Environment and Natural Resources Trust Fund
2015 Request for Proposals (RFP)

Project Title: **ENRTF ID: 042-B**

Reducing Nitrogen Pollution in Groundwater with Perennial Grasses

Category: B. Water Resources

Total Project Budget: $ 482,186

Proposed Project Time Period for the Funding Requested: 2 years, July 2015 - June 2017

Summary:

Measuring the environmental benefits and economic viability of perennial grass crops: quantifying reductions in nitrogen leaching to groundwater, seed/grain yield, and biomass of switchgrass, native prairies, and perennial wheat.

Name: Craig Sheaffer

Sponsoring Organization: U of MN

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Location

Region: NW, SW, SE

County Name: Polk, Redwood, Waseca

City / Township: Waseca, Lamberton, Crookston

Alternate Text for Visual:

Quantifying the "nitrogen budget" of perennial grass crops to mediate nitrogen pollution to groundwater. Perennial grass crops provide environmental benefits by decreasing nitrogen loss to groundwater. They can also be economical because they require less nitrogen fertilizer and can save on costs needed to clean groundwater of nitrate.

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

PROJECT TITLE: Reducing nitrogen pollution in groundwater with perennial grasses

I. PROJECT STATEMENT

Nitrogen leaking from agricultural fields degrades the health of Minnesota waters; however, nitrogen fertilizer is needed for the high yields that support Minnesota's current agricultural economy. Perennial grasses – with their extensive root systems and limited fertilizer needs – present a way to slow the nitrogen leak while maintaining the economy. We will measure the flow and fate of nitrogen fertilizer and biomass production of three ecologically inspired perennial systems – **switchgrass**, **native polyculture grasslands** and **perennial wheat** (aka intermediate wheatgrass) – and compare the results to conventional corn systems. We will quantify the reduction in nitrogen pollution to groundwater by perennial crops, and then estimate the economic value of that reduction. We will also measure the economic value of seed and biomass from perennial crops for both grain and bioenergy markets. Using an existing network of research sites across Minnesota, we will measure nitrogen inputs (e.g. fertilizer), outputs (e.g. leaching), and concentrations in the major sinks: the atmosphere, harvestable plant tissue, root tissue, soil, and water. We will develop a "nitrogen budget" for these new perennial crops and corn to learn where conserved nitrogen fertilizer accumulates and to determine how much is lost to groundwater via leaching.

Nitrogen leaching from cornfields is substantial. For example, in 2010, Minnesota farmers invested in and applied more than 800 million pounds of nitrogen fertilizer to corn (NASS 2014), of which only about 40% was recovered for food or fuel production. The remaining 60% (or about 480 million pounds) did not contribute to agricultural productivity, and accumulated in the soil, was lost to air, or leaked into water, where it can act as a pollutant. Residents of Park Rapids, MN are paying $2.5 million for a new water treatment facility to remove nitrates from groundwater, and other communities are faced with similar economic challenges. It is not known how much of this cost could be offset by changing land use practices to perennial crops, but our project will produce information to estimate potential savings. Perennial crops require less nitrogen fertilizer and are more efficient at capturing applied nitrogen compared to annual crops, thus maximizing the farmers' initial investment in nitrogen fertilizer.

The ecological benefits of perennial crops can only be gained if they are economically viable. Along with the economic benefits of perennial grasses related to preventing nitrate pollution, we will measure the economic value of agricultural products produced from these systems as they relate to multiple biomass markets. We recognize that the bioenergy market cannot solely support perennial crops at this time, but it exists as a future possibility. Our perennial wheat has been specifically bred to produce high grain yields for food production. Following grain harvest, leftover biomass from stems and leaves can be harvested for bioenergy without depleting soil as corn does. Similarly, seeds can be harvested from switchgrass and native grasslands and sold prior to harvesting the remaining biomass for energy. We will estimate economic viability based on 1) the values of agricultural products such as seed and biomass, and 2) estimates of cost savings realized by more efficient nitrogen use by perennial crops. This project will generate quantitative information on nitrogen budgets for perennial and corn crops, which we will use to measure economics of these systems so that state and federal agencies, farmers, and the broader public can make ecologically and economically sound decisions to reduce nitrogen pollution in Minnesota's groundwater.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Track the flow and fate of nitrogen in perennial and conventional systems* **Budget: $ 382,500**

We will measure the amount of nitrogen in harvestable biomass, roots, soil, atmosphere, and water in switchgrass, native grasslands, perennial wheat, and conventional corn. Accounting for all of these pools, we can assess the nitrogen use efficiency, loss, and potential mediation of groundwater contamination.

