforts   **Budget: $81,360**

The State has focused extensive effort on lake protection – successfully keeping high quality lakes from crossing the threshold of impairment. But what to do with lakes that are already impaired? The State (MPCA) now welcomes an objective and sound approach to identify which impaired lakes are the best targets for restoration resources and efforts. We will categorize each lake by its ecological risk and recoverability and use this information to help guide agencies and lake managers in most effectively implementing restoration strategies and dollars. This innovative approach will be summarized in a final report and presented to agency personnel and stakeholders at workshops in the Twin Cities and at regional venues. The project will be featured in posts on the Research Station's website and blog, which reach a wide public and professional audience.

Outcome	Completion Date
1. Final report with objective targeting of impaired lakes for restoration success	*June 2021*
2. Workshops: Twin Cities and regional	*June 2021*
3. Public dissemination: "Field Notes"	*March 2021*

III. PROJECT STRATEGY
A. Project Team/Partners
This project will be carried out by the PhD-level scientific staff of the St. Croix Watershed Research Station. Mark Edlund and Adam Heathcote will lead site selection and core collection. Daniel Engstrom will be responsible for core dating and phosphorus analysis, Edlund will analyze diatoms, and Heathcote will carry out the statistical analyses; all hands will help with data synthesis and presentation.

B. Project Impact and Long-Term Strategy
This project will provide an objective ranking of nutrient-impaired lakes based on ecological risk and recoverability for a more effective allocation of restoration activities and dollars. Results will fully leverage State TMDL efforts and supplement other selection criteria including importance to user groups, level of local cooperation, and feasibility of key restoration actions. Future extension of this approach to other impaired lakes and ecoregions would be beneficial.

C. Timeline Requirements
The project will require three years to complete. Site selection and coring will continue through year-1, with diatom and phosphorus analyses in year-2. Data synthesis will begin in year-2 and finish in the first half of year-3. Reporting and dissemination will be our focus in the final half of year-3.

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2018 Detailed Project Budget

Project Title: Establishing priorities for restoring Minnesota's nutrient-impaired lakes

IV. TOTAL ENRTF REQUEST BUDGET 3 years

| BUDGET ITEM	AMOUNT
Personnel: Edlund, Project management & diatom analysis, 33% FTE 3 Years $111,300 Heathcote, Lake coring, statistical data analysis 33% FTE 3 Years $92,400 Engstrom, Core dating, P budgets, 25% FTE 3 Years $86,640 Technician, Lake coring, 23% FTE 1 Year $7,200 (Fringe Benefits for senior personnel = 39%; Seasonal technician = 12%)	$ 297,540
Professional/Technical/Service Contracts: Greg Seitz: editor, writer, and media coordinator for *Field Notes* , the Research Station's website and blog	$ 6,000

Equipment/Tools/Supplies:
  Field Supplies
    Polycarbonate core tubes: 50 @ $80 = $4,000
    Sample jars & vials: $300
    Coring pistons: 5 @ $100 = $500
    Expendables (end caps, wipes, bags, ice, labels, etc.) $200
	$ 5,000

Travel: Field travel to 50 impaired lakes for sediment coring Hotel: 2 persons for 20 nights @ $76.50 = $3,060 Per diem: 2 persons for 25 days @ $51 = $2,550 Mileage & gas: 5,000 miles @ $0.67 = $3,350	$ 8,960

Additional Budget Items: Analytical Services at SCWRS:
  Core subsampling: 50 sediment cores @ $50 = $2,500
  Magnetic core scans: 50 sediment cores @ $100 = $5,000
  Loss-on-Ignition: 250 sediment samples @ $10 = $2,500
  Lead-210 dating: 200 sediment samples @ $150 = $30,000
  Sediment P: 100 sediment samples @ $150 = $15,000
  Diatom sample prep: 250 sediment samples @ $10 = $2,500
	$ 57,500

TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 375,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
"Other Non-State $ To Be Applied To Project During Project Period: Science Museum of Minnesota: Unrecovered support services (lab & equipment maintenance, infrastructure, support staff, project administration) 40.83% of direct costs	$ 153,112	Pending
Other State $ To Be Applied To Project During Project Period: None	$ -	
In-kind Services To Be Applied To Project During Project Period: None	$ -	
Past and Current ENRTF Appropriation: M.L. 2015, Chap 76, Sect 2, Subd 10 "Tracking and preventing harmful algal blooms ($93,000) M.L. 2016, Chap 186, Sect 2, Subd 04A "Tracking and preventing harmful algal blooms ($500,000) ($474,483 unspent as of Jan 1, 2017; $460,784 to be spent by July 1, 2018)	$ 593,000	Secured
Other Funding History: None	$ -	

