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

Project Title: **ENRTF ID: 070-B**

Impact of Migratory Birds on Minnesota Water Quality

Category: B. Water Resources

Total Project Budget: $ 272,000

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

Summary:

We will clarify the impact of waterfowls on biological water quality, and construct a model to predict concentrations of pathogens based on the geese counts and other environmental parameters.

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Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Pathogen concentrations predicted based on the geese counts and other environmental parameters can improve the water quality monitoring program in Minnesota.

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

PROJECT TITLE: Impact of Migratory Birds on Minnesota Water Quality

I. PROJECT STATEMENT

Water recreation activities such as fishing, canoeing, and swimming are very common in Minnesota. Minnesota's beautiful lakes and beaches attract many tourists to the state and greatly contribute to the economy of Minnesota. Good water quality is key in maintaining our water resources. Among various water pollutants, pathogen contamination is of great concern because it can cause human and animal diseases.

In addition to tourists and state residents, lakes and watersheds in Minnesota also attract many waterfowl, such as Canada geese. Canada geese are known to harbor human pathogens such as *Campylobacter*, bacteria known to be the leading cause of human diarrheal diseases in Minnesota and the greater U.S. These birds can readily contaminate water environments, dispersing pathogens to wide areas through their fecal droppings. However, the impact of geese populations on water quality is poorly understood.

The best way to evaluate microbiological water quality is to directly measure concentrations of pathogens. Although measuring pathogens in water samples is technically feasible (Ishii et al. 2014), it requires specialized equipment and skilled professionals. Therefore, this approach is difficult to apply to the routine water quality monitoring. In contrast, it is relatively easy for lake and beach managers to measure environmental parameters such as temperature, number of geese, and levels of fecal indicator bacteria in water environments. If we can predict concentrations of pathogens based on these environmental parameters, we can evaluate water quality without the labor and resources required to measure the concentrations of pathogens.

The overall goal of this project is to evaluate water quality and improve public health for recreational water users. To achieve this goal, we will first measure the concentrations of pathogens in water and geese fecal samples (Activity 1). We will analyze if and how geese contribute to the distribution of pathogens (Activity 2). We will also analyze the correlations between pathogen concentrations and environmental parameters such as temperature, number of geese, and levels of fecal indicator bacteria. Based on these results, we will construct a model to predict pathogen concentrations in water samples (Activity 3).

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *State-wide water quality survey* **Budget: $103,000**

To clarify the distribution of pathogens in the lakes in Minnesota, water samples will be collected from lakes throughout the state during the summer and fall seasons of 2017. Environmental parameters (temperature, number of geese, levels of fecal indicator bacteria, etc.) will be also measured. We will also collect fecal samples from geese near the lake sampling sites. Concentrations of various pathogens in the water and fecal samples will be measured using the culture-independent gene quantification method (Ishii et al. 2013). We will also isolate *Campylobacter* pathogens from the lake water and the geese fecal samples by using *Campylobacter*-specific culture media.

Outcome	Completion Date
1. Concentrations of various pathogens in the lakes throughout the state	*June 30, 2018*
2. Concentrations of various pathogens in geese fecal samples	*Dec. 31, 2018*
3. Campylobacter strains isolated from lake water and geese fecal samples	*Dec. 31, 2018*

Activity 2: *Temporal dynamics in the pathogen concentrations* **Budget: $85,000**

Based on the results from Activity 1, we will select two lakes for further intensive sampling. One lake will be selected from Prairie Pothole Region and another lake will be selected from the Twin Cities metro area. By collecting water samples periodically (e.g., every month from April to November), we can analyze temporal dynamics in the pathogen concentrations. We will measure concentrations of various pathogens found in our samples and isolate *Campylobacter* pathogens in a similar manner as described in Activity 1.

We will characterize the *Campylobacter* strains by sequencing their virulence factor genes. By comparing the sequence patterns of the *Campylobacter* strains isolated from the lake water and those from the geese fecal samples, we can estimate the impact of geese on the *Campylobacter* contaminations in the lake water.

Outcome	Completion Date
1. Temporal variations in relation to the pathogen concentrations in the lakes	*June 30, 2019*
2. Degree of contribution of the geese on pathogen loading of the lakes	*Dec. 31, 2019*

Activity 3: *Construction of pathogen predictive models* **Budget: $84,000**

Based on the data obtained in Activities 1 and 2, we will calculate the correlations between pathogen concentrations and various environmental parameters (temperature, number of geese, levels of fecal indicator bacteria, etc.). We will then construct a mathematical model to predict pathogen concentrations in lake water samples. By using this model, we will be able to predict concentrations of pathogens based on the environmental parameters (i.e., without actually measuring the concentrations of pathogens). We will evaluate the accuracy of the model, then apply the model to assess the water quality in the Minnesota lakes. We will then calculate the potential health risks of Minnesota lake waters for recreational users.

