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

Project Title: **ENRTF ID: 142-D**

Using CO2 to Kill Undesirable Fish including Carp

Category: D. Aquatic and Terrestrial Invasive Species

Total Project Budget: $ 470,000

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

Summary:

We will develop techniques to for controlling nuisance and invasive fish species. Adding CO2 under ice is effective and inexpensive with great potential to improve water quality and aquatic habitat.

Name: James Cotner

Sponsoring Organization: U of MN

Address: 1479 Gortner, Dept. Ecology, Evolution and Behavior

Saint Paul MN 55108

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Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

The image shows a picture of a clear and turbid (algae-dominated) lake and suggests that we can switch lakes to the clear state and get rid of undesirable fish by treating the lakes with dissolved CO2 under the ice.

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

PROJECT TITLE: Using CO_2 to kill undesirable fish including carp

I. PROJECT STATEMENT

- **Why this work needs to be done:** Managers need new tools to kill undesirable fish and increase water quality. Our shallow lakes are threatened by invasive carp, black bullheads and fathead minnows. Water quality is also getting worse in many lakes due to eutrophication and persistent undesirable fish populations, which experience winter kill conditions less frequently due to milder winters. To address both of these problems, lake managers seek to shift turbid, algae-infested lakes to clear, aquatic plant dominated lakes where water quality is much better and non-native fish are less likely to take hold. Presently, lake managers use a toxic chemical, rotenone, to kill undesirable fish and restore the clear water state and improve water quality. The toxicity of this compound to humans, as well as fish, makes it imperative that we find alternative methods that are harmless to humans but equally effective on fish.
- The **Goals** of this project are to: **Develop a method and evaluate the effectiveness of killing undesirable fish using under-ice additions of carbon dioxide (CO_2).** At the completion of this project, the MN-DNR (MN Department of Natural Resources) and the USGS (United States Geological Survey), both partners with us on this project, will have an additional tool to 'switch' aquatic systems from the turbid to clear state and to remove undesirable fish. This work addresses the LCCMR goal of reducing 'the spread of invasive species' and provide 'alternative control techniques' for containing or suppressing invasive species already present in Minnesota (Priorities D2, D3). It also will provide 'research, monitoring, or evaluation to increase sustainability of water resources (B1). **Additional benefits:** This method will likely be effective against other invasive species such as zebra mussels, the banded mystery snail and silver carp. Currently, CO_2 has not been approved to be used in this capacity in the field so we will work with the MN DNR and our USGS collaborators to obtain permits for Minnesota lakes. It should be noted that we discussed this method with personnel at the Minnesota Aquatic Invasive Species Center and they felt this work was outside their current funding priorities.
- **How we will achieve this:** We will determine effective doses of CO_2 and best practices for using it to kill undesirable fish safely. We will add CO_2 to three lakes and evaluate success based on toxicity to target and non-target (desirable) species and water quality in experimental and control lakes.

II. PROJECT ACTIVITIES AND OUTCOMES

We will determine effective concentrations, examine delivery techniques for the CO_2, and optimize timing of CO_2 delivery underneath the ice in shallow lakes. We will treat and monitor three lakes with CO_2 and compare them to three non-treated lakes. CO_2 will be added to lakes either in solid (dry ice) or liquid (LCO2) form.

Activity 1: *Quantify abundance of target and non-target species in six lakes.* **Budget: $150,000**

We will locate six shallow lakes and evaluate the abundance of fish species, water quality and chemistry. The goal is to locate six turbid lakes that have similar poor water quality and similar species composition and to treat three of them with CO_2.