Over 350 Minnesota lakes are impaired with excess nutrients and noxious algae
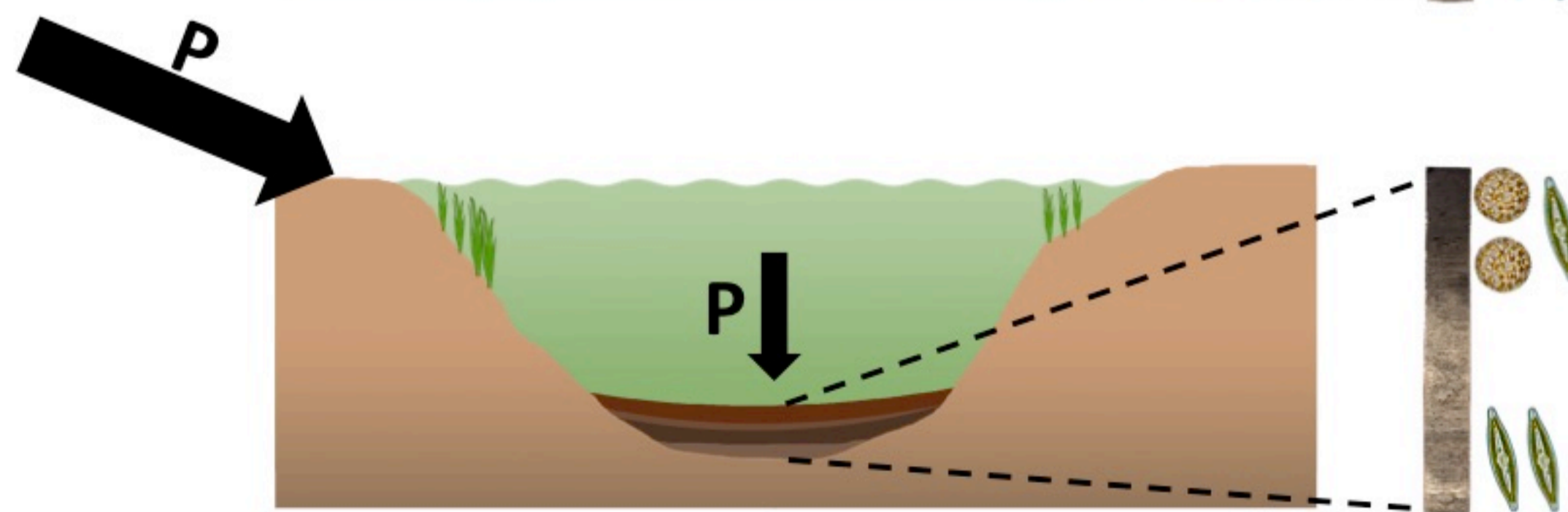

