Environment and Natural Resources Trust Fund
2020 Request for Proposals (RFP)

Project Title: **ENRTF ID: 215-F**

Lignin-coated Fertilizers for Phosphate Control

Category: F. Methods to Protect, Restore, and Enhance Land, Water, and Habitat

Sub-Category:

Total Project Budget: $ 279,382

Proposed Project Time Period for the Funding Requested: June 30, 2022 (2 yrs)

Summary:

This project will test a new natural slow-release fertilizer coating made from processed wood, which will decrease phosphorus runoff from farmland while also storing carbon in soils.

Name: Eric Singsaas

Sponsoring Organization: U of MN - Duluth NRRI

Job Title:

Department: Natural Resources Research Institute

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Duluth MN 55811

Telephone Number: (218) 788-2648

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Web Address: https://www.nrri.umn.edu/strategic-research/wood-products-bioeconomy

Location:

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Problem=Eutrophication; Innovation=Biodegradable Fertilizer Coatings; Impact=Reduced Runoff and Stored Carbon

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

PROJECT TITLE: Lignin-coated fertilizers for phosphate control

I. PROJECT STATEMENT

This proposed project will provide a real-world test of a novel, bio-based, fertilizer coating that slows nutrient release to reduce nutrient runoff from agricultural fields. Anthropogenic phosphorus pollution is reaching dangerously high levels in freshwater basins around the world, with mineral phosphate fertilizers from cereal grain farming being among the largest contributing sources[1]. Phosphorus is a common component of both mineral and manure fertilizers because it is necessary to achieve high crop yields necessary to support conventional family farms in Minnesota. However, a large portion of phosphorus applied as fertilizer is not taken up by plants, and either builds up in the soil or washes into rivers, lakes and coastal seas. Minnesota has implemented policies aimed at reducing agricultural runoff through wetlands preservation and increased buffer strips around fields. Another way to reduce fertilizer runoff is to coat fertilizer particles in a material that controls water diffusion so that the nutrients are released slowly over time, giving the crop roots a chance to absorb the fertilizer before percolation and runoff can remove the product. There has been work on developing slow release fertilizers, but there remains a need to address issues of cost, performance, and effective implementation by farmers[2].

We are developing a technological solution to address this need. We have created a slow-release fertilizer coating made from lignin, a byproduct of cellulosic ethanol production. This form of lignin has properties that allow it to be processed like a plastic, yet it is a 100% natural and biodegradable material made from wood. We have developed formulations with this material that can be coated onto granulated fertilizers to control the rate of dissolution and thereby maintain a constant nutrient supply in fields without the need to over application. When the fertilizer is used up from a coated particle, the lignin coating becomes part of the slow-turnover carbon pool in the soil. Therefore, implementation of this technology throughout the agricultural sector has the potential both to decrease eutrophication and increase carbon sequestration.

At the end of this project, we will have demonstrated the scale-up of the coating process and have acquired necessary real-world data on the efficacy of this coating material to bring it to market. NRRI is working with the University of Minnesota Technology Commercialization office to patent the technology and identify commercialization partners. Likely partners would include Minnesota-based fertilizer distributer Mosaic for agricultural markets and Ohio-based Scotts for lawn and golf course markets. The results from this research program are essential to attracting high-profile commercialization partners such as these.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1 Title: Scale-up of lignin-material coated fertilizer and performance testing.

Description: *We will purchase 500 kg of granulated high phosphate fertilizer and apply our best-performing lignin-based coating, developed in collaboration with colleagues from the Technical University of Cologne, Germany. This work will be done at NRRI's prototype laboratory using a pilot spheronizer. We will produce sufficient quantities for all greenhouse testing in year 1. We will make formulation adjustments based on finding from greenhouse studies during scale-up for field production. We will contribute to greenhouse and field trials with chemical and statistical analyses and reporting.*

ENRTF BUDGET: $ 145,939

Outcome	Completion Date
1. Sample coated fertilizer for greenhouse testing	*December 2020*
2. Measurements of phosphate dissolution rate and comparison with uncoated fertilizers	*December 2020*
3. Scaled-up production of fertilizer	*April 2021*
4. Analyze samples and data from greenhouse and field performance	*June 2022*