Outcome: Establish baseline conditions for evaluating treatment effectiveness	Completion Date
1. Sample 6-12 shallow lakes in central MN and quantify dissolved CO_2, fish, plant and invertebrate concentrations and abundance, algae, alkalinity, and dissolved nutrient concentrations (carbon, nitrogen and phosphorus).	1 Jan 2019
2. Analyze and quantify biological (fish, amphibians, invertebrates, algae) and chemical (carbon, nitrogen, phosphorus, alkalinity, dissolved CO_2) samples.	1 Jul 2019
3. Evaluate the physical location of each of the lakes for a) similarity to other lakes in terms of chemistry and biology and b) convenience and effectiveness of sampling.	1 Jul 2019
4. Use results to determine which lakes will be treated with CO_2 and treatment levels.	1 Jul 2019

Activity 2: *Add CO_2 to three lakes and evaluate field implementation practices.* **Budget: $200,000**

We will deliver CO_2 into three shallow lakes using either solid (dry ice) or liquid CO_2 depending on current costs and delivery effectiveness. Our goal will be to exceed the toxicity levels that others have established in laboratory experiments (about 150 mg/L).

Outcome: Develop a method for field implementation of CO_2 to kill undesirable fish	Completion Date
1. Determine the most effective method to deliver CO2 into the lakes (either as liquid CO_2 or dry ice).	1 Jul 2019
2. Develop simple technology to deliver CO_2 in the field.	1 Jul 2019
3. Develop protocols for delivery of CO_2 that will insure the safety of humans that are applying it.	1 Jul 2019
4. Negotiate with vendors to obtain the cheapest price on liquid CO_2 or dry ice.	1 Jul 2019
5. Deliver CO_2 under the ice into three lakes and measure changes in water chemistry that accompany delivery (dissolved carbon, nitrogen and phosphorus, alkalinity, and dissolved CO_2).	1 Jul 2020

We will assess impacts of CO_2 on target and non-target species (desirable and undesirable fish, invertebrates, plants), water quality, and whether lakes shift states (i.e., from turbid to clear) by sampling the lakes after treatment. We will quantify fish, amphibians, aquatic invertebrates, submerged aquatic plants, algae, dissolved carbon, phosphorus and nitrogen levels in the water, as well as water pH and metal solubility. We expect substantial reductions in fish abundance, algae, and nutrients, and increased aquatic invertebrates and plants. We expect aquatic invertebrates and amphibian populations will rebound quickly in the spring after CO_2 treatment.

Activity 3: *We will evaluate toxicity on target and non-target species in the field as well as evaluating effectiveness in lake restoration.* **Budget: $120,000**

Outcome: Restore water quality to shallow lakes	Completion Date
1. Analyze and quantify biological (fish, amphibians, invertebrates, algae) and chemical (carbon, nitrogen, phosphorus, alkalinity, dissolved CO_2) samples five times subsequent to CO_2 treatment.	1 Jul 2021
2. Compare the water quality and species composition of the treated vs. the untreated lakes.	1 Jul 2021
3. Assess the efficacy of CO_2 in inducing a shift from clear to turbid state.	1 Jul 2021

III. PROJECT STRATEGY

A. Project Team/Partners

- Dr. James Cotner (University of Minnesota-Twin Cities; supervision and water chemistry; $379,000)
- Dr. Kyle Zimmer (University of St. Thomas; invertebrates and fish, $91,000)
- Nicole Hansel-Welch, Brian Herwig, and Danelle Larson (MN DNR; in kind support on project implementation [$23,000], fish and amphibians)
- Aaron Cupp and Kim Fredricks (USGS; in kind support on permitting procedures and fish analyses).

B. Project Impact and Long-Term Strategy

This project is a priority for the MN DNR improve water quality and remove undesirable and invasive fish.

C. Timeline Requirements

This project will require three years to complete. Sampling will begin the fall of 2018 and will be completed in the summer of 2021. Final reports will be issued July 2021 and project scientists will disseminate results.