NCHF Ecoregion
(study area)
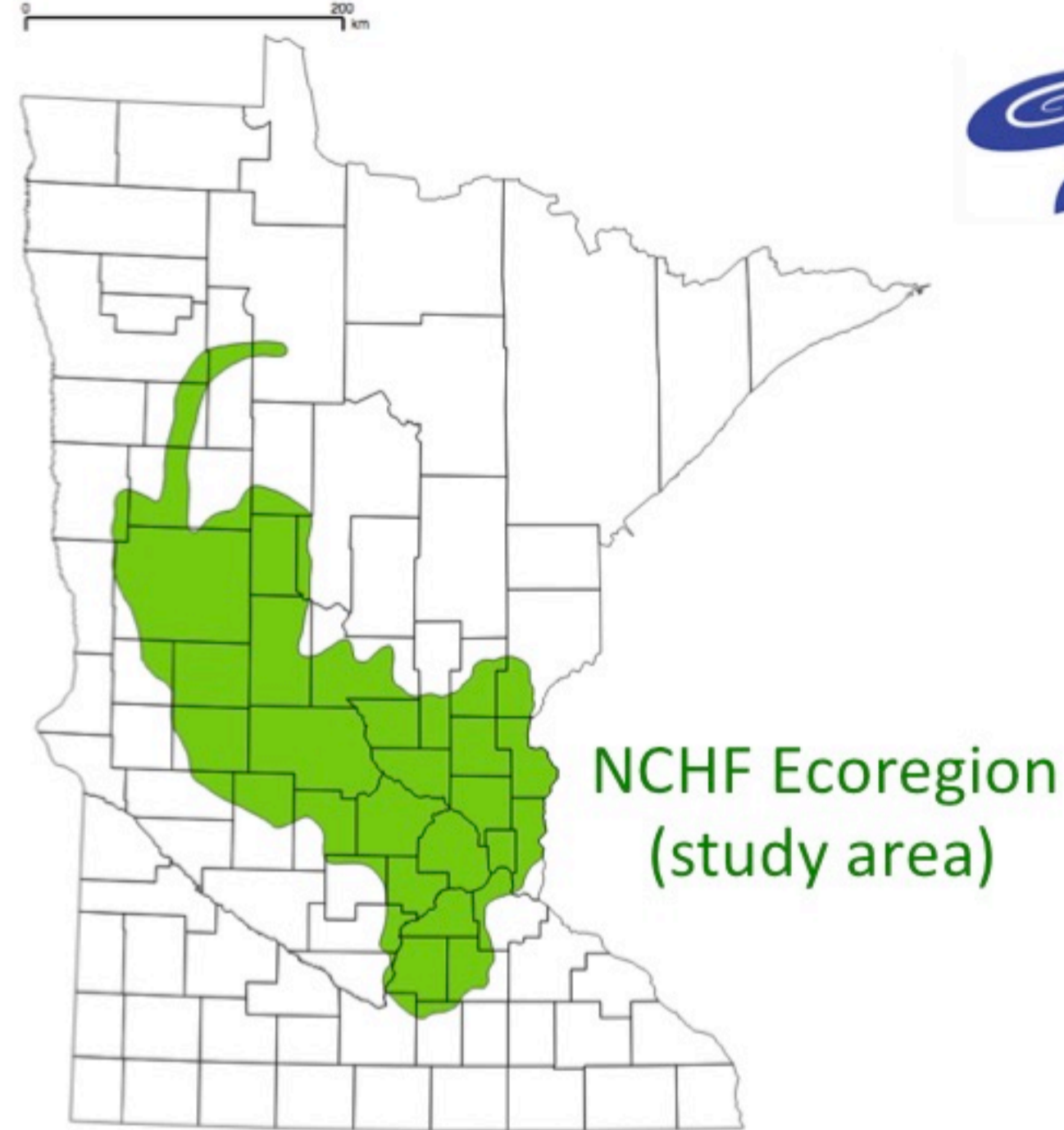
- We *have* to fix them, but how do we decide where to start?

- We will measure ecological risk and likelihood of recovery for 50 nutrient-impaired Minnesota lakes
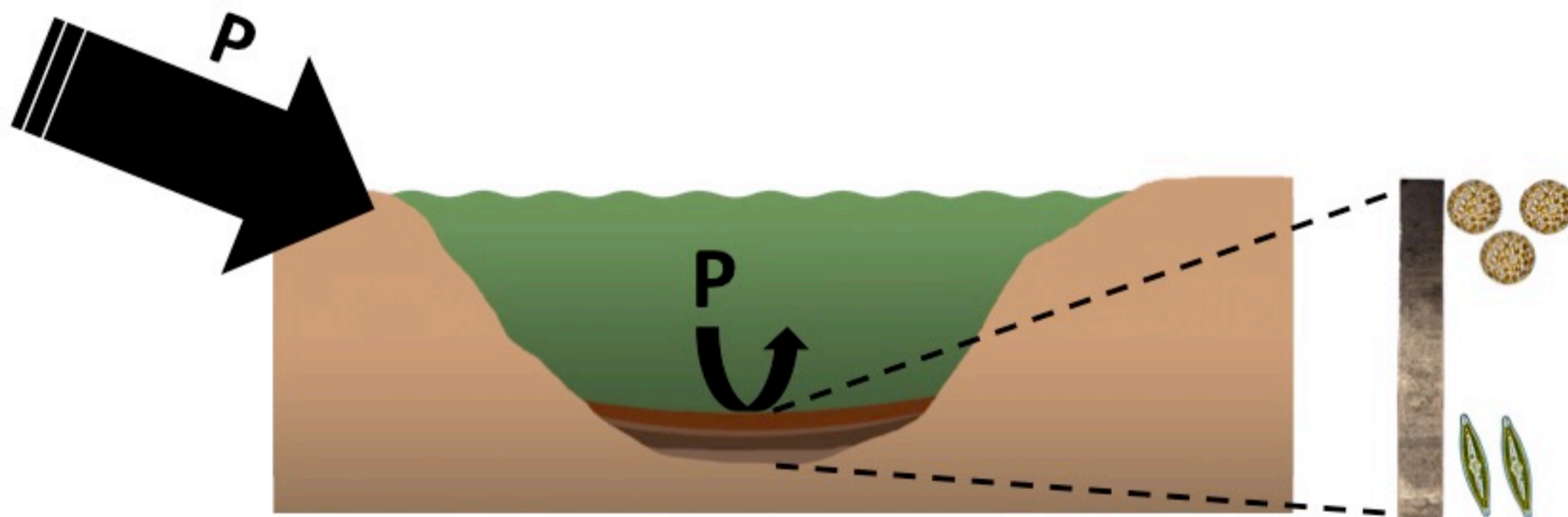
Lake 1
- Large changes in biology
- Excessive P inputs and recycling from sediments

