Environment and Natural Resources Trust Fund
2012-2013 Request for Proposals (RFP)

Project Title: **ENRTF ID:** **036-C1**

Controlling Invasive Species by Injecting CO2 in Lakes

Topic Area: C1. Invasive Species - Aquatic

Total Project Budget: $ 432,000

Proposed Project Time Period for the Funding Requested: 3 yrs, July 2013 - June 2016

Other Non-State Funds: $ 0

Summary:

We will examine the feasibility and effectiveness of using liquid carbon dioxide under the ice of shallow lakes as a management technique for removing rough and invasive fish species.

Name: James Cotner

Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

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

PROJECT TITLE: Controlling invasive species by injecting CO_2 in lakes

I. PROJECT STATEMENT

A carpenter cannot build a cabinet without a hammer, nor can a doctor diagnose a patient without a stethoscope. Resource managers need tools to do their jobs, and there is a great need for tools to help them manage shallow lakes and invasive species in these ecosystems. Extensive loss and degradation of shallow lake habitats in Minnesota, and increased invasive species pressure necessitate management strategies that maximize ecosystem services of these basins. Shallow lakes are often managed for the clear-water state instead of the turbid-water analog due to increased habitat suitability for species of fish, amphibians, waterfowl, and aquatic invertebrates. However, some planktivorous and benthivorous fish, many of which are invasive species, can destabilize these lakes and shift them from the clear to turbid state. Thus, managers of these systems often seek to reduce the abundance of undesirable fish by using reverse aeration, stocking piscivores, and application of rotenone. However, reverse aeration has shown little promise, stocking of piscivores has been effective only in a limited number of lakes, and rotenone is expensive and hazardous, thus strongly regulated and under increasing environmental scrutiny. Lake managers need better tools for manipulating fish (bio-manipulation) in Minnesota shallow lakes.

Goal: Our goal is to provide an innovative and cost-effective tool for managing shallow lakes. We will assess the efficacy of using liquid carbon dioxide (LCO_2) to kill invasive and rough fish via injection under the ice in Minnesota shallow lakes. Research has shown that high levels of dissolved CO_2 can be fatal to fish, but its toxicity to target fish in Minnesota (e.g. fathead minnows, carp and black bullheads) is not known.

In the first component of this project, we'll use lab experiments to estimate toxicity levels of CO_2 for fathead minnows and black bullheads under chemical and physical conditions expected in shallow lakes under the ice. These experiments will provide information on the amount of CO_2 needed to induce fish mortality. In the second component of the project, we will make field measurements of CO_2 and dissolved O_2 concentrations in a variety of lakes across the state and intensively in a small subset of lakes to determine how these two critical parameters vary seasonally and spatially. Lastly, we will conduct field trials where LCO_2 will be pumped under the ice of three experimental lakes, while three similar lakes serve as controls. Data are currently being collected on some of these lakes and, coupled with the work described here, will provide a three-year data set before LCO_2 application, and a two-year data set afterwards. For the field trials we will assess the success of the LCO_2 application in reducing and eliminating populations of fish, assess whether LCO_2 can induce shifts to a clear water state, estimate impacts of the application on non-target aquatic invertebrates, amphibians, aquatic plants, and assess influences on water chemistry and contaminants in the experimental lakes. Also in part three, based on results of our lab experiments and field trials, we will make recommendations on the efficacy of LCO_2 application as a biomanipulation tool to the MN DNR.

II. DESCRIPTION OF PROJECT ACTIVITIES

Activity 1: Effects of CO_2 on fathead and black bullhead survival **Budget:** $ 129,000

We will examine the effects of pH, CO_2, dissolved O_2 and other water quality parameters on the survival and lethality of fathead minnows in the laboratory. We have chosen this target species because of its potential to shift lakes from the clear to the turbid state, the ubiquity of this species in shallow lakes, and also due to its tolerance of extreme conditions in natural ecosystems (Zimmer 2001).

Outcome: Effects of CO_2 on fathead and black bullhead survival	Completion Date
1. Assess the toxicity of LCO_2 to fathead minnows in the laboratory	1 Jul 2014
2. Assess the toxicity of LCO_2 to black bullheads in the laboratory	1 Jul 2015

Outcome: Effects of CO_2 on fathead and black bullhead survival	Completion Date
3. Use results from these two species to advise field LCO_2 delivery levels	1 Jul 2015

Activity 2: Determine variation and seasonality of ambient CO_2 under the ice **Budget:** $147,000
The concentrations of CO_2 will be measured underneath the ice in 6 study lakes throughout the winters of 2013-2015. In winter 2013-14 and 2014-15, we will also measure CO_2 concentrations in a subset of 60 lakes throughout the state.

Outcome: Determine variation and seasonality of ambient CO2 under the ice	Completion Date
1. Intensive measurements of CO_2 in 6 study lakes	1 Jul 2016
2. Measure CO_2 concentrations under the ice in 60 lakes in 5 MN ecoregions.	1 Jul 2015

Activity 3: Determine the feasibility and effectiveness of LCO_2 for biomanipulation under ice in shallow lakes **Budget:** $156,000
In the second winter, we will deliver LCO_2 into three of the treatment lakes that contain fathead minnows and black bullheads and determine the effectiveness of this method for killing these fish. In the third winter of the project, we will use information from the laboratory studies and the previous year's field work to inform LCO_2 application into one of the three treatment lakes.