Activity 2 Title: Assess high lignin coating impact on soils in greenhouse
Description: *A replicated (4 x) and repeated (2X) greenhouse experiment will assess the ability of lignin-coated fertilizer to provide P to agronomic an agronomic crop(s) as indicated by plant biomass accumulation at 30 days after planting. At the end of the study the amount of extractable P in the soil will be determined.*
ENRTF BUDGET: $54,015

Outcome	Completion Date
1. Greenhouse testing of lignin coated fertilizer	*April 2021*
2. Chemical analysis of extractable phosphorus from greenhouse study	*July 2021*

Activity 3 Title: Replicated field trials of lignin-coated fertilizer
Description: *Replicated plot-scale field testing will assess agronomic crop (s), wheat or corn response to incorporated lignin coated P fertilizer. The study will be repeat in space (at least 3-locations). Crop biomass and yield will serve as plant response indicators. Soil samples will be collected at two depth increments (0-15; 15-30 cm) at the end of the and assessed for extractable P.*
ENRTF BUDGET: $79,428

Outcome	Completion Date
1. Plot-scale field testing to assess agronomic crop response	*August 2021*
2. Soil sampling and processing	*October 2021*
3. Extractable phosphorus determination.	*December 2021*

III. PROJECT PARTNERS AND COLLABORATORS:

A. Partners receiving ENRTF funding

Name	Title	Affiliation	Role
Jane Johnson	Research Soil Scientist	USDA-ARS North Central Soil Conservation Research Laboratory	Field trial leader

B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
Mike Riebel	Vice President	Attis Innovations	Consultation
Dr. Stéphan Barbe	Professor	TH Köln	Consultation

IV. LONG-TERM IMPLEMENTATION AND FUNDING:

A key program deliverable is a product that will be sold into the agricultural fertilizer market. We will consult with Attis Innovations to develop a business plan to bring this into widespread use.

V. PROJECT TIMELINE:

This project will be completed in 2 years

1. Mekonnen MM, Hoekstra AY. Global Anthropogenic Phosphorus Loads to Freshwater and Associated Grey Water Footprints and Water Pollution Levels: A High-Resolution Global Study. *Water Resour Res*. 2018;54(1):345-358.
2. SHAVIV A, MIKKELSEN RL. Controlled-Release Fertilizers to Increase Efficiency of Nutrient Use and Minimize Environmental Degradation - a Review. *Fertilizer Research*. 1993;35(1-2):1-12.

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Eric Singsaas
Project Title: Lignin-coated fertilizers for phosphate control
Organization: University of Minnesota Duluth
Project Budget: $279,382
Project Length and Completion Date: 2 years (completed 06/30/2022)
Today's Date: 04/06/2019

