Environment and Natural Resources Trust Fund
2014 Request for Proposals (RFP)

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Project Title:

Using CO2 and Drawdown to Manage Shallow Lakes

Category: B. Water Resources

Total Project Budget: $ 452,000

Proposed Project Time Period for the Funding Requested: 3 Years, July 2014 - June 2017

Other Non-State Funds: $ 0

Summary:

We will develop a new method for controlling rough fish and invasive species using dry ice in winter and evaluate best practices for nitrogen and phosphorus removal from shallow lakes.

Name: James Cotner

Sponsoring Organization: U of MN

Address: 100 Ecology/1987 Upper Buford Cir
St. Paul MN 55108

Telephone Number: (612) 625-1706

Email cotne002@umn.edu/awards@umn.edu

Web Address www.tc.umn/~cotne002

Location

Region: Statewide

County Name: Statewide

City / Township:

MP: 0613-2-152-proposa
Budget: 0613-2-152-bud
Qual: 0613-2-152-qualifi
Map: 0613-2-152-map-Fi
Resolution:
List:

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

Environment and Natural Resources Trust Fund (ENRTF)
2014 Main Proposal
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PROJECT TITLE: Using CO_2 and drawdown to manage shallow lakes

I. PROJECT STATEMENT

Why this work needs to be done: Lake water quality and waterfowl habitat is increasingly threatened by eutrophication, invasive species and changing climates. Typically, shallow lake managers desire to shift turbid, algal-dominated systems toward a clear, aquatic plant-dominated state and this can be done by lowering the lake level or killing rough fish such as carp and bullheads that feed on the bottom (see figures). The Minnesota Department of Natural Resources (MN-DNR) spends $1.5-2 million each year to monitor, maintain and restore shallow lake ecosystems but new tools and strategies need to be developed to a) increase the efficacy of current practices such as lake level drawdown, b) to provide new, more cost-effective treatments for inducing and maintaining the clear water state, and c) allow for removal of rough fish and invasive species without using expensive and highly regulated compounds such as rotenone.

The **Goals** of this project are to: **1. Develop a new method for controlling rough fish and invasive species in shallow lakes using under-ice additions of carbon dioxide. 2. Evaluate the effectiveness of lake management practices (carbon dioxide and lake level drawdown) for removing nutrients (nitrogen and phosphorus) from the landscape.** Overall, we hypothesize that clear lakes are better able to remove phosphorus by burying it in the lake sediments, and also that clear lakes will remove nitrogen from surface waters by releasing it into the atmosphere as harmless, N_2 gas.

How we will achieve this: We will determine if carbon dioxide can be released into lakes to effectively kill rough and invasive species. We will conduct laboratory experiments to determine what concentrations of CO_2 are toxic to fish. In addition, we will add CO_2 to three lakes to determine if we can induce toxicity in the field and evaluate the effects of CO_2 on non-target species such as invertebrates and plants. Finally, we will determine if lakes that have been restored via management from the turbid to clear state, either via carbon dioxide additions or lake level drawdown, can remove phosphorus and release nitrogen back into the atmosphere more effectively than do unmanaged, algal-dominated lakes.

II. DESCRIPTION OF PROJECT ACTIVITIES

Overview. Our strategy is to treat and monitor three lakes with CO_2 additions and 13 lakes that have been treated via lake level drawdown. The lakes will be monitored for nutrient concentrations and dynamics before and after treatment. Nearby, untreated lakes will also be monitored as reference sites. Carbon dioxide has been used as a fish toxicant in laboratory settings in the past and it will need to be evaluated in a field context. Carbon dioxide will be added to lakes either in solid (dry ice) or liquid (LCO_2) form under the ice. This past winter, with support from MN-DNR, we treated a small, 1-acre pond with dry ice as a proof of concept with great success, increasing dissolved CO_2 concentrations by 5 times the initial concentration. We were not funded sufficiently to determine how effective the CO_2 was in killing fish in the lake but casual observations suggested that many fish died. Monitoring fish survival in the field is an important aspect of the work proposed here.

