Environment and Natural Resources Trust Fund
2017 Request for Proposals (RFP)

Project Title: **ENRTF ID: 111-D**

New Technology to Control Invasive Carp

Category: D. Aquatic and Terrestrial Invasive Species

Total Project Budget: $ 389,000

Proposed Project Time Period for the Funding Requested: 3 years, July 2017 - June 2020

Summary:

We developed a new technology that can significantly reduce or eradicate an invasive species with no harm to native species. We will apply this to control invasive carp.

Name: Michael Smanski

Sponsoring Organization: U of MN

Address: 1479 Gortner Ave, 140 Gortner Lab

St. Paul MN 55108

Telephone Number: (612) 624-9752

Email smanski@umn.edu

Web Address http://www.bti.umn.edu/labs/smanski/

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

The figure shows that we will create sterile males that can no longer reproduce with wild fish. By controlled release of these males, the population numbers of invasive fish will decline. We will not perform any experiments outside of controlled laboratory tanks.

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

PROJECT TITLE: **New technology to control invasive carp**

I. PROJECT STATEMENT

The **overall goal** of this project is to develop a novel approach for controlling aquatic invasive species using invasive carp as a proof-of-concept. Invasive fish species present an estimated $5.4 billion burden on our domestic economy, and much of that extends to the lakes and rivers of Minnesota. For example, the foraging habits of the invasive common carp, *Cyprinus carpio*, diminishes water quality, reduces vegetative cover and waterfowl numbers, and reduce the ability of lakes to absorb nutrients that enter water systems through agricultural runoff. More recently introduced species of carp, including the bighead carp, *Hypophthalmichthys nobilis*, and the silver carp, *H. molitrix*, are spreading up the Mississippi River Basin and pose a threat to native fish species. Current control methods have not been able to stem the tide of invasive species, so improved strategies are urgently needed.

We have developed a novel approach for eradicating invasive species using tools in modern precision genetics that avoid issues associated with older recombinant DNA-based methods. We will produce carp that cannot reproduce in the wild, and these can be used to reduce or eliminate populations of invasive carp. Unlike available methods to reduce invasive fish populations, which include poisoning lakes or netting fish, our strategy will not kill native fish populations. Because of this, our method for producing sterile fish in a species-specific manner can be considered more environmentally friendly than existing options. *We are requesting funding to perform proof-of-concept experiments over the next three years*, first in small laboratory fish, and then in carp. We will develop and test our system in safe and controlled laboratory settings and will demonstrate that it is an improvement over current approaches for invasive species control.

The **direct outcome** of this project will be a demonstration that our innovative solution to eradicate invasive species will work in fish. If this project is successful, it could be expanded to solve problems related to agricultural pests and even disease-carrying insects.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Demonstrate sterile fish technology in a well-studied fish species (year 1) **Budget: $138,000**

'Zebrafish' is a small fresh-water aquarium fish species that has been studied for decades in research labs, and is the best understood fish species from a genetic level. During the first year of funding, we will take advantage of the knowledge-base in this species to demonstrate a proof-of-concept of our new biocontrol method. This is an essential step that will make implementing the application in carp more efficient and less costly.

Outcome	Completion Date
1. Use the latest tools in precision genetics to identify at least 5 specific genes in a well-studied laboratory fish species that are also present in wild invasive species and that could be targeted to produce sterile fish.	*March 2018*
2. Complete demonstration in a well-studied laboratory fish species that our sterile fish approach is safe, effective, and specific. Evidence will include data that show our ability to reduce or eliminate a population of these fish in controlled laboratory settings.	*June 2018*

Activity 2: Demonstrate sterile fish technology in common carp *(C. carpio)* **Budget: $251,000**

After first establishing that tools for modern precision genetics will work in C. carpio during year one, we will build on the knowledge gained in Activity 1 to bridge our sterile fish technology into carp species. We will also develop robust protocols for isolating male carp, and we will test the safety and efficacy of our approach in a controlled lab setting. After completion of Activity 2, we will have a technology that is ready to test for safety and efficacy in controlled indoor tanks.

Outcome	Completion Date
1. Develop protocols modern precision genetics in carp. We will verify that our methods are as effective in carp as in small laboratory fish.	*June 2018*

2. We will replicate our experiments completed during Activity 1, but this time in an invasive carp species.	*June 2019*
3. We will develop and demonstrate simulation computer models to determine the precise population levels and time frames needed to reduce or eliminate invasive species from a given body of water.	*September 2019*
4. We will perform safety and efficacy trials in controlled laboratory tanks, the difference in time required for this outcome in activity 2 vs activity 1 reflects the 2-3 year maturation requirement for carp.	*June 2020*

