Environment and Natural Resources Trust Fund
2012-2013 Request for Proposals (RFP)

Project Title: **ENRTF ID: 141-I**

Removing Pesticides and Nitrate with Optimized Wetlands

Topic Area: I. Water Resources

Total Project Budget: $ 323,841

Proposed Project Time Period for the Funding Requested: 3 yrs, July 2013 - June 2016

Other Non-State Funds: $ 0

Summary:

This project will remove pesticides and nitrate in restored wetlands that are optimized for solar and biological treatment processes based on loading, depth, and location of wetlands on the landscape.

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Sponsoring Organization: U of MN

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Location

Region: SW

County Name: Blue Earth, Nicollet, Redwood

City / Township:

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

PROJECT TITLE: Removing pesticides and nitrate with optimized wetlands

I. PROJECT STATEMENT

The Minnesota River derives large and important economic benefits from agriculture. However, agricultural drainage/runoff carries with it nitrogen and pesticides (a term that includes both insecticides and herbicides) that become pollutants when they reach receiving waters. To meet mandated water quality requirements, the loads of nitrogen and pesticides must be reduced. New proposed water quality standards for nitrate will be especially difficult to meet with traditional on-farm practices (nutrient management). Wetland restoration is touted as a means to capture drainage/runoff to reduce flooding and improve water quality. Small areas of the landscape can be used for wetland restoration. The specific parameters (e.g., area, depth, retention time) that lead to optimum treatment for removal of pesticides and nitrate are poorly understood. The goals of this work are to take advantage of natural solar and biological processes to remove pesticides and nitrate for improved water quality and to provide guidance for the design of restored wetlands based on hydraulic and pollutant loading, depth of the wetland, and location on the landscape. The implementation of properly sited and designed restored wetlands to collect and treat pesticides and nitrate will improve water quality in Minnesota's streams and rivers, reduce peak flows during storm events, and provide habitat for waterfowl and other wildlife. There are aesthetic benefits of restored wetlands, as well.

The benefits of this project will be

- Specific guidelines for wetland depth, area, and holding time to treat nitrate and pesticides
- Optimization of processes for nitrate and pesticide removal, and
- Improved selection of sites to target for wetland restoration.

II. DESCRIPTION OF PROJECT ACTIVITIES

Activity 1: Solar destruction of pesticides **Budget: $180,830**

Sunlight can destroy pesticides. This happens via two processes. The first is direct destruction by the light itself, and the second is destruction of the pesticides via reaction with highly reactive species that are generated when the light interacts with other dissolved constituents in the water. The relative importance of these two processes is not well understood. In this task, we will determine how the presence of specific dissolved constituents affects pesticide loss under sunlight. Using waters collected from three sites (restored wetlands receiving agricultural drainage in Seven Mile Creek (Nicollet County) and Elm Creek (Blue Earth County) as well as runoff from a farm along Plum Creek (Redwood County)) and pilot scale field experiments, we will conduct studies of herbicides from five different classes to determine the solar processes that dictate their removal and how to optimize these processes through wetland design. Key design parameters will be wetland area and depth, which dictate the amount of water exposed to light and light penetration efficiency. The wetlands are non-vegetated treatment wetlands, although emergent vegetation may grow at the edges. While sunlight is expected to be the major driver of pesticide removal, we will also investigate processes occurring in the wetland sediments.

Outcome	Completion Date
1. Water collection and characterization (seasonally)	4/31/14
2. Determine pesticide removal rates and relevant processes	7/31/15
3. Pesticide destruction in wetland sediments	7/31/15
4. Wetland design to optimize pesticide destruction process	1/31/16