Activity 1: *Develop a new method for controlling rough fish and invasive species in shallow lakes using wintertime additions of carbon dioxide.*	**Budget: $216,000 (ca. $75,000 per lake)**

We will examine the effects of CO_2 additions on pH, dissolved CO_2, dissolved O_2 and other water quality parameters and the survival of fathead minnows and black bullheads in the laboratory. We chose these target species because of their potential to shift lakes from the clear to the turbid state, the ubiquity of these species in shallow lakes, and also due to their tolerance of extreme conditions in natural ecosystems. We will implement CO_2 treatments to three lakes and examine the effects on water chemistry and aquatic foodwebs before and after treatment.

Outcome: Develop a new method for controlling rough fish and invasive species in shallow lakes using under ice additions of carbon dioxide	Completion Date
1. Assess the toxicity of CO_2 to fathead minnows and bullheads in the laboratory.	1 Jul 2015
2. Use results from these two species to advise field CO_2 delivery levels.	1 Jul 2016
3. Assess efficacy of CO_2 as fish toxicant and effects on non-target species.	1 Jul 2017
4. Assess efficacy of CO_2 in inducing shifts from turbid to clear water state.	1 Jul 2017

Activity 2: *Evaluate the effectiveness of lake management practices for inducing nutrient removal (nitrogen and phosphorus) from the landscape.* **Budget: $236,000 (ca. $18,000 per lake)**

Lakes play an important role in regulating nutrient flow on landscapes by collecting nitrogen and phosphorus in the sediments and releasing gases (N_2) back into the atmosphere. Removing N_2 (and decreasing nitrates in water supplies) has become particularly important with increased fertilizer use on croplands in the past 60 years. In this portion of the project, we will assess nutrient removal processes in restored lakes and make management recommendations for future restoration priorities based on this assessment. The surface sediments of thirteen post-drawdown lakes and the three CO_2-treated lakes, covering a wide-range of time and degree of successful restoration will be sampled and analyzed. These findings will provide the management community with useable tools and the necessary background knowledge to anticipate the future success of shallow lake restoration.

Outcome: Evaluate the effectiveness of lake management practices for inducing nutrient removal (nitrogen and phosphorus) from the landscape	Completion Date
1. Nutrient binding capacity of surface sediments in post-CO_2 and post-drawdown lakes.	1 Jul 2016
2. Validate GIS-based tools for predicting success of CO_2 and lake drawdown.	1 Jul 2017

III. PROJECT STRATEGY

A. Project Team/Partners

This project will be carried out under the supervision of Dr. James Cotner (University of Minnesota-Twin Cities), with collaborators, Dr. Kyle Zimmer (University of St. Thomas), Dr. William Hobbs (St. Croix Watershed Research Station, Science Museum of Minnesota), and Dr. Dalma Martinovic (University of St. Thomas), and with collaborators from MN-DNR (Nicole Hansel-Welch and Dr. Mark Hanson).

B. Timeline Requirements: 3 years

This project will require three years to complete (initial, during and post-treatment assessments). Sampling will begin the fall of 2014 and will be completed in the summer of 2017. Final reports will be issued July 2017 and project scientists will begin disseminating results.

C. Long-Term Strategy and Future Funding Needs interim

This project is a priority for the MN DNR Shallow Lakes Program and staff scientists will directly implement the findings. This project will fill a significant knowledge gap in assessing management techniques and their effects nutrient cycling, enabling the MN-DNR to improve the health and value of Minnesota's shallow lakes and wetlands.

