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

Project Title: **ENRTF ID:** **105-E**

Optimizing Environmental and Economic Value of Harvested Cattails

Category: E. Air Quality, Climate Change, and Renewable Energy

Total Project Budget: $ 1,545,750

Proposed Project Time Period for the Funding Requested: 3 years, July 2015 - June 2018

Summary:

Cleaning water and creating green fuels and fertilizers utilizing two novel technologies which recycle nutrients and create green products from high-moisture cattails harvested in Red River basin flood retention structures

Name: Richard Hemmingsen

Sponsoring Organization: U of MN

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Location

Region: NW

County Name: Clay, Kittson, Marshall, Norman, Traverse, Wilkin

City / Township:

Alternate Text for Visual:

A biorefining model for processing cattails

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

PROJECT TITLE: Optimizing Environmental and Economic Value of Harvested Cattails

I. PROJECT STATEMENT

Significant efforts are underway in the Red River basin (Minnesota Legislative-Citizens Commission on Minnesota Resources, Red River Basin Commission, Mn Pollution Control Agency, International Red River Board, International Institute for Sustainable Development) to initiate a novel nutrient reduction strategy utilizing distributed flood storage reservoirs to grow and harvest emergent cattails (*typha spp*).

Cattails have demonstrated the potential for improving downstream water quality by capturing and retaining phosphorus. Some work is underway to harvest dry cattails and produce pellets as a bioenergy heating source. However, in order to maximize phosphorus retention, cattails must be harvested and removed from the watershed at relatively high moisture contents. This project will develop and evaluate two novel conversion technologies selected specifically for their ability to efficiently convert high moisture biomass, reclaim phosphorus and produce high value bioenergy products.

These efforts will enhance the prospects of developing this novel agro ecosystem management concept by concurrently improving water quality via nutrient reclamation and recycling and providing economic value from the feedstock as harvested. In concert with existing efforts, this work combines to help shape a unique agro ecosystem management concept that integrates distributed flood water storage, nutrient capture and recycling, and high value bioenergy feedstock production and conversion. This systems approach can transform the correlated flood and water quality risks in the RRB into a major sustainable development opportunity.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Utilizing Hydrothermal Carbonization (HTC) technology to capture and recycle phosphorus and create consolidated biochar, a renewable energy product **Budget: $ 615,805**

The HTC process utilizes relatively low temperatures and pressures to convert wet/slurry biomass into a solid biochar fuel. Plant phosphorus is captured as a soil amendment and the biochar product is suitable for commercial and residential solid fuel heating systems and has potential utility as a wood pellet binder. This activity will result in a pilot scale processing facility with a projected output of 50 – 100 kg/day.

Outcome	Completion Date
1. Develop pre-processing protocols to prepare cattail biomass for HTC processing	06/30/2016
2. Design, assemble and commission a HTC pilot plant for processing wet cattails	12/31/2017
3. Characterize and evaluate resulting product streams (biochar and phosphorus)	08/31/2018
4. Quantify mass and energy balance to inform Life Cycle Analysis (Activity 4)	12/30/2017

Activity 2: Developing an advanced microwave assisted gasification (fMAG) conversion technology to recycle phosphorus and create high value bioenergy products **Budget: $ 767,255**

This new gasification technology will yield two valuable product streams; syngas (for gaseous fuel or upgrading to liquid hydrocarbons) and biochar (containing minerals and P for recycling as a soil amendment). It is based on the same principles as microwave assisted pyrolysis (MAP) technology previously supported by ENTRF funding but utilizes much higher heating rates and temperatures and is better suited for conversion of wet biomass.

Outcome	Completion Date
1. Design and assemble prototype fMAG reactors with cattails as the feedstock	06/30/2016
2. Develop process protocols and process conditions for optimal product yields and quality	12/31/2017
3. Produce test batches, characterize and evaluate product streams	06/30/2018
4. Quantify mass and energy balance to inform Life Cycle Analysis (Activity 4)	06/30/2018

Activity 3: Quantifying content, bioavailibity, and mobility of phosphorus when soil applied as biochar co-products. **Budget: $ 72,030**

The economic value of the harvested cattail biomass is enhanced to the degree that the conversion co- products are an organic source of phosphorus for agricultural production. Utilizing a combination of chemical extractions and biological assays, this activity will assess nutrient bioavilability and soil mobility of residual phosphorus.