	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 157,485	$ -	$ 157,485
Eric Singsaas (NRRI, Project Manager); $73,777 (74% salary, 26% benefits), 20% FTE each year for two years.			
Matthew Young (NRRI, coatings and fertilizer scale-up); $22,140 (77% salary, 23% benefits), 25% FTE year 1 and 10% FTE year two.			
Oksana Kolomitsyna (NRRI, chemical analysis to evalate fertilizer performance); $21,985 (74% salary, 26% benefits), 20% FTE year 1, 10% FTE year 2.			
Timothy Hagen (NRRI, coatings and agglomeration development); $39,583 (74% salary, 26% benefits), 15% FTE each year for two years.			
***Note: NRRI research staff salaries are largely sponsored by external funds.**			
Professional/Technical/Service Contracts			
Contract with USDA-ARS Morris, MN to perform greenshouse and field trials.	$ 108,319	$ -	$ 108,319
	$ -	$ -	$ -
Equipment/Tools/Supplies			
Analytical reagents for phosphate measurement (ammonium molybdate, antimony potassium tartrate, ascorbic acid, sulfuric acid, sodium bisulfite, Ammonium persulfate, potassium sulfate)	$ 1,015	$ -	$ 1,015
Solvents and supplies for coatings scale-up (organosolv lignin, butanol, butyl acetate, acetic acid, spray equipment, acetone, sodium hydroxide)	$ 9,135	$ -	$ 9,135
	$ -	$ -	$ -
		$ -	$ -
Capital Expenditures Over $5,000			
	$ -	$ -	$ -
Fee Title Acquisition			
	$ -	$ -	$ -
Easement Acquisition			
	$ -	$ -	$ -
Professional Services for Acquisition			
	$ -	$ -	$ -
Printing			
	$ -	$ -	$ -
Travel expenses in Minnesota			
2 round trips for Singsaas/Young/Hagen from NRRI to Morris, MN (1 trip in year one, 1 trip in year two) to assist with setting up field testing and measurments. (500 miles round trip x $0.58/mile) + $94/day lodging + $192.50 per diem. (Travel is in accordance with UMN Policy.)	$ 3,428	$ -	$ 3,428
	$ -	$ -	$ -
Other			
	$ -	$ -	$ -
COLUMN TOTAL	$ 279,382	$ -	$ 279,382

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	**Status (secured or pending)**	**Budget**	**Spent**	**Balance**
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: $105,874 unrecovered F&A rate of 54% on MTDC of $196,063	secured	$ 105,874	$ -	$ 105,874

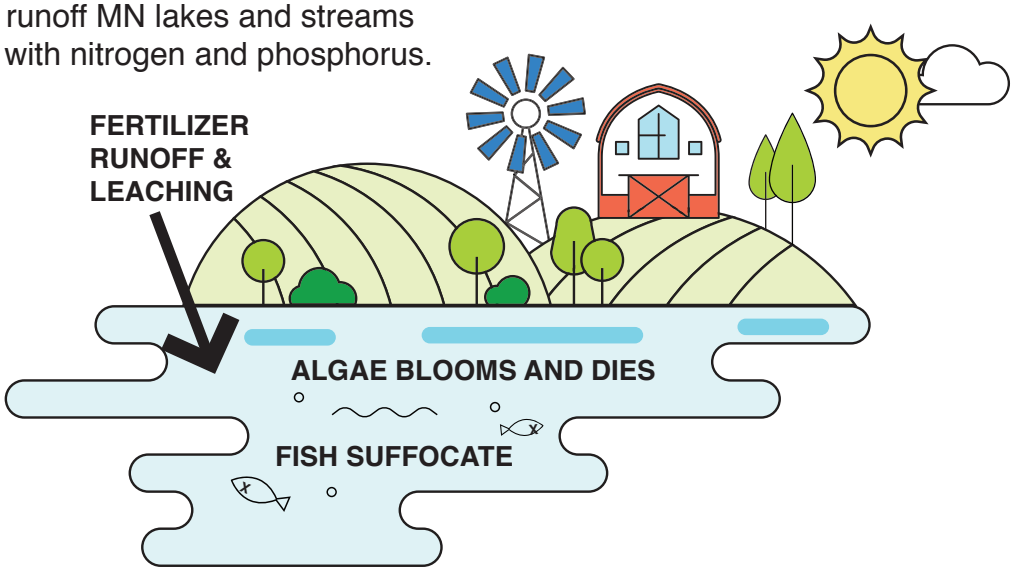
Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	**Amount legally obligated but not yet spent**	**Budget**	**Spent**	**Balance**
		$ -	$ -	$ -

PROJECT DESCRIPTION:

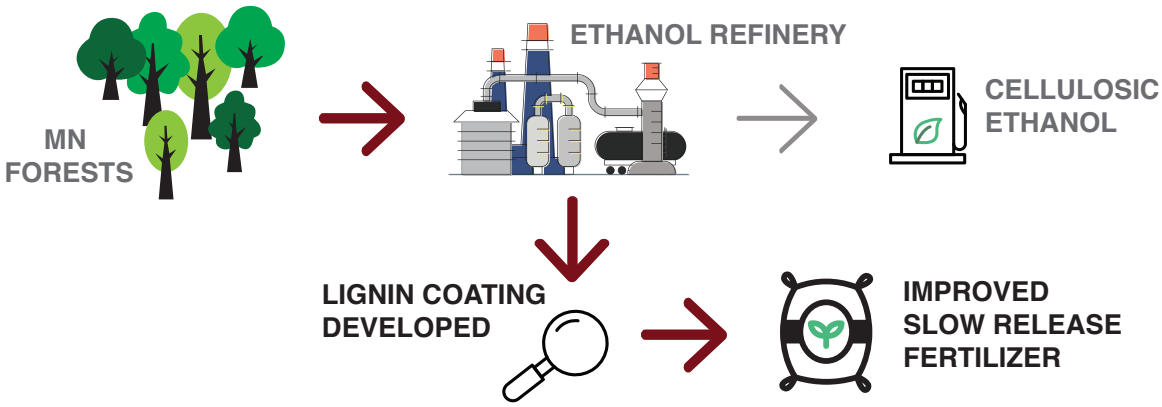
Biodegradable fertilizer coating designed to slow runoff, improve water quality and capture carbon in soil

Problem: Eutrophication

Due to fertilizer runoff MN lakes and streams are overloaded with nitrogen and phosphorus.



Innovation: Biodegradable Coating for Fertilizer Slows Runoff



Impact: Reduces Fertilizer Runoff, Directly Impacts MN Water Quality

- Utilizes a natural byproduct made by Minnesota biorefineries
- Empowers fertilizer applicators to use less overall fertilizer
- Stabilizes soil phosphate levels
- Addresses Minnesota's environmental need to reduce fertilizer runoff
- Sequesters carbon in agricultural soil
- Agricultural application process remains the same

PROJECT TITLE: Lignin-coated fertilizers for phosphate control

2020 LCCMR Project Manager Qualifications and Organization Description

Dr. Eric Singsaas, Natural Resources Research Institute, University of Minnesota Duluth

EDUCATION

Ph.D. 1997	University of Wisconsin – Madison	Plant Physiology and Biochemistry
B.A. 1992	Concordia College – Moorhead	Biology and Chemistry

RELEVANT RESEARCH EXPERIENCE

2009 – 2015 Research Director Wisconsin Institute for Sustainable Technology, University of Wisconsin Stevens Point

2001 – 2015 Professor of Biology, University of Wisconsin Stevens Point

2000 – 2001 Associate Research Scientist, University of Michigan

1998 – 2000 Postdoctoral Scientist, Department of Plant Biology, University of Illinois

KEY QUALIFICATIONS

Dr. Eric Singsaas is the Director for the Bioeconomy and Materials Research Group at the University of Minnesota's Natural Resources Research Institute. He holds a BA in biology and chemistry from Concordia College in Minnesota and a Ph.D. in plant physiology and biochemistry from the University of Wisconsin. Before joining the NRRI he was a professor of biology and forestry at the University of Wisconsin Stevens Point, where he co-founded the Wisconsin Institute for Sustainable Technology to promote economic development through innovation in the agricultural and forest products industry. He holds patents in woody biomass processing and bio-based chemical production from engineered microbes. In addition to applied technology development, Dr. Singsaas has more than 30 academic publications in the fields of plant-environment interactions and forest responses to climate change. He holds patents in biorefinery technology development and founded two bioeconomy spinout companies.

Dr. Singsaas will have chief management responsibilities for overseeing the proposed project. He will be responsible for working with NRRI staff scientists Oksana Kolomitsyna, Tim Hagen, and Matt Young, and collaborate with Dr. Jane Johnson of USDA-ARS in Morris to ensure that project goals, results, and timelines are met.

The Natural Resources Research Institute is a University of Minnesota applied research organization. NRRI's mission is to deliver research solutions to balance Minnesota's economy, resources and environment for resilient communities. The collective research and organizational experiences of the project team members and the resources available to this project from the University of Minnesota Duluth should ensure the successful completion of the proposed project goals.