2014 Detailed Project Budget

Project Title: Using CO2 and drawndown to manage shallow lakes

IV. TOTAL ENRTF REQUEST BUDGET - 3 years

BUDGET ITEM	AMOUNT
Personnel: James Cotner, PI, one month of summer salary per year. 75% salary, 25% fringe benefits. Dr. James Cotner will have overall responsibility for the project, and supervise a technician, undergraduate students and graduate student (100% time, summers only). Cotner has asked for 1 month summer support for all three years for these efforts.	$ 45,000
Personnel: One graduate student each summer. 81% salary, 19% fringe benefits. The graduate student will assist with field work, data acquisition.	$ 28,000
Personnel: One undergraduate student each summer. 93% salary, 7% fringe benefits. The undergraduates will assist with field work, data acquisition.	$ 11,000
Personnel: One Lab Technician for 3 months each year. 73% salary, 27% fringe benefits. We request three months support for a technician who will prepare field equipment and sample containers, analyze samples, order supplies and facilitate database management.	$ 52,000
Contracts: University of St. Thomas: A portion of the work on this project will be done by Dr. Kyle Zimmer and Dr. Dalma Martinovic at the University of St. Thomas. Dr. Martinovic will conduct experiments on the effects of CO2 on fish mortality and Dr. Zimmer will collect field samples for invertebrate and fish community analyses. They will hire 3-5 undergraduates to assist with field work and experiments.	$ 176,000
Contracts: St. Croix Watershed Research Station: A portion of the work on this project will be done by Dr. William Hobbs at the St. Croix Watershed Research Station. Dr. Hobbs will collect sediments cores, date them and make geochemical measurements to characterize nutrient removal in the lakes.	$ 82,000
Equipment/Tools/Supplies: Laboratory supplies include analytical standards, reagents, solvents, disposable labware, filters, and maintenance costs of large equipment such as spectrophotometers, and fluorometer, microplate readers, etc. We have also requested funds for three carbon dioxide sensors that will be deployed under the ice, before, during and after dry ice application.	$ 44,000
Acquisition (Fee Title or Permanent Easements):	$ -
Travel: We have requested funds for travel associated with the field work on this project for the P.I., graduate student and/or technician or undergraduates. These annual expenses include vehicle rental and mileage ($2800), lodging ($900) and per diem ($800).	$ 14,000
Additional Budget Items:	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 452,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ Being Applied to Project During Project Period:	$ -	
Other State $ Being Applied to Project During Project Period:	$ -	
In-kind Services During Project Period:	$ -	
Remaining $ from Current ENRTF Appropriation (if applicable):	$ -	
Funding History:	$ -	

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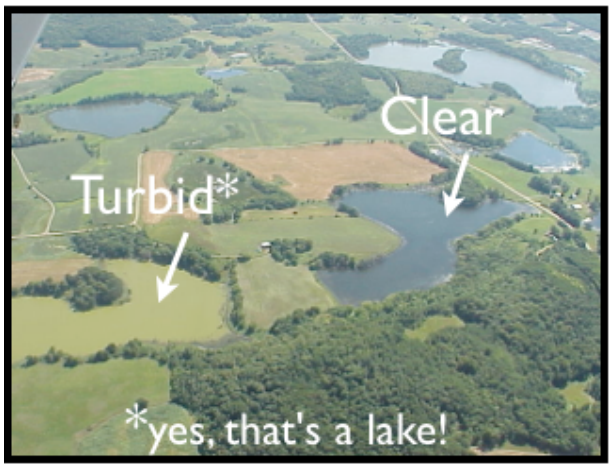
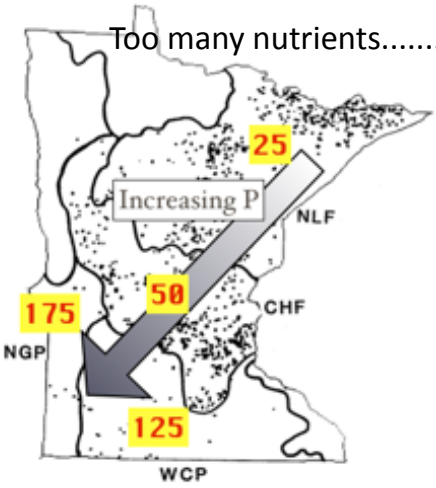
The Problem:



The Causes:

Too many nutrients.....



... and too many rough fish*

The Solutions:

Adding dry ice to Carlos Avery pond Feb 2013

Lake Level drawdown

Project Manager Qualifications and Organization Description

Project Manager: Dr. James Cotner, Professor, Department of Ecology, Evolution and Behavior, 1987 Upper Buford Circle, St. Paul 55108, 612-625-1706; cotne002@umn.edu

Education:

Ph.D., University of Michigan, Ann Arbor, 1990, Biology; (Major professor-Dr. Robert Wetzel-deceased).
M.Sc., Kent State University, Kent, Ohio, 1984, Biology; (Major professor-Dr. Robert Heath).
B.A., Wittenberg University, Springfield, Ohio, 1981, Biology.

