Environment and Natural Resources Trust Fund
2011-2012 Request for Proposals (RFP)

LCCMR ID: 154-F3+4

Project Title: Mitigating Climate Change through Biochar, a Biomass Byproduct

Category: F3+4. Renewable Energy

Total Project Budget: $ $729,000

Proposed Project Time Period for the Funding Requested: 3 yrs, July 2011 - June 2014

Other Non-State Funds: $ 0

Summary:

compare the ability of three selected biomass byproducts to mitigate climate change and improve soil fertility, with an emphasis on Minnesota's regional industries, soil types and ecosystems

Name: Robert Morrison

Sponsoring Organization: U of MN

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Web Address

Location

Region: NE, Central, Metro, SE

Ecological Section: Western Superior Uplands (212K), Minnesota and NE Iowa Morainal (222M), North Central Glaciated Plains (251B)

County Name: Becker, Dakota, Hennepin

City / Township:

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

PROJECT TITLE: Mitigating climate change through biochar, a biomass byproduct

I. PROJECT STATEMENT:

Biochar is a biomass byproduct that is a highly stable form of carbon and as such, has the potential to act as long term storage of carbon (reducing CO_2 emission to the atmosphere) and potential secondary agronomic benefits when applied to soil. Producing biochar may be an appropriate means to convert "waste streams" into valuable commodities of sequestered carbon. The biomass would otherwise be recycled (microbial decay and release of CO_2 to the atmosphere) or in the case of human waste, could be an environmental and health risk. This project combines biochar-based carbon sequestration with bioenergy production and biochar applications in soil improvement.

The goal is to compare the ability of biochars to store carbon long term and improve soil fertility, with an emphasis on Minnesota's regional industries, soil types and ecosystems.

The three-year research project is to be conducted as three activities. In activity 1, a portable pyrolysis unit that exists as a direct result of past LCCMR support will be used to produce biochars from three major biomass sectors:

- Forestry (e.g. wood waste, fallen tree debris, paper mill sludge, Emerald Ash Borer)
- Agriculture (e.g. corn stover, manure, poultry litter, distillers grain, grasses, biofuel residues)
- Urban (e.g. food and yard wastes, sewage sludge, municipal solid waste[i]).

The biochars will be screened to narrow the selection to one feed stock per sector for further field assessment in Activity 2. In Activity 3, economic analyses and environmental life cycle assessments of the biochar production systems will be performed.

II. DESCRIPTION OF PROJECT ACTIVITIES:

Activity 1: Producing biochar from Minnesota biomass feed stocks Budget: $272,333

Prior to the production of large amounts of biochar using the portable pyrolysis unit, bench scale research will be conducted to optimize biochar production processes for a wide variety of biomass feed stocks from the three biomass sectors. Biochar samples will be produced to conduct laboratory incubations for assessing soil microbial impacts and carbon sequestration potential. The amount of carbon sequestered, degradation patterns in soil, soil amendment capability (nutrient profile, nutrient release, soil structure, and water holding capacity improvement), and pathogen elimination will be the evaluated. From these observations, one biochar will be identified for each sector for further evaluation in activity 2. The optimized microwave assisted pyrolysis (MAP) conditions will be used to produce 400 lb biochar from each of the three selected biomass feed stocks using the portable pyrolysis unit. Bio-oil and syngas produced from the MAP process will be considered as value-added products and included in the life cycle assessment and economic analysis in activity 3.

Outcomes	Completion Date
1. Optimize baseline biochar production processes	*9/30/2011*
2. Provide biochar samples for Activity 1	*9/30/2011*
3. Optimize pilot scale process using a pilot MAP system	*12/31/2011*
4. Produce 400 lb biochar for each biomass category for field tests	*4/30/2012*

Activity 2. Compare biochar soil amendment and carbon storage abilities Budget: $247,833

One biochar from each of the three sectors will be applied to three different ecosystems in triplicate random block design to assess the impact and stability in a variety of field settings: (1) agricultural (Rosemount, MN), (2) urban setting (community garden and/or green roof application), and (3) replanted forest stands (Minnesota replants approximately 3000 acres year^{-1}). Data will be collected during production on the overall energy balance to assist in the economic modeling of biochar production (Activity 3). During this field plot research, evaluations will be done of the stability and degradation rate of the biochars in the various ecosystems (assessed through CO_2 respiration measurements and surface

gas flux quantification), soil nutrient cycling and plant growth, and yields. In addition, potential negative aspects of biochar use (polyaromatic hydrocarbon and phenol contamination) will be assessed.