Outcome	Completion Date
1. Develop a nitrogen budget for perennial crops and corn	*Summer 2017*
2. Report groundwater nitrate reduction in perennial crops compared to corn	*Summer 2017*

Activity 2: *Quantifying productivity and economic value of perennial systems* **Budget: $ 64,620**

We will measure biomass from each plant system as it pertains to two different markets; grain for food and restoration and biomass for renewable energy. We will estimate cost savings related to nitrogen use efficiency for farmers and prevented groundwater nitrate contamination.

Outcome	Completion Date
1. Measure seed and grain yield from perennial crops and corn.	*Fall 2016*
2. Measure herbaceous biomass yield from perennial crops and corn.	*Fall 2016*
3. Evaluation of economic savings by prevented nitrogen leakage	*Summer 2017*

Activity 3: *Data analysis and reporting* **Budget: $ 35,066**

Data will be analyzed and reported in media forms appropriate for multiple audiences. We will submit our findings to peer-reviewed journals. We will develop "fact-sheets" for both state and federal agencies and for growers that highlight the ecological and economic benefits of perennial crops.

Outcome	Completion Date
1. At least two peer-reviewed papers describing the nitrogen budget of perennial crops	*Summer 2017*
2. At least four informational fact-sheet for various Minnesota agencies and growers	*Summer 2017*

III. PROJECT STRATEGY

A. Project Team/Partners

This project will involve an interdisciplinary team from sectors of academia, state, and federal agencies. The University of Minnesota (UMN) will lead the project with collaborations from USGS and USDA.

- Project Manager: Dr. Craig Sheaffer, UMN. No salary.
- Collaborator: Dr. Jacob Jungers, UMN. Salary.
- Collaborator: Jared Trost, USGS. Salary.
- Collaborators: Dr. Donald Wyse, Dr. Clarence Lehman, Dr. John Nieber, UMN. No salary.
- Collaborator: Dr. John Baker, USDA-ARS. No Salary
- Collaborator: David Wall, MPCA. No salary.

B. Project Impact and Long-Term Strategy

Our research on perennial plants will address LCCMR's priority area of improving water and land use practices. The long-term strategy is to expand the acreage of perennial land cover to maximize ecosystem services such as water quality, pollinator habitat, and renewable energy. This project has a potentially large impact because it builds on previous research and existing infrastructure. The proposed study will take place across a network of existing research sites in Minnesota; therefore the results will be applicable for various regions of the state. The perennial systems are currently established in research plots at Lamberton, Waseca, and Crookston, MN and are ready to be instrumented and monitored in new ways. General Mills, Inc. has supported preliminary research on perennial wheat, thus increasing the market value of this new crop. Previous LCCMR and external funding have supported research on the use of native grasslands for bioenergy and we will apply these results to the proposed research. This project is part of the Forever Green Initiative, an effort to develop new perennial-based cropping systems that provide essential ecosystem services such as N cycling while enhancing the prosperity of Minnesota agriculture. The Forever Green Initiative is broad in scope and provides a long-term strategy, but its success depends on focused research projects like the study proposed here.

C. Timeline Requirements

The project will begin during the summer of 2015. Fields with the proposed treatments are in place but not yet instrumented. Water quality and nitrogen flux instrumentation will occur in 2015. A subset of data will be collected in fall of 2015. Full-scale data collection will begin in spring of 2016 and will continue into fall of 2016. Data will be analyzed and prepared for publication by summer of 2017.