Activity 2: Nitrogen removal with bio-fiber mats **Budget: $115,403**

Nitrogen export is a major water quality concern in the entire Mississippi River basin. New water quality standards will mean that new technology is needed to supplement traditional Best Management Practices. Nitrate conversion to harmless nitrogen gas is mediated by bacteria during a process known as denitrification. To successfully remove nitrate, a carbon rich environment must be provided so that

bacteria can thrive by building a biofilm along the surface of the carbon source. We propose to use a mat made of plant fibers which is installed along the bottom of the wetland. We will begin with coir (coconut fiber) which is used for erosion control, but will also investigate locally sourced materials such as wheat straw and wood chips. Coir has been used successfully in studies located in Asia to remove nitrate and pesticides from contaminated water. It is more effective than other carbon sources such as activated carbon, wheat straw, or cotton fiber because it is more permeable and more amenable to formation of bacterial biofilms than other carbon sources. Wetlands with fiber mats are expected to be much more effective at removing nitrate and pesticides than wetlands without fiber mats. Using the same wetland/runoff sites proposed for Activity 1, we will conduct laboratory column experiments and a pilot field study to develop protocols for implementation of the bio-fiber mats to maximize nitrate removal in agricultural drainage waters.

Outcome	Completion Date
1. Identify most effective bio-fiber mat materials in laboratory experiments	9/30/14
2. Measure bio-fiber mat removal efficiencies in existing wetlands 3. Develop recommendations for use and installation of bio-fiber mats in wetlands	6/30/16

Activity 3: Site selection optimization **Budget: $27,608**

Having design guidelines regarding flow rate and depth is critical for optimizing wetland performance. Finding appropriate sites to build the wetlands is also essential. Sites must have the appropriate land surface shape and must also have appropriate connections to drainage. In a previous ENRTF project, Dr. Mulla developed a method to select sites in three watersheds, but the method will need to be extrapolated to other watersheds and updated to include optimization of water quality. These tasks will be conducted during the final year of the project.

Outcome	Completion Date
1. Develop and test protocols to identify sites where wetland restoration leads to significant removal of nitrate and pesticides	1/31/16
2. Protocols to identify sites for wetland restoration/pollutant removal	6/30/16

III. PROJECT STRATEGY

A. Project Team/Partners

The project team consists of the Principal Investigator (PI) David Mulla (University of Minnesota, Soil, Water & Climate) and the co-PI William Arnold (UMN, Civil Engineering). Mulla will provide guidance on the bio-filter mats for nitrate removal, and he will lead the site selection/optimization efforts. Arnold will be responsible for the portion of the project focused on solar destruction of pesticides. He also will assist on the nitrate removal studies. The collaborative effort is necessary to develop a holistic guide for reconstructed wetland design.

B. Timeline Requirements

The proposed project will be completed in the allotted three-year period

C. Long-Term Strategy and Future Funding Needs

Arnold has extensive experience in studying the solar destruction of various pollutants and the detection of dissolved reactive species responsible for such reactions. He has also determined mechanisms of pesticide removal in groundwater and in lake sediments. Mulla has extensive experience in testing alternative practices for removal of agricultural pollutants. He also has extensive experience in identifying sites on the landscape where the efficiency of pollutant removal can be optimized. The long term goal is to develop a a method to select sites for wetland restoration and provide wetland design considerations based on water flow, water quality goals, and pollutant levels.

2012-2013 Detailed Project Budget

IV. TOTAL ENRTF REQUEST BUDGET: 3 years

BUDGET ITEM	AMOUNT
Personnel: Arnold (PI, 8% time per year, salary 83% of cost, fringe benefits 17% of cost). Project supervision, and responsibility for the portion of the project focused on solar destruction of pesticides. Assist on the nitrogen removal studies, and supervision of graduate student #2 and project reporting.	$ 37,819
Personnel: Graduate student #1 (50% time during academic year, 50% time in summer; 57% salary, 31% tuition, 12% fringe benefits). Conducting nitrogen removal experiments and site location/design optimization.	$ 126,261
Personnel: Graduate student (50% time during academic year, 50% time in summer; 57% salary, 31% tuition, 12% fringe benefits). Conducting solar pesticide removal evalutions, water collection and characterization, and site location/design optimization.	$ 126,261
Equipment/Tools/Supplies: Supplies (biofiber mats, pesticide standards, instrument/analytical time, solvents, consumable supplies, notebooks, software licenses; $23,500 total). Instrument maintenance and repair ($6,000 total)	$ 29,500
Travel: Mileage charges and univeristy vehicle rental charges for trips to the three field sites for sample collection and conducting pilot experiments. $4,000 total.	$ 4,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 323,841

