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

Project Title: **ENRTF ID: 074-B**

Measuring Reductions in Nitrate Pollution from Precision Agriculture

Category: B. Water Resources

Total Project Budget: $ 159,833

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

Summary:

Our project will quantify nitrate losses for corn production in drain-tiled fields, comparing next-generation precision agriculture to conventional management methods.

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Location

Region: Central

County Name: Renville

City / Township: Olivia

Alternate Text for Visual:

Applying fertilizer based on spatial and temporal demand by crops should result in higher N-use efficiency and reduced N loss through drain tiles.

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

PROJECT TITLE: Measuring reductions in nitrate pollution from precision agriculture

I. PROJECT STATEMENT

Agriculture is the economic engine of southern Minnesota, but corn production is also a major contributor to nitrate loading in groundwater and surface waters. Nitrate loss is especially high where drain tiles are installed, where excess water is shunted off of fields and into drainage ditches and ultimately into rivers. Next-generation precision agriculture (NGPA)—managing crops in real-time using multispectral imagery and environmental data collected at high spatial and temporal resolution—has the potential to allow farmers to reduce fertilizer inputs without reducing yields, thereby benefiting farmers economically while also reducing pollution.

The goal of our study is to quantify potential reductions in nitrate losses from next-generation precision agriculture for corn production in drain-tiled fields. The outcomes of this project include: 1) development of a new predictive model forecasting growth patterns for corn based on sensory data and high resolution multispectral imagery; 2) quantification of nitrogen use efficiency and nitrate loss through drain tiles from precision agriculture and control treatments; and 3) analysis of economic and environmental costs and benefits of implementing next-generating precision agriculture technology.

We will use a dedicated agricultural plot in Renville County for the field experiments. High-resolution multi-spectral imagery will be collected from a Sentera Multispectral Digital Camera mounted to a robotic rover and an unmanned areal vehicle. Plant health will be calculated based on the Normalized Difference Vegetation Index (NDVI), and nitrogen fertilizer will surgically applied at the time and location where it is required by crops. Nitrate loss through the drain tile network will be quantified using nitrate sensors and water level loggers installed in both the NGPA and control plots.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Develop predictive model forecasting growth patterns of corn based on high-resolution multispectral imagery.* **Budget: $25,524**

The first phase of this project focuses on developing, testing, and refining models that integrate the high volume and variety of information collected to predict corn growth patterns and determine the nitrogen requirements of individual plants. This objective builds on our team's ongoing work.

Outcome	Completion Date
1. Conduct greenhouse experiments collecting imagery of corn under a variety of environmental conditions and nutrient states.	*December 2018*
2. Develop predictive models using large datasets to determine timing and quantity of fertilizer required.	*May 2018*
3. Test predictive models in field conditions, and refine over subsequent seasons	*June 2020*

Activity 2: *Quantify nitrogen use efficiency and nitrate loss through drain tiles from precision agriculture and control treatments.* **Budget: $99,661**

We will compare crop yields, nitrogen use efficiency and nitrate loss from fields through drain tiles, in sections of a field where nitrogen application is managed through NGPA and where fertilizer is applied conventionally. Nitrate export through drain tiles will be measured using nitrate and water level sensors installed in the drain tile network.

Outcome	Completion Date
1. Sensor installation and preliminary field testing	*October 2018*
2. Intensive field measurements	*October 2019*

Activity 3: *Conduct a cost-benefit analysis NGPA, considering economic and* **Budget: $34,648**

The ultimate goal of this project is to develop NGPA that can reduce nitrate pollution while maintaining crop yields, whereby savings from reduced fertilizer application can offset the costs of the technology, so that these efforts are revenue-neutral to the farmer. We will quantify potential reductions in nitrate loading, and the net costs or savings to farmers, under different environmental and economic contexts.

Outcome	Completion Date
1. Calculate costs and savings of applying next-generation precision agriculture at a range of spatial scales and economic contexts.	*June 2020*
2. Calculate yields and nitrate losses from NGPA and conventionally managed fields under a range of environmental conditions (e.g. precipitation, temperature, background soil fertility).	*June 2020*
3. Share research results through talks at local and national meetings, and publications in professional journals.	*June 2020*

III. PROJECT STRATEGY

A. Project Team/Partners

Project partners receiving funds:

- Dr. Gaston Small [$89,462]: Will serve as project manager, and will oversee field measurements of nitrogen export. He requests support for an undergraduate research student, sampling supplies and consumables, travel to the field site, and probes for field measurements.
- Dr. Chih Lai [$70,371]: Will oversee collection of multispectral imagery and sensor data and development of the predictive model described in Activity 1. He requests funding to support for a graduate research student, and meters and probes for field measurements.