2018 Detailed Project Budget

Project Title: Using CO2 to kill undesirable fish including carp

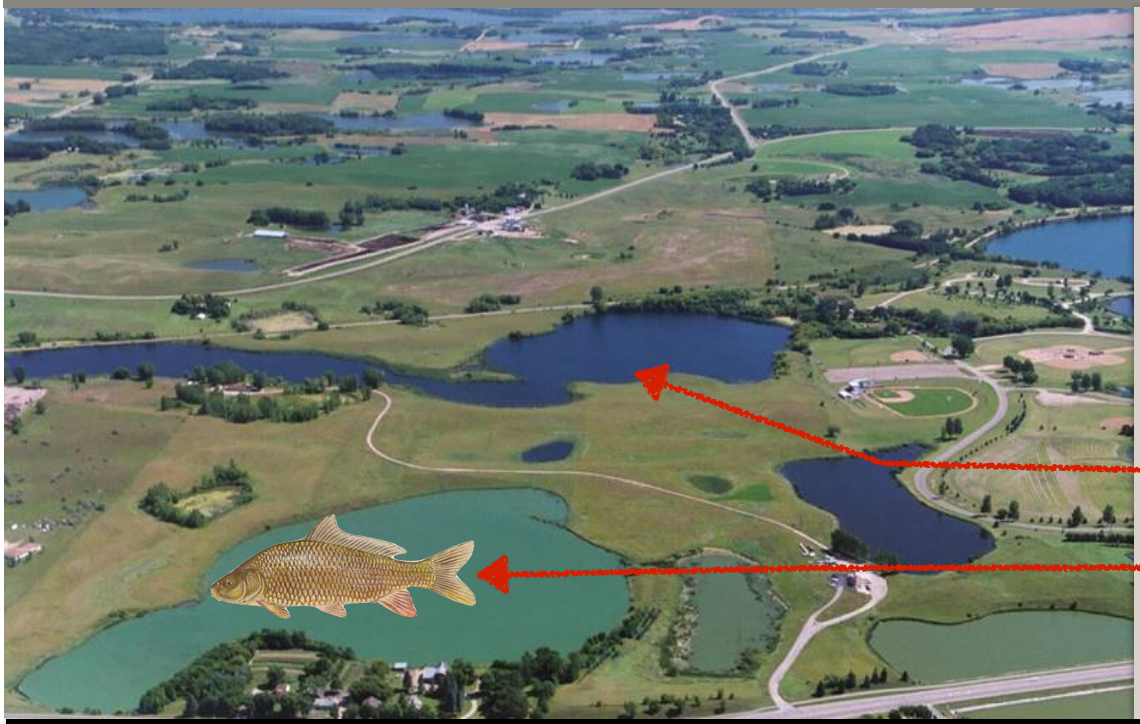
IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel:	$ -
James Cotner: (75% salary, 25% benefits) One half month salary per year for all three years	$ 25,000
Postdoc (82% salary, 18% benefits) 12 months for one postdoc in years 2 & 3. 100% FTE	$ 121,000
Graduate Student (52% salary, 48% fringe during the academic year and 87% salary, 13% fringe during the summer) One semester plus the summer at 50% FTE for years 1 & 2.	$ 53,000
Undergrads and/or Temp/Casual Employees (93% salary, 7% fringe)	$ 10,000
Technician (79% salary, 21% fringe) Six months support for 3 years at 100% FTE.	$ 103,000
Professional/Technical/Service Contracts:	$ -
Subcontract to University of St. Thomas for field assistance related to treating lakes and measurements of macroinvertebrates and fish composition and abundance.	$ 91,000
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 dry ice that will be added to our three treatment lakes (ca. 3000 lbs per lake x 3 lakes).	$ 56,000
Travel: We estimate 3636 miles per year (8 round trips) for travel to and from the field sites in central Minnesota @ 0.535/mile = $2000/year. Lodging is estimated at $100/night for 7 nights per year and per diem is esimated at $55/day and 15 days per year.	$ 11,000
Additional Budget Items:	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 470,000

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: Indirect costs associated with this proposal	$ 198,000	Secured
Past and Current ENRTF Appropriation:	NA	NA
Other Funding History:	NA	NA