Outcome	Completion Date
1. Quantify P content and bioavailability from the fMAG residual biochar co-product stream	06/30/2018
2. Quantify P content and bioavailability from the HTC process residual co-product stream	06/30/2018
3. Evaluate nutrient mobility in soils when above products are utilized as a source of P	06/30/2018

Activity 4: Life Cycle Analysis (LCA), Economic Assessment **Budget: $ 90,660**

A life cycle assessment and analysis of market potential will be completed. The stages for life cycle analysis will include harvest, biomass conversion, and reuse of the biochar as a soil amendment. Environmental impacts for analysis will include energy performance, GHG emissions and eutrophication.

Outcome	Completion Date
1. Develop and adapt life cycle analysis model	12/31/2016
2. Complete impact analysis and evaluation of two technology scenarios	06/30/2018
3. Analysis of potential markets for conversion co-products	06/30/2018

III. PROJECT STRATEGY

A. Project Team/Partners

The project team includes faculty and staff in the University of Minnesota's Department of Bioproducts and Biosystems Engineering, Natural Resources Research Institute, and the Crookston Campus. Project collaborators include the Red River Basin Commission and the International Institute for Sustainable Development.

Project Team Members Receiving ENTRF Funds:

Team Cluster	Members/Roles & Responsibilities
Bioproducts and Biosystems Engineering	Richard Hemmingsen, M.Ed - Project PI and Project Manager **(Activities 1-4)**; Dr. Roger Ruan, Paul Chen - Research Associate Professor and graduate research assistants (TBD) **(Activity 1)**; Dr. Jason Hill and research associate (TBD) **(Activity 4)**
Natural Resources Research Institute	Don Fosnacht, PhD – Director; Andriv Khotkevych, - Research Associate; Thomas Levar – Scientist; T Hagen – Coordinator, Lab Technicians (TBD) **(Activity 2)**
UofM Crookston	Dr. K. Nannenga, students (TBD) **(Activity 3)**

B. Project Impact and Long-Term Strategy

The proposed technologies build upon previous research and development investments by the University of Minnesota's Initiative for Renewable Energy and the Environment (IREE), and the LCCMR by demonstrating the concepts of an integrated biorefinery, and providing a model for a robust bioeconomy for Minnesota. It is envisioned that these technologies will be applicable to a wider range of potential biomass feedstocks.

C. Timeline Requirements

The project is three years in duration commencing in July, 2015 and concluding on June 30, 2018. Following first year equipment set-up and calibration this schedule will permit conversion of two years' harvest of cattails in late summer of 2016 and 2017 with sufficient time for equipment optimization and subsequent analysis.

2015 Detailed Project Budget

Project Title: Optimizing Environmental and Economic Value of Harvested Cattails

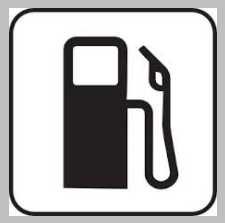
IV. TOTAL ENRTF REQUEST BUDGET *3* **years**