Outcome	Completion Date
1. Correlations between pathogen concentrations and environmental parameters	*Dec. 31, 2019*
2. A mathematical model to predict pathogen concentrations	*June 30, 2020*
3. Potential health risks of Minnesota lake waters for recreational users	*June 30, 2020*

III. PROJECT STRATEGY

A. Project Team/Partners

Satoshi Ishii (Assistant Professor, Department of Soil, Water, and Climate, the University of Minnesota) will lead and manage the project. One graduate student will collect samples, perform experiments, analyze the data, and create a predictive model. One research technician will assist field samplings and experiments.

Steve Cordts (Waterfowl Staff Specialist, Minnesota Department of Natural Resources) will assist with the waterfowl population surveys and arrange the geese fecal sampling, without funding support from ENRTF. Dr. Ishii will be responsible for the financial budgeting and all other aspects of this project.

B. Project Impact and Long-Term Strategy

The pathogen predictive model constructed in this study can be applied to future routine water quality monitoring. We will collaborate with the Minnesota Pollution Control Agency in hopes that our model can improve their existing water quality monitoring program. By improving quality assessment protocols, water resources can be more accessibly monitored to provide beachgoers with important health and safety information required for safe recreational decisions.

The results obtained in this study will be also useful to establish strategies to control geese populations. If we find geese significantly contributing to the pathogen loading of Minnesota lakes, we will work with the Minnesota Department of Natural Resources and other stakeholders to discuss possible options to control geese populations.

C. Timeline Requirements

We expect to complete the proposed project in 36 months. In the first year, we will measure concentrations of pathogens in water and geese fecal samples collected throughout the state (Activity 1). Based on data collected during the first field season, we will perform intensive and periodical sampling from two lakes in the second year (Activity 2). In the third year, we will analyze the data and construct a predictive model (Activity 3).

2017 Detailed Project Budget

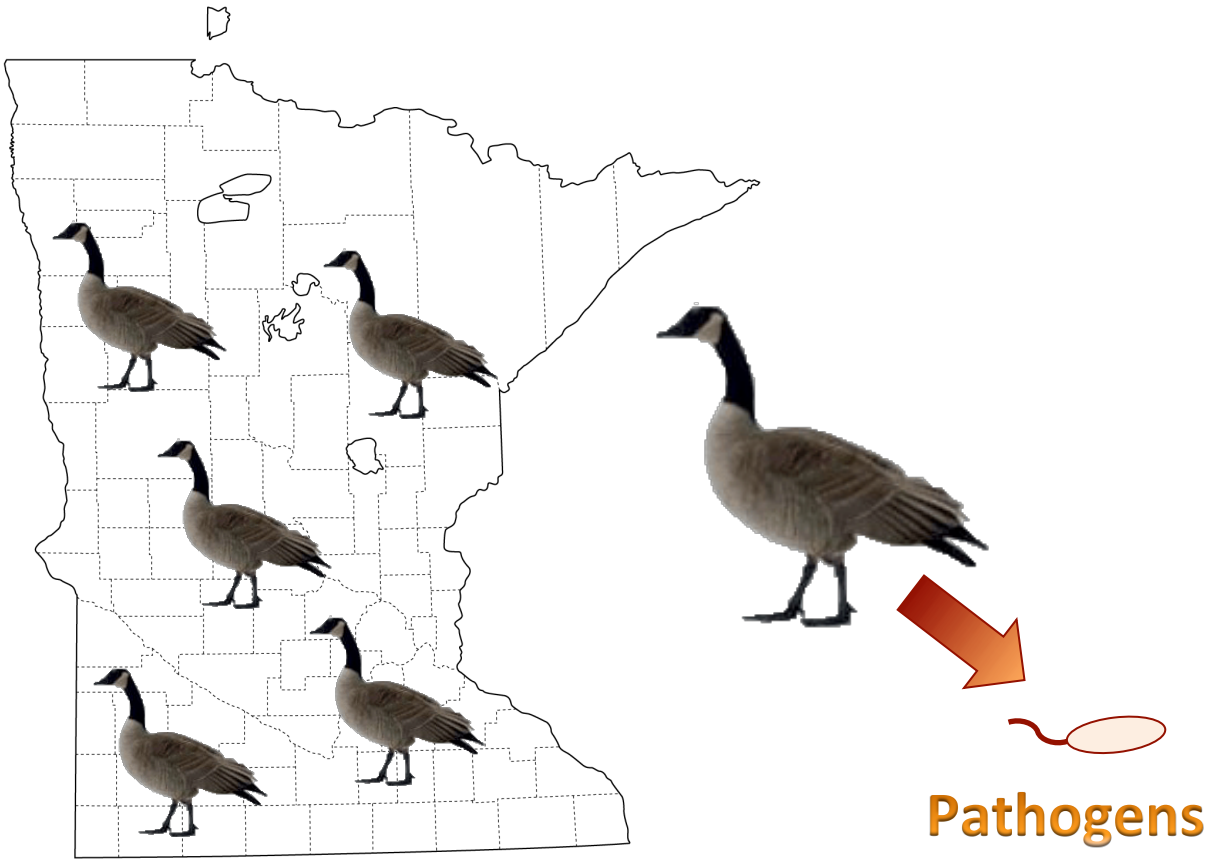
Project Title: *Impact of Migratory Birds on Minnesota Water Quality*