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ Being Applied to Project During Project Period: none	$ -	
Other State $ Being Applied to Project During Project Period: none	$ -	
In-kind Services During Project Period: Mulla (PI, 2% time per year in kind, $12,333). Project supervision, provide guidance on the bio-filter mats for nitrogen removal, and he will lead the site selection/optimization efforts. Supervision of graduate student #1 and project reporting. Mulla is on 12 month contract and does not require LCCMR salary support. Arnold will also devote 1% time per year in kind ($4914).	$ 17,247	
Remaining $ from Current ENRTF Appropriation (if applicable): no prior projects directly related to proposed project	$ -	
Funding History: none	$ -	

Wetlands can remove agricultural pollutants

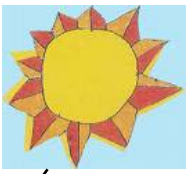
Before wetland restoration

Direct discharge to surface water

Nitrate
Herbicides

Stream receiving polluted water

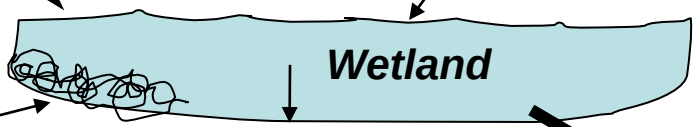
After wetland restoration



Sunlight destroys herbicides

Discharge captured by wetland

Nitrate
Herbicides



Nitrate removed In bio-fiber mat

Clean water released from wetland

Stream receiving clean water

http://www.lm.doe.gov/land/sites/oh/fernald_orig/Future/restp.htm

Benefits

- Reduced toxicity to fish and animals
- Better water clarity
- Reduced algal blooms
- Restored habitat

Project Manager Qualifications and Organization Description

Project Manager: David Mulla

Current Position: Professor and Larson Chair for Soil and Water Resources; Dept. Soil, Water & Climate; University of Minnesota. This department is ranked nationally in the top 5 for research productivity and quality on soil, water and environmental quality issues.

Education:

- Ph.D (1983) Purdue Univ.; W. Lafayette, IN
  - Agronomy with emphasis on Soil Physics
- MS: (1981) Purdue Univ.; W. Lafayette, IN
  - Agronomy with emphasis on Soil Chemistry

Experience:

Twenty nine years experience in research on soil and water resources at two Land Grant Universities (Washington State Univ. 1983-1995; Univ. Minnesota 1995-present). Appointed Founding Fellow to Univ. MN Institute on Environment in 2007. Elected Fellow Soil Science Society of America (1997) and Fellow American Society of Agronomy (1999). World Pioneer in research on Precision Agriculture and Precision Conservation. Co-leader of Energy Production and Use Team for LCCMR Statewide Conservation Plan (2008). Member, Scientific Advisory Panel for Lake Pepin TMDL Process, St. Paul, MN. (2005-present). Member, Gulf of Mexico Hypoxia Task Force for White House Committee on Environment and Natural Resources, (1998). Team Leader Environ. Quality Board GEIS Animal Agriculture Water Quality Impacts (1999-2001). Published 130 refereed articles on Soil and Water Resources in scientific journals. Awarded over $16 million in scientific research grants. Invited to present research findings at conferences and workshops in 25 countries around the world.

--Major projects have included:

- Integrated modeling and management of the Minnesota River Basin. Funded by NSF/EPA for $813,000 from 1996-1999.
- Sustainable farming systems. Funded by LCCMR for $910,000 from 1997-2001.
- Generic Environmental Impacts Study of Animal Agriculture. Funded by Environ. Quality Board for $132,000 from 1999-2001.
- Paired watershed nutrient reduction strategies. Funded by USDA-CSREES for $539,000 from 2001-2005.
- Minnesota Statewide Conservation and Protection Plan. Funded by ENRTF for $496,000 from 2007-2008.
- Statewide ecological ranking of CRP and other critical lands. Funded by ENRTF and Emerging Issues Fund for $275,000 from 2009-2011.
- Strategic planning for MN natural and artificial watersheds. Funded by ENRTF for $327,000 from 2010-2012.

Organization Description

The University of Minnesota is both the state land-grant university, with a strong tradition of education and public service, and the state's primary research university