Organization description: University of Minnesota, Twin Cities Campus; Education and research facility serving the entire state of Minnesota.

Project responsibilities: Professor Cotner will oversee all research activities. He will supervise PIs from the University of St. Thomas and St. Croix Watershed Research Station, undergraduates, and a technician. He will see that field samples are analyzed, interpreted, and used to make management recommendations to the MN DNR and also that all reports are filled out on time.

Research Interest: Microbial ecology and biogeochemistry of wetlands and large lakes; human influences on water quality in wetlands and lakes.

Relevant Publications:

Theissen, KM, WO Hobbs, JM Ramstack Hobbs, KD Zimmer, LM Domine, JB Cotner, and S Sugita. 2012. The Altered Ecology of Lake Christina: A Record of Regime Shifts, Land-use Change, and Management From a Temperate Shallow Lake. The Science of the Total Environment 433: doi:10.1016/j.scitotenv.2012.06.068.

Cotner, JB, and EK Hall. "Comment on "A Bacterium That Can Grow by Using Arsenic Instead of Phosphorus"." Science (New York, N.Y.) 332, no. 6034 (2011): doi:10.1126/science.1201943.

Kolka, R. K.; Mitchell, C.P.J.; Jeremiason, J. D.; Hines, N. A.; Grigal, D. F.; Engstrom, D. R.; Coleman-Wasik, J.K.; Nater, E. A.; Swain, E.B.; Monson, B. A.; Fleck, J. A.; Johnson, B.; Almendinger, J. E.; Branfireun, B. A.; Brezonik, P.L.; Cotner, J.B. 2011. Mercury cycling in peatland watersheds. In “Kolka, R.K.; Sebestyen, S. .; Verry, E. S.; Brooks, K.N., eds. Peatland biogeochemistry and watershed hydrology at the Marcell Experimental Forest. Boca Raton, FL: CRC Press: 349-370.

Cotner J.B., E.K. Hall, T. Scott and M. Heldal. 2010. Freshwater bacteria are stoichiometrically flexible with a nutrient composition similar to seston. Front. Microbio. doi: 10.3389/fmicb.2010.00132

Cory, R M, K McNeill, J B Cotner, A Amado, J M Purcell, and A G Marshall. 2010. Singlet Oxygen in the Coupled Photochemical and Biochemical Oxidation of Dissolved Organic Matter. Environmental Science & Technology 44: 3683-3689.

Tranvik, L.J., J.A. Downing, J.B. Cotner and others. 2009. Lakes and reservoirs as regulators of carbon cycling and climate. Limnology and Oceanography 54: 2298-2314.

Hall, E.K., A.R. Dzialowski, S. M. Stoxen, and J.B. Cotner. 2009. The effect of temperature on the coupling between phosphorus and growth in natural bacterioplankton communities. Limnology and Oceanography 54: 880-889.

Stets, E.G., and J.B. Cotner. Littoral zones as sources of biodegradable dissolved organic carbon in lakes. Canadian Journal of Fisheries and Aquatic Science 65 :2454-2460.

Cory, R.M., J.B. Cotner and K. McNeill. 2009. Quantifying interactions between singlet oxygen and aquatic fulvic acids. Environmental Science and Technology 43: 718-723.

Hall, E.K., C. Neuhauser and J.B. Cotner. 2008. Toward a mechanistic understanding of how natural bacterial communities respond to changes in temperature in aquatic ecosystems. ISME Journal 2: 471-481.

Stets, E.G. and J.B. Cotner. 2008. The influence of dissolved organic carbon on bacterial phosphorus uptake and bacteria-phytoplankton dynamics in two Minnesota lakes. Limnology and Oceanography 53: 137-147.

Hall, E. K.; Cotner, J. B. 2007. Interactive effect of temperature and resources on carbon cycling by freshwater bacterioplankton communities. Aquatic Microbial Ecology 49: 35-45.