2015 Detailed Project Budget

Project Title: Reducing nitrogen pollution in groundwater with perennial grasses

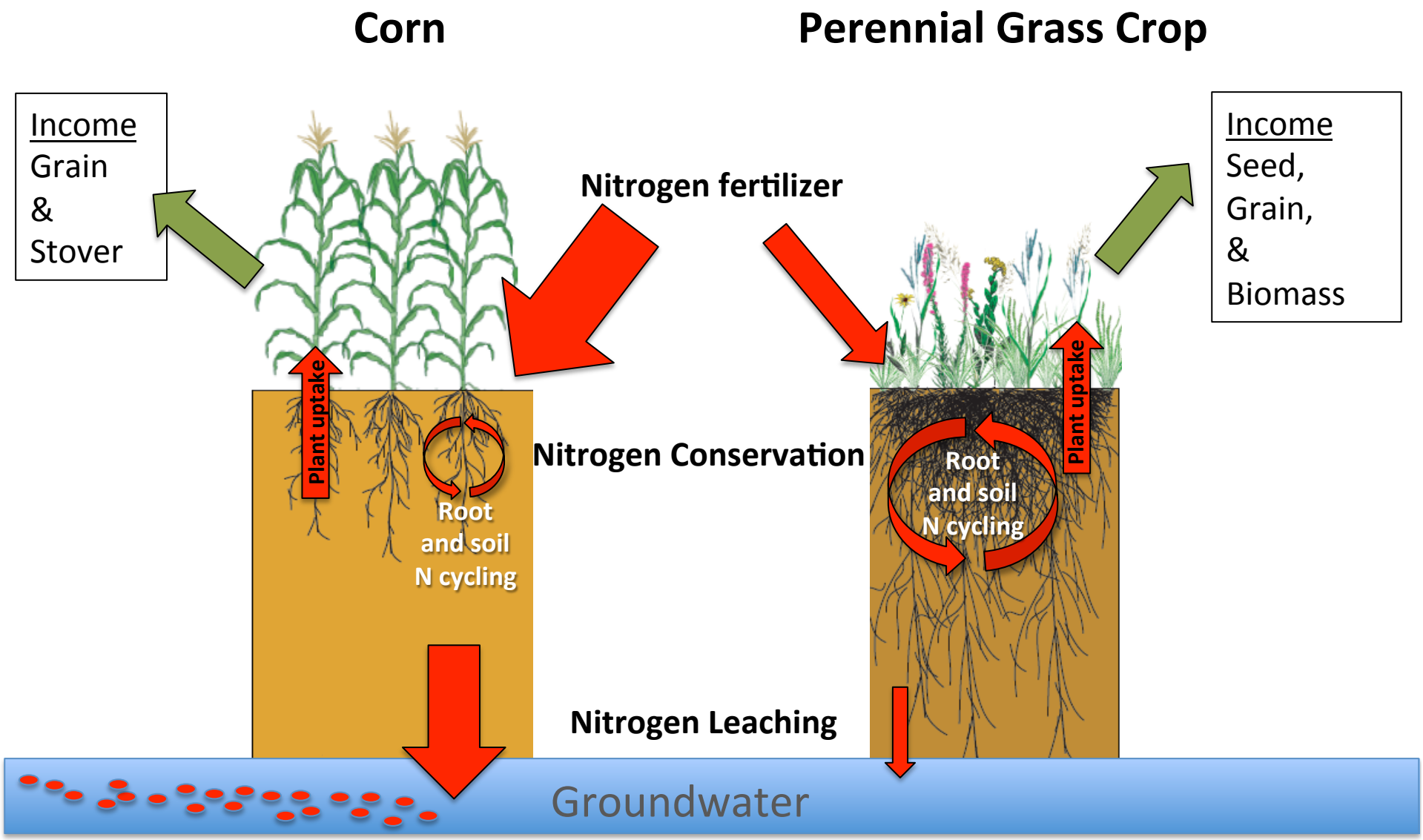
IV. TOTAL ENRTF REQUEST BUDGET 2 **years**

BUDGET ITEM	AMOUNT
Personnel:	
Jacob Jungers, post-doctoral researcher (83% salary, 17% benefits); 100% FTE for 2 years.	$ 111,090
Field manager (73% salary, 27% fringe); 50% FTE for 2 years.	$ 49,428
Graduate Student (56% salary, 44% fringe); 100% FTE for 2 years.	$ 107,263
Field Intern (91% salary, 9% fringe); 100% FTE for 2 years.	$ 59,130
Contracts:	
Jared Trost, USGS hydrologist (69% salary, 31% fringe); 25% FTE for 2 years	$ 51,950
National QA/QC and database support	$ 12,000
Nitrogen Isotope analysis: 600 samples at ($38/sample)	$ 22,800
Travel and lodging: 5 days ($50/day per diem and $83/night lodging) + 1600 miles ($0.56/ mile)	$ 1,700
Field supplies (sampling vials, QA/QC materials, field analytical supplies)	$ 1,200
Shipping of materials and samples	$ 1,350
Equipment/Tools/Supplies:	
Materials for nitrogen gas exchange enclosures (pvc, adhesives, tubing) - $2000	$ 2,000
Lysimeters/piezometers: 36 at $105 each	$ 3,780
Soil moisture sensors: 54 at $85 each	$ 4,590
Soil chemical analysis: 500 total nitrogen ($11/sample) & inorganic nitrogen ($5/sample) samples	$ 8,000
Plant chemical analysis: 100 biomass and 800 root samples (total nitrogen @ $11/sample)	$ 9,900
Bromide tracer supplies: Bromide probe 1 at $700, vials and disposables ($100); inorganic N ($5/sample) for 2500 samples, 11 kg bromide at $51/kg	$ 13,860
Nitrogen gas flux analysis: 700 gas chromotography samples ($5/sample)	$ 3,500
Soil water chemical analysis: 500 inorganic nitrogen ($5/sample)	$ 2,500
Nitrogen mineralization: 325 samples inorganic nitrogen ($5/sample)	$ 1,625
Travel: Travel and lodging to Lamberton, Waseca, and Crookston throughout the growing season to collect samples. Per diem and lodging for 40 nights ($40/day per diem and $83/night lodging) +	$ 10,520
Additional Budget Items: Publication costs for 2 papers and 4 reports	$ 4,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 482,186