III. PROJECT STRATEGY

A. Project Team/Partners

This is a collaborative effort conceived and implemented by an interdisciplinary group of professors at the University of Minnesota. **Dr. Michael Smanski** (Professor in the Department of Biochemistry, Molecular Biology, and Biophysics at UMN) and **Dr. Maciej Maselko** (Postdoctoral research associate in the UMN BioTechnology Institute) developed this novel approach and founded the collaborative team. Dr. Smanski's roles will include overseeing research progress and setting/adjusting project milestones, as well as disseminating results through yearly updates and regular publication in high-impact journals. Dr. Maselko's role will include leading biweekly research meetings, guiding the experimental design, and aiding in experimental work. **Dr. Perry Hackett** (Professor in the Department of Genetics, Cell Biology, and Development at UMN) and **Dr. Karl Clark** (Professor of Biochemistry and Molecular at the Mayo Clinic) are experts in fish genomics and genetics. They were involved 25 years ago in generating growth-enhanced fish; they understand regulatory and public concerns with genetic engineering and will ensure that methods used and fish that are developed will be acceptable to the general public. Drs. Hackett and Clark will provide laboratory fish handling facilities and will guide genetic experiments in fish during year 1. **Dr. Przemyslaw Bajer** (Research Professor in the Department of Fisheries, Wildlife, and Conservation Biology at UMN) is an expert on carp biology and invasive species control. Dr. Bajer will provide carp handling facilities and will oversee carp research and proof-of-concept population control studies for Activity 2. Lastly, **Dr. James Parker** (Instructor in the Computer Science and Engineering Department) will write programs for the simulation modeling experiments. All funding will be managed by Smanski.

B. Project Impact and Long-Term Strategy

The long-term objective of this study is to rid lakes of aquatic invasive species that place an environmental and economic burden on the state of Minnesota. Carp populations in excess of 100 kg biomass/ha have been shown to damage shallow lake ecosystems by increasing water turbidity, decreasing vegetative cover, and decreasing waterfowl populations. Fortunately, this effect is reversed when carp populations are reduced through intervention efforts. Simulation models suggest that our novel biocontrol strategy is an improvement over competing systems. *This three-year project is specifically aimed at demonstrating a new technology for managing populations of invasive carp. The technology being developed in this proposal has already been issued a provisional patent through the University of Minnesota, and future efforts to commercialize it will be in the economic interest of the University and state.* This technology could be easily transferred from common to bighead or silver carp. Lastly, the goals of this project align strongly with the Minnesota Aquatic Invasive Species Research Center, and one of our team members, Dr. Bajer is a member of the center.

C. Timeline Requirements

The experiments described here for this project are realistic and will be completed entirely in controlled lab environments and so will not require field work. We will demonstrate our new technology in fast-growing, easy-to-handle laboratory fish species during the first year, and we will demonstrate our technology in carp in three years. The extra time required for carp reflect the slow growth and maturation of this species compared to fish species typically studied in research laboratories.

2017 Detailed Project Budget

Project Title: New technology to control invasive carp

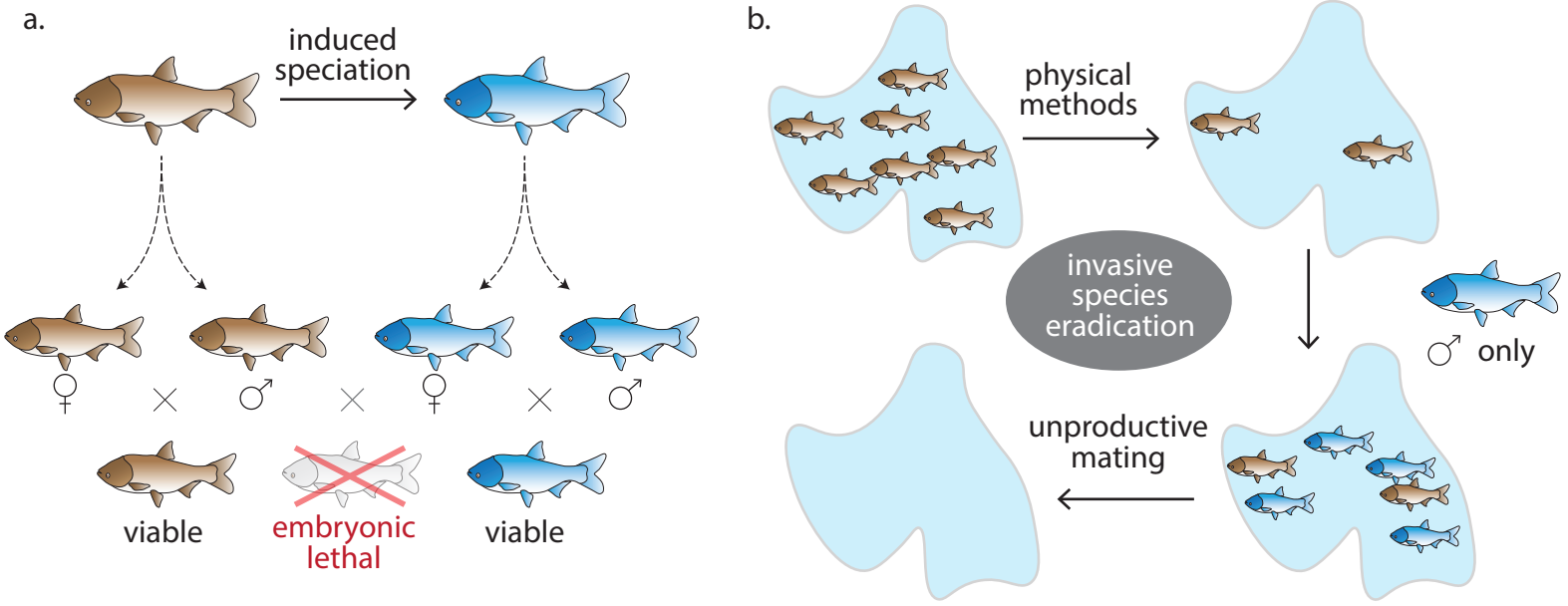
IV. TOTAL ENRTF REQUEST BUDGET *3* **years**