Project partners not receiving funds:

- Larry Rauenhorst: Will provide access to field sites and agricultural support.
- Scott Morgan: Will oversee field deployment of rover and associated plant-based field measurements.
- Dr. Cheol-Hong Min: Will oversee weather station data collection and analysis.
- Dr. Chong Xu: Will contribute to autonomous rover development and environmental sensor data collection.

B. Project Impact and Long-Term Strategy

Improving water quality without adversely affecting agriculture is an important goal for Minnesota. Technological advances in data collection, data analysis, and robotics, hold promise in moving us towards this goal, but these potential benefits have not yet been quantified. This proposed research is an extension of research efforts currently underway by the precision agriculture research group at the University of St. Thomas. Results from this project will be presented at state-level and national scientific and engineering meetings, and will be published in professional journals.

C. Timeline Requirements

Project year 1 will focus on greenhouse experiments, model development, and installation and preliminary testing of field sensors. Year 2 will focus on extensive data collection during the field component of the research. Year 3 will focus on conducting the cost-benefit analyses and communicating project results.

2017 Detailed Project Budget

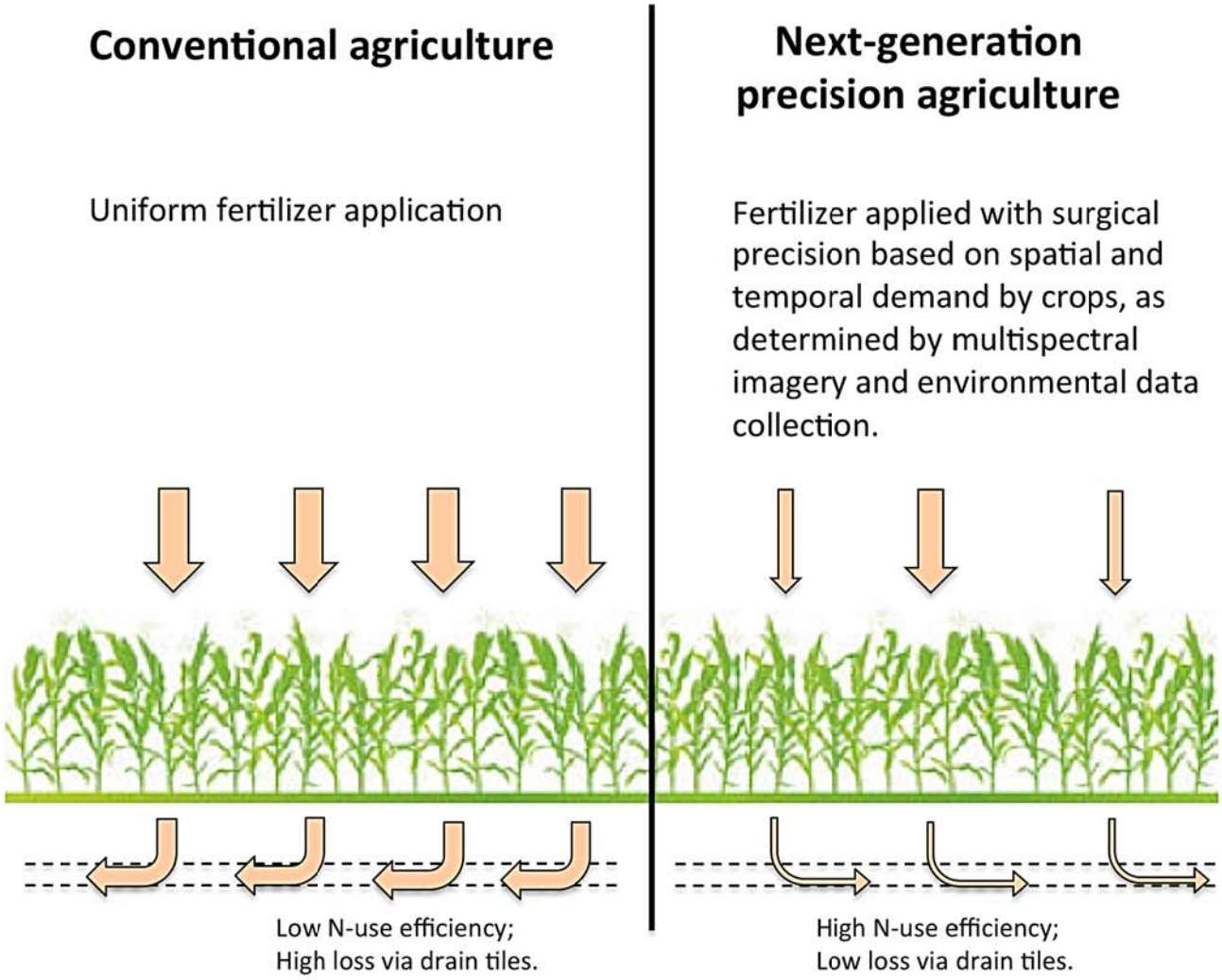
Project Title: Measuring Reductions in Nitrate Pollution from Precision Agriculture

IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel:	$ 100,947
Gaston Small, Project Manager: $23,365 (92% salary, 8% benefits): 8.33% FTE each year for 3 years.	
Chih Lai, Project Collaborator: $23,365 (92% salary, 8% benefits): 8.33% FTE each year for 3 years.	
1 Graduate Research Assistant: $35,602 (92% salary, 8% benefits): 36% FTE each year for 3 years.	
1 Undergraduate Research Assistant: 22,806 (100% salary, 0% benefits during academic year; 92% salary, 8% benefits in summer): 36% FTE each year for 3 years.	
Equipment/Tools/Supplies:	$ 52,333
Hach nitrate sensors and accessories (4 @ $8227 each)	
Sentera multispectral digital camera and maintenance ($4974)	
Hobo water level loggers (4 @ $495 each)	
Soil Testing at University of Minnesota Research Analytical lab	
Lab and analysis cunsumbables including water filters, labels, chemicals for water analyses, nutrient extractions, etc.	
Field supplies including materials for sensor installation	
Travel:	$ 6,553
Travel to field site in Olivia, MN. 20 trips x year x 3 years x 200 miles round-trip x $0.54/mile	
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 159,833

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	$ 37,000	*Secured*
University of St. Thomas ($37,000). Support for two work-study students (40 hrs/week in summer, 10 hrs/week in academic year); $5000 annually in internal research funding.		
Other State $ To Be Applied To Project During Project Period:	N/A	
In-kind Services To Be Applied To Project During Project Period:	$ 14,990	*Secured*
Sentera ($14,990). In-kind support for training, testing, sensor integration, and data processing.		
Funding History:	N/A	
Remaining $ From Current ENRTF Appropriation:	N/A	



We will quantify the changes in yield, N-use efficiency, and N loss via drain tiles, from corn produced using next-generation precision agriculture compared to conventional management.

Project Manager Qualifications and Organization Description

Gaston Small, University of St. Thomas – Dr. Small is an ecosystem ecologist whose research focuses on nutrient cycling in agro-ecosystems, and in mitigating the effects of nutrient pollution in rivers and lakes. He is an assistant professor in the Biology Department at the University of St. Thomas (2012-present), and has published 22 peer-reviewed articles since 2008. He has served as a reviewer for 25 different scientific journals, and has served on review panels for the National Science Foundation, the US Environmental Protection Agency, and the Wisconsin Water Resources Institute. He previously worked as a postdoctoral researcher at the University of Minnesota on a series of projects studying nutrient dynamics in the Great Lakes. Dr. Small received his Ph.D. in Ecology from the University of Georgia in 2010.

In the proposed project, Dr. Small will be responsible for experimental design, overseeing measurements of nitrogen export from fields, and for communicating project results.

The University of St. Thomas – The largest private university in Minnesota (11,000 students and 461 full-time faculty), UST combines liberal arts education and career preparation, with a focus on solving community problems through education and service-learning programs. 56% of UST students receive need-based *scholarship or grant* aid. UST offers bachelor's degrees in 85 major fields of study and 45 graduate degree programs, and is ranked as a National University. UST's Science Division has ca $5.7 million of capital equipment, nearly half of which is owned/maintained by Biology. Faculty members in Biology receive $5000 annually to support research, plus additional funds to hire two full-time undergraduate researchers each summer. UST also offers stipends and housing grants for student research during the academic year and summer.