BUDGET ITEM	AMOUNT
Personnel: Activity One: Fosnacht, 0.05FTE (75% salary/25% fringe) - $29,500; Khotkevych 0.40 FTE (75% salary/25% fringe) - $81,400; Hagen, 0.20 FTE (76% salary/24% fringe) - $98,200; Levar, 0.10 FTE (73% salary/37% fringe) - $23,900; 2 TBA lab tech 0.50 FTE, (73% salary/37% fringe) - $104,000; **Activity Two**: Roger Ruan, 0.10 FTE per year (75% salary/25% fringe) - $51,200; Paul Chen, 0.35 FTE per year (75% salary/25% fringe) - $120,000; Research associate, 1.0 FTE per year, (75% salary/25% fringe) - $165,500; Grad Research assistant, 0.50 FTE per year, (57% salary; 42% fringe) - $130,750; **Activity Three:** Nannenga, 1 mo. summer salary/2 years (75% salary/25% fringe) - $18,000; Nannega student support .25 FTE, $10,000; **Activity Four:** Hill, 0.01 FTE for 1 year - contributed; Research associate, 0.5 FTE 1 year (57% salary; 43% fringe) - $44,000; **Activities One-Four:** Richard Hemmingsen - PI/Project Manager, 0.35 FTE per year (75% salary 25% fringe) - $226,300	$ 1,102,750
Contracts: Red River Basin Commission staff support and providing samples of harvested biomass $10,000 (**All activities)**; Design/certification for high pressure continuous pilot processing equipment for hydrothermal carbonization - $21,000 **(Activity One)**	$ 31,000
Equipment/Tools/Supplies: **Activity One - NRRI ($160,750)** NRRI lab supplies $10,600. Capital equipment: biomass chopper - $7,200; Supply assembly - $7,500; pump station (partial) $4,500; reactor assembly $9,600; Recovery vessel $7,050; centrifuge $6,900; briquette press $6,900; framing and looping $21,340; thermal oil heater loop (3) - $79,1600 **Activity Two - BBE ($205,000)** fast microwave assisted gasification demonstration system ($50,000); misc. shop supplies, minor equipment, fMAG reactor components, supplies $155,000; **Activity Three - UMC: ($20,000)** Nannenga greenhouse/lab supplies, reagants, etc.	$ 385,750
Travel: In-state travel for four teams (Coleraine Lab, Crookston, St. Paul) for project meetings; to/from harvest sites in Red River Valley, supply purchases, biomass and sample transport, etc. according to University of Minnesota rates and procedures	$ 14,000
Additional Budget Items: (Activity One): On-site NRRI analytical and characterization lab services	$ 12,250
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 1,545,750

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	$ -	
Other State $ To Be Applied To Project During Project Period: PUTF and O/N NRII funds for equipment for Activity 2	$ 311,000	*Secured*
In-kind Services To Be Applied To Project During Project Period: Unrecovered F&A	$ 650,000	*Pending*
Funding History: 2007 LCCMR $500,000 allocation to Ruan Lab for microwave assisted pyrolysis (MAP) system	$ 500,000	
Remaining $ From Current ENRTF Appropriation:	$ -	

Optimizing Environmental and Economic Value of Harvested Cattails: Clean Water Green Fuels Green Fertilizer



Green fuels

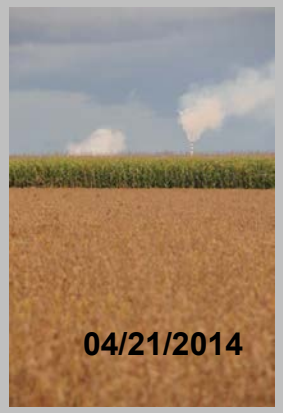
Biorefinery

Cleaner water

Green Fertilizer

Biomass, Nutrients

Reduced nutrients



Excess Nutrients

Excess Nutrients

Harvested cattails

Project Manager Qualifications and Organization Description

Richard A. (Dick) Hemmingsen, M.Ed. will serve as project lead and coordinator for the project. Dick is a Senior Fellow in the Department of Bioproducts and Biosystems Engineering in the College of Food, Agricultural, and Natural Resource Sciences at the University of Minnesota. Dick was the founding director of the Initiative for Renewable Energy and the Environment (IREE) at the University and was responsible for developing funding protocols and managing a research portfolio typically consisting of 100 active research projects in a wide range of renewable energy technologies with a strong emphasis on interdisciplinary, systems-oriented approaches. Dick serves as the University of Minnesota's representative on the Next Generation Energy Board.

Project team members are faculty and staff from the following University of Minnesota units; Department of Bioproducts and Biosystems Engineering in the College of Food, Agricultural and Natural Sciences; The Natural Resources Resource Institute (UMD); the Department of Math, Science and Technology (UMC). These academic units conduct research and academic programs which are at the forefront in the discovery, development and application of the renewable resources and sustainable technologies required to meet the global population's increasingly sophisticated needs, while at the same time enhancing and preserving the Environment. Collaborators on the project include staff from the Red River Basin Commission (Jeff Lewis, Joe Cournyea) University of Minnesota – Crookston (Dan Svedarsky); International Institute for Sustainable Development, Winnipeg, MB.