BUDGET ITEM	AMOUNT
Personnel:	$ -
Project Manager (75% salary, 25% benefits) (8% FTE for 1 month of summer salary) (1 year, salary for other 2 years provided in kind by department) Prof. Smanski	$13,000
Research Assistant Professor to complete carp work (activity 2) (75% Salary, 25% benefits) (8% FTE for 1 month of summer salary per year) (3 years) Prof. Bajer	$41,000
Professor to lead Activity 1 in laboratory fish species (75% salary, 25% benefits)(8% FTE for 1 month of summer salary) (1 year) Prof. Hackett)	$13,000
Postdoctoral Researcher (81% salary, 19% benefits)(100% FTE) 3 years, one person	$164,000
Technician (78% salary, 22% benefits) (66% FTE) 3 years, one person	$76,000
Equipment/Tools/Supplies:	$ -
Controlled laboratory fish rearing and handling facilities for initial laboratory fish studies, includes costs for space rental, food, tank and handling equipment, tools for egg harvesting, and cleaning equipment (for year 1)	$10,000
Controlled large fish rearing and handling facilities for carp studies, includes costs for space rental, food, tank and handling equipment, tools for egg harvesting, and cleaning equipment ($10,000 per year for 3 years)	$30,000
Molecular biology reagents (includes $6,000 per year to purchase enzymes and chemicals to perform modern precision genetics tests on fish, also includes an additional $2,000 to purchase DNA elements that are required for tests performed in this study	$20,000
Core facility costs (DNA sequencing): will cover costs associated with 'reading' the DNA of the fish that are used in experiments to determine success of experiments	$7,000
Lab consumables (including disposable plasticware, for example test tubes and petri plates, as well as media needed for production of molecular biology reagents made in the lab	$15,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 389,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	N/A	
Other State $ To Be Applied To Project During Project Period:	N/A	
In-kind Services To Be Applied To Project During Project Period: In kind services will be provided by the BMBB Department and BioTechnology Institute to cover indirect costs associated with managing the research project and providing administrative support to researchers (53% of total costs; $206,170). Two years salary support for Smanski will be provided by his department (8% effort, salary plus fringe; $26,740)	$ 233,000	Secured
Funding History:	N/A	
Remaining $ From Current ENRTF Appropriation:	N/A	

Figure for project "New technology to control invasive carp"



*In this funding period, we will only perform experiments in controlled laboratory tanks. This illustration merely depicts the future application once we have shown it to be safe and effective.

PROJECT MANAGER QUALIFICATIONS: *Michael J. Smanski (PI)*

PROFESSIONAL PREPARATION

University of California, San Diego	Biochemistry	B.S., 2006
University of Wisconsin, Madison	Microbiology	Ph.D., 2011
Massachusetts Institute of Technology	Biological Engineering	2011-2014

APPOINTMENTS

Since 2014 Assistant Professor, Department of Biochemistry, Molecular Biology, and Biophysics, University of Minnesota, Twin Cities

QUALIFICATION STATEMENT

Dr. Smanski's research group leverages the latest technologies in precision genetics for diverse applications, including the discovery of new antibiotics and the control of invasive species. He is well-trained in Biochemistry, Microbiology, Molecular Biology, and Engineering. Recently, his group has demonstrated a proof of concept in *Saccharomyces cerevisiae* for a new molecular method of biocontrol (still unpublished), on which this LCCMR application is based.

HONORS AND AWARDS

HHMI Fellow of the Damon Runyon Cancer Research Foundation	2012-2014
Dale F. Frey Award for Breakthrough Scientists	2014

MOST CLOSELY RELATED PUBLICATIONS

1. Smanski MJ, Bhatia S, Zhao D, Park YJ, Woodruff L, Giannoukos G, Ciulla D, Busby M, Calderon J, Nicol R, Gordon DB, Densmore D, Voigt CA. (2014) Functional optimization of gene clusters by combinatorial design and assembly. Nat. Biotechnol. 32:1241-1249.
2. Smanski MJ, Zhou H, Claesen J, Shen B, Fischbach MA, Voigt CA (2016) Synthetic biology to access and expand nature's chemical diversity. *Nat. Rev. Microbiol.* **14**:135-142.

ORGANIZATION

The University of Minnesota is a world-class research university. Its official mission statement can be found at http://regents.umn.edu/sites/regents.umn.edu/files/policies/Mission_Statement.pdf