Outcome: Determine the feasibility and effectiveness of LCO_2 for biomanipulation under ice in shallow lakes	Completion Date
1. Deliver LCO_2 into three shallow lakes.	1 Jul 2015
2. Assess changes in fish and invertebrate community composition	1 Jul 2016
3. Re-apply LCO_2 to one of the treatment lakes and assess effectiveness	1 Jul 2016

III. PROJECT STRATEGY

A. Project Team/Partners

Our project team consists of a biogeochemist (Cotner; Univ. Minnesota-Twin Cities), a fish physiologist (Martinovic; Univ. St. Thomas) and an aquatic ecologist (Zimmer; Univ. St. Thomas) with collaboration with the MN-DNR (M. Hanson and B. Herwig). Cotner will oversee the entire project and coordinate meetings and activities among scientists and managers and will make measurements of water chemistry in the shallow lakes. Zimmer will assess the effects of LCO_2 on fish and invertebrate communities and Martinovic will conduct laboratory experiments to determine the acute and chronic toxicity levels of CO_2 for fathead minnows and black bullheads. Hanson and Herwig will assist in the delivery of LCO_2 and assessment of its effects on fish and invertebrate communities. Cotner, Martinovic and Zimmer will receive ENRTF funds and the services of Hanson and Herwig will be in kind, with their involvement supplemented from the MN-DNR.

B. Timeline Requirements

Toxicity assessment for the two species of fish will be performed in the first 24 months of the project. The results of this work and the first winter's lake measurements of CO_2, pH and O_2 will be used to determine how much LCO_2 needs to be delivered to the treatment lakes in years 2 and 3.

C. Long-Term Strategy and Future Funding Needs

This project builds on ongoing LCCMR and NSF-funded work on carbon removal by shallow lakes.

2012-2013 Detailed Project Budget

IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel: Cotner (8%) Project lead; 64% salary, 36% fringe	$ 44,000
Post-doctoral fellow (100%): Field LCO2 experiments and fish physiology; 77% salary, 23% fringe	$ 152,000
Undergraduate students: (100% summer; 25% school year); laboratory analyses and field work; 90% salary, 10% fringe	$ 14,000
Technician (25%) Laboratory analyses and data management; 59% salary, 41% fringe	$ 49,000
Contracts: University of St. Thomas (Zimmer and Martinovic)	$ 113,000
Equipment/Tools/Supplies: Equipment: We have requested $6000 for two CO2 sensors that will be deployed in the lakes underneath the ice. We have also requested an additional $2,500 for computer that will be used to download data from these instruments in the field. **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.	$ 48,000
Acquisition (Fee Title or Permanent Easements): none	$ -
Travel: Travel to field sites, hotel accommodations and per diem	$ 12,000
Additional Budget Items:	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 432,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ Being Applied to Project During Project Period:	$ -	*Indicate: Secured or Pending*
Other State $ Being Applied to Project During Project Period:	$ -	*Indicate: Secured or Pending*
In-kind Services During Project Period:	$ -	
Remaining $ from Current ENRTF Appropriation (if applicable):	$ -	*Indicate: Unspent? Not Legally Obligated? Other?*
Funding History:	$ -	

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

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 a post-doc, undergraduates, and a technician and coordinate efforts with colleagues at University of St. Thomas and MN-DNR. He will see that field samples are analyzed, interpreted, and used to make management recommendations to the MN DNR.

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

Relevant Publications:

Scott, J.T., J.B. Cotner and T.M. LaPara. 2012. Variable stoichiometry and homeostatic regulation of bacterial biomass elemental composition. Frontiers in Aquatic Microbiology.

Cotner, James B, and Edward K 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.

Cotner, J.B., J. Kenning and J.T. Scott. 2009. The microbial role in littoral zone biogeochemical processes: Why Wetzel was right. Verh. Internat. Verein. Limnol. 30 (6): 981-984.

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.

Cotner, J B, B A Biddanda, W Makino, and T Stets. 2004. Organic Carbon Biogeochemistry of Lake Superior. Aquatic Ecosystem Health and Management 7: 451-464.

Cotner, J B, T H Johengen, and B A Biddanda. 2000. Intense Winter Heterotrophic Production Stimulated by Benthic Resuspension. Limnology and Oceanography 45(7): 1672-1676.

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.

Other issues relevant to the proposed project:

Cotner has been doing research on shallow lakes in Minnesota for the past 12 years. He is collaborating with Kyle Zimmer at the University of St. Thomas and colleagues at the Minnesota DNR. He has been working at the Itasca Biological Station and Laboratories for the past 10 years and has deployed a buoy with meteorological station and water quality monitoring in Lake Itasca for the past 6 years. This experience will greatly enhance the present project as we plan to deploy similar instrumentation in shallow lakes throughout the state.