Lake 2
- Lake biology near tipping point
- P inputs balanced by P burial

Start here!

Restoration should target the most imperiled <u>and</u> most recoverable lakes to maximize resources and success

Project Manager Qualifications

MARK B. EDLUND

1. Education

Ph.D. 1998   University of Michigan, (Natural Resources & Environment)
M.S. 1992   University of Michigan, (Natural Resources)
B.A. 1987   University of Minnesota (Biochemistry)

2. Positions

2007-   Sr. Scientist, St. Croix Watershed Research Station, Science Museum of Minn.
2002-07   Assoc. Scientist, St. Croix Watershed Research Station, Science Museum of Minn.
2000-02   Ass't. Scientist, St. Croix Watershed Research Station, Science Museum of Minn.
2004-   Adjunct Professor, Water Resources Science, University of Minnesota
1987-99   Research Ass't I, Center for Great Lakes and Aquatic Sciences, University of Michigan

3. Research Expertise

Aquatic biology, limnology, paleolimnology, and phycology; environmental drivers of ecological change; use of lake sediment records to understand short- and long-term environmental change
Current Research:
- Biomonitoring of lakes in Great Lakes region National Parks
- Paleolimnology of Upper and Lower Red Lake
- Understanding and predicting harmful algal blooms (HABs)

4. Recent Publications (of more than 90)

Reavie, E.D., **Edlund, M.B.**, Andresen, N.A., Engstrom, D.R., Leavitt, P.R., Schottler, S., Cai, M. 2017. Paleolimnology of the Lake of the Woods southern basin: Continued water quality degradation despite lower nutrient influx. *Lake and Reservoir Management* DOI: 10.1080/10402381.2017.1312648

Hobbs, W.O., **Edlund, M.B.**, Umbanhowar, C.E. Jr., Camill, P. Lynch, J. Geiss, C. and Stefanova, V. 2017. Holocene evolution of lakes in the forest-tundra biome of northern Manitoba, Canada. *Quaternary Science Reviews* 159:116-138.

VanderMeulen, D.D., Lafrancois, B.M., **Edlund, M.B.**, Ramstack Hobbs, J.M. and Damstra, R. 2016. Pairing modern and paleolimnological approaches to evaluate the nutrient status of lakes in Upper Midwest National Parks. *Journal of the American Water Resources Association (JAWRA)*: 1-19.

Ramstack Hobbs, J., Hobbs, W.O., **Edlund, M.B.**, Zimmer, K.D., Theissen, K.M., Hoidal, N., Domine, L.M., Hanson, M.A., Herwig, B.R., Cotner, J.B. 2016. The legacy of large regime shifts in shallow lakes. *Ecological Applications* doi:10.1002/eap.1382

Organization Description

The Science Museum of Minnesota (SMM) is a private, non-profit 501(c)3 institution dedicated to encouraging public understanding of science through research and education. The St. Croix Watershed Research Station the environmental research center of the SMM with the mission to foster, through research and outreach, "a better understanding of the ecological systems of the St. Croix River basin and watersheds worldwide." The SCWRS supports an active year-round program in environmental research and graduate-student training, guided by a dedicated in-house research staff with direct ties to area universities and colleges. It collaborates closely with federal, state, and local agencies with responsibility for managing the St. Croix and upper Mississippi rivers and is a full partner with the National Park Service for resource management in parks of the western Great Lakes region. Its research has played a central role in setting management policy for the St. Croix and Mississippi rivers, for establishing water-quality standards for Minnesota lakes and for developing long-term monitoring plans for the National Park Service.