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

BUDGET ITEM	AMOUNT
Personnel:	
Assistant Professor, Satoshi Ishii, project management (75% salary, 25% benefits); 8% FTE; Project supervision, supervision of graduate student, project reporting.	$ 37,000
1 Graduate Research Assistant, sample collection and analysis (55% salary, 45% benefits); 50% FTE for each of 3 years	$ 112,000
1 Research Technician, sample collection (78.5% salary, 21.5% benefits); 50% FTE for each of 3	$ 67,000
Professional/Technical/Service Contracts:	
University of Minnesota Genomics Center: Sequencing bacteria virulence factor genes (500 bacteria samples x 2 genes x 2 sequencing reactions at $5/sample; Next generation sequencing $3,000/run x 2 runs)	$ 16,000
Equipment/Tools/Supplies:	
CO2 Incubator, variable O2 control	$ 22,000
Culture media, test tubes (30 water samples x 3 replicates at $22/sample)	$ 2,000
Reagents for water chemical analysis: (30 water samples x 3 replicates at $22/sample)	$ 2,000
Reagents for PCR: (500 bacteria samples at $10/sample)	$ 5,000
General lab suppplies (sampling bags, pipet tips, glassware, etc): $1,000/year x 3 years	$ 3,000
Travel:	
In-state travel to collect samples (10 trips/year for 3 years at $200/trip with the University vehicle and the mileage rate of $0.54/mile; expecting 200-300 miles/trip)	$ 6,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST	$ 272,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: N/A	$ -	N/A
Other State $ To Be Applied To Project During Project Period: N/A	$ -	N/A
In-kind Services To Be Applied To Project During Project Period: *University of Minnesota (53% of the funding requested to LCCMR ENRTF program)*	$ 144,000	pending
Funding History: N/A	$ -	N/A



Geese on the lake!

- Can we predict pathogen concentrations from the number of geese?
- Is our lake safe for recreational activities?

Project Manager Qualifications

Dr. Satoshi Ishii is Assistant Professor in the BioTechnology Institute (BTI) and the Department of Soil, Water, and Climate (SWC) at the University of Minnesota. He joined the BTI and SWC in April, 2015. He was hired as a part of the MnDRIVE (Minnesota's Discovery, Research and InnoVation Economy) initiative, to advance industry and conserve our environment. Prior to this position, he was Assistant Professor in the Division of Environmental Engineering at Hokkaido University, Japan, for 4 years, and Research Assistant Professor at the Department of Applied Biological Chemistry at the University of Tokyo, Japan, for 3.5 years.

Dr. Ishii has over 10 years of research experiences on water quality microbiology. He has used biotechnology, microbiology, molecular biology, analytical chemistry, and engineering approaches to solve environmental problems. He has extensive experiences in the occurrences of pathogens such as *E. coli* and *Campylobacter* in soil and water environments (e.g., Ishii et al. 2006; Ishii et al. 2014). He has developed a novel tool to simultaneously quantify multiple pathogens (Ishii et al. 2013), and applied this tool to assess water quality (Ishii et al. 2014; Byppanahalli et al. 2015).

Dr. Ishii's lab is located on 322 Snyder Hall (750 sq. ft) in the University of Minnesota St. Paul campus. The Ishii's Lab is equipped with all the necessary items for the proposed research and is certified for the experiments handling BSL2 pathogens. Next generation sequencing and analysis will be done in the University of Minnesota Genomics Center.

Selected publications related to the proposed research:

Byappanahalli, M.N., M. B. Nevers, R. L. Whitman, and S. Ishii. 2015. Application of a microfluidic quantitative polymerase chain reaction technique to monitor bacterial pathogens in beach water and complex environmental matrices. Environ. Sci. Technol. Lett. 2:347–351.

Ishii, S., T. Nakamura, S. Ozawa, A. Kobayashi, D. Sano, and S. Okabe. 2014. Water quality monitoring and risk assessment by simultaneous multipathogen quantification. Environ. Sci. Technol. 48:4744–4749.

Ishii, S., T. Segawa, and S. Okabe. 2013. Simultaneous quantification of multiple food and waterborne pathogens by use of microfluidic quantitative PCR. Appl. Environ. Microbiol. 79:2891-2898.

Ishii, S., T. Yan, D. A. Shively, M. N. Byappanahalli, R. L. Whitman, and M. J. Sadowsky. 2006. *Cladophora* (Chlorophyta) harbors human bacterial pathogens in nearshore water of Lake Michigan. Appli. Environ. Microbiol. 72:4545-4553.

Organization Description

The University of Minnesota is the main research and graduate teaching institution in the state of Minnesota. The BioTechnology Institute provides advanced research, training, and university-industry interaction in biological process technology. In the Department of Soil, Water, and Climate, we seek to improve and protect the quality of soil, air, and water resources in natural and managed ecosystems, through research, reaching, and extension.