BETTER LAKES FOR MINNESOTA



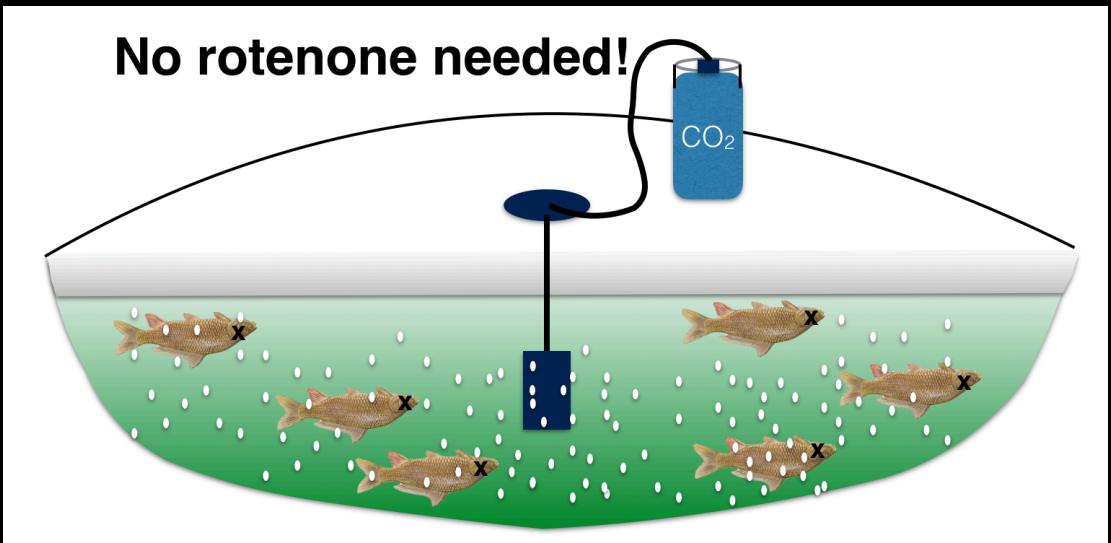
We need better water quality and better fish.

In other words:

- We want more of this....
- ...and less of this

How do we get there?

- USE DISSOLVED CO_2 TO KILL UNDESIRED FISH
- ALLOW THE SYSTEM TO RECOVER WITH DESIRED FISH OR STOCK FISH
- ENJOY BETTER WATER QUALITY, BETTER WILDLIFE AND BETTER FISHING



Project Manager Qualifications and Organization Description-Using CO_2 to kill undesirable fish including carp

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 and personnel. He will assist with the design, implementation and science questions focused on CO_2 delivery and effects on organisms in lakes and wetlands. He has directed a laboratory, including post-doctoral fellows, undergraduate and graduate students and technicians for 25 years. He also has experience working with agency personnel (NOAA, MN DNR, MN PCA, USGS) on management issues in aquatic systems.

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

Relevant Publications:

Godwin, Casey M, *Emily A Whitaker*, and James B Cotner. "Growth Rate and Resource Imbalance Interactively Control Biomass Stoichiometry and Elemental Quotas of Aquatic Bacteria." Ecology. doi:10.1002/ecy.1705.

Zimmer, Kyle D., William O. Hobbs, Leah M. Domine, Brian R. Herwig, Mark A. Hanson, and James B. Cotner. "Uniform Carbon Fluxes in Shallow Lakes in Alternative Stable States." *Limnol. Oceanogr.* (2015): doi:10.1002/lno.10215.

Ramstack Hobbs, Joy M, William O Hobbs, Mark B Edlund, Kyle D Zimmer, Kevin M Theissen, Natalie Hoidal, Leah M Domine, Mark A Hanson, Brian R Herwig, and James B Cotner. "The Legacy of Large Regime Shifts in Shallow Lakes." Ecological Applications 26, no. 8 (2016): 2660-2674.

Hall, Ed K, Don R Schoolmaster Jr, Andre M Amado, Edward G Stets, Jay T Lennon, Leah Domine, and Jim B Cotner. 2016. "Scaling Relationships Among Drivers of Aquatic Respiration: From the Smallest to the Largest Freshwater Ecosystems." Inland Waters 6: 1-10.

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

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.

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.