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: If awarded, the USGS will provide a 30% match for their subcontract portion of this project.	$ 27,000	*Pending*
Other State $ To Be Applied To Project During Project Period: Proposal submitted to the Minnesota Department of Agricultures NextGen process to support bioenergy production and ecosystem service monitoring of perennial crops.	$ 81,600	*Pending*
In-kind Services To Be Applied To Project During Project Period: Land rental expenses will be covered as in-kind match by UMN CFANS: $10,000. PI and co-PI salaries will be covered as in-kind	$ 50,000	*Secured*
Funding History: Funding from the UMN IonE was awarded to initate a breeding program, field plot establishment, and initial agronomic testing on new variaties of Intermediate Wheatgrass. Grant period: 9/2011 to 6/2016.	$ 695,000	Secured
Remaining $ From Current ENRTF Appropriation:	$ -	*NA*

Perennial grass crops have potential to reduce nitrogen pollution in groundwater while providing farmers with income from seed/grain and bioenergy



Perennial grass crops provide environmental benefits by **decreasing nitrogen loss to groundwater**. They can also be economical because they require less nitrogen fertilizer and can **save on costs needed to clean groundwater of nitrate**.

PROJECT TITLE: Using perennial crops to mediate nitrogen pollution

I. Manager Qualifications: Dr. Craig Sheaffer

Dr. Craig Sheaffer is a Professor in the Department of Agronomy and Plant Genetics at the University of Minnesota. He has been studying native and domesticated perennial crops and organic agriculture at the University of Minnesota since 1977. He has served as the director of the Sustainable Agriculture Program and advised graduate students in Applied Plant Sciences, Agronomy and Plant Genetics, and the Conservation Biology Graduate Programs. Dr. Sheaffer has won numerous national awards for both agricultural research and teaching, and is a fellow for the American Society of Agronomy and the Crop Science Society of America. He teaches undergraduate classes in sustainable agriculture and food production systems. Currently, his research is focused on risk analysis of alternative cropping systems and the bioenergy potential of native grassland and agroforestry systems.

Dr. Sheaffer established and maintains a comprehensive laboratory on the St. Paul campus that employs full-time scientists and undergraduate technicians. His lab is one of only a few in the state that has the tools and expertise to estimate bioenergy potential of grassland biomass using near-infrared spectroscopy. His lab team conducts field research on grassland bioenergy at sites across Minnesota. Some relevant publications from his research include:

Jungers, J.M., **C.C. Sheaffer**, J.E. Fargione, and C. Lehman. 2014. Short-term harvesting of conservation grasslands maintains plant diversity. Global Change Biology: Bioenergy. Accepted for publication.

Jungers, J.M., J.E. Fargione, **C.C. Sheaffer**, D.L. Wyse, and C. Lehman. 2013. Energy potential of biomass from conservation grasslands in Minnesota, USA. PLoS ONE 8(4): e6 1209. Doi:10.1371/journal.pone.0061209

Gilitzer, P.A., D.L. Wyse, **C.C. Sheaffer**, S.J. Taff, and C. Lehman. 2012. Biomass production potential of grasslands in the oak savanna region of Minnesota, USA. Bioenergy Research: DOI 10.1007/s12155-012-9233-z.

Gilitzer, P., A.C. Martin, M. Kantar, K. Kauppi, S. Dahlberg, D. Lis, J. Kurle, **C. Sheaffer**, and D. Wyse. 2012. Optimization of screening of native and naturalized plants from Minnesota for antimicrobial activity. J. Medicinal Plants Res 66:938-949.

Mangan, M. M., **C.C. Sheaffer**, D. L. Wyse, N.J. Ehlke, and P. Reich. 2011. Establishment and productivity of native perennial polycultures for biomass. Agron. J. 103:509-519.

II. Organization description: University of Minnesota

The University of Minnesota is the state's main research and graduate teaching institution. Our university has been repeatedly ranked number-one in the nation for Ecology/Environment, based on the citational influence of its scientific publications.