Outcomes	Completion Date
1. Selection of biochar from three sectors	*12/31/2011*
2. Establishment of field plots	*4/30/2012*
3. Evaluation of impact of biochar on productivity of various ecosystems	*7/31/2013*
4. Assess organic contaminant potential and partitioning	*12/31/2013*
5. Develop specific recommendations of biochar application and use	*6/30/2014*

Activity 3. Economic impact and environmental life cycle assessment Budget: $247,833

Data collected during Activities 1 and 2 will be used to conduct side-by-side comparisons of biochar options with particular attention given toward optimizing economic viability and environmental benefit. Economic analysis will consider direct production costs along with expected benefits from increased soil fertility bioenergy generation and climate change mitigation. Environmental impact of biochar production and use will be evaluated within the context of life cycle assessment, which will be calibrated using input and output parameters specific to Minnesota.

Outcomes	*Completion Date*
1. MAP data & 1st crop season collected & analyzed	*12/31/2012*
2. MAP data & 1st and 2nd crop season analyzed & interpreted	*6/30/2014*

III. PROJECT STRATEGY

A. Project Team/Partners

Dr. Robert Morrison, Professor, College of Veterinary Medicine, UMN will serve as overall project coordinator. Through his interest in climate change and agriculture, he has become involved with researchers around the country on aspects of methane capture, soil carbon sequestration and biochar production. He assembled this research team and brings inspired leadership to coordinate the project. Dr. Roger Ruan, Professor & Director of Center for Biorefining, Department of Bioproducts and Biosystems Engineering (BBE), UMN is an expert in biomass conversion and characterization and will be responsible for overseeing Activity 1. Dr. Paul Chen, Program Director, Center for Biorefining, Dept of BBE, UMN, Xiaoquan Wang, Yanling Cheng, and Zhenyi Du, BBE and Center for Biorefining, will produce and evaluate biochar in activities 1 & 2. Dr Kurt Spokas, Research Soil Scientist, USDA-ARS is an expert in evaluation of biochar's impact on soil microbial populations and soil nutrient cycling. He will be responsible for the laboratory incubations (Activity 1) and field plot studies (Activity 2). Dr. Jason Hill, Resident Fellow, Institute on the Environment, UMN is an expert in bioenergy sustainability and will be responsible for leading the life cycle assessment and economic analysis (Activity 3). Dr. Doug Tiffany, Extension Scientist in Dept of Applied Economics is an expert in agricultural energy use, and will oversee the economic analysis.

B. Timeline Requirements

This project will be completed in three years. Three biochar targets will be identified in year one and these will be compared over the subsequent two growing seasons.

C. Long-Term Strategy and Future Funding Needs

Proving long term carbon sequestration and secondary agronomic benefits for certain biochars will call for mobile pyrolysis units producing biochar throughout the state. Evaluating long term environmental and economic impact will be critical.

[i] - 60% of municipal solid waste in Minnesota is still deposited in landfills.

Project Budget

IV. TOTAL PROJECT REQUEST BUDGET (*3* years)

BUDGET ITEM	AMOUNT (3 yrs)
Personnel:	
Robert Morrison - 0.2 FTE 3 yrs; 66.7% salary, 33.3% fringe; Project oversight & coordination	$101,000
Paul Chen - 0.2 FTE 3 yrs; 66.7% salary, 33.3% fringe; MAP evaluation & analysis	$58,000
Post doc - 1FTE 3 yrs; 80.3% salary, 19.7% fringe; MAP experiments	$149,000
Research assistant - 0.5 FTE 3 yrs; 54% salary, 46% fringe; MAP analysis	$97,000
Jason Hill - 0.1 FTE 2 yrs; 76% salary, 24% fringe; LCA	$27,000
Post doc - 0.5 FTE 2 yrs; 76% salary, 24% fringe; LCA & evaluation	$83,000
Doug Tiffany - 0.1 FTE 2 yrs; 66.7% salary, 33.3% fringe; Economic analysis	$21,000
Undergraduate students - 12,000 hrs, $11 / hr, 0% fringe; lab & field work	$132,000
Equipment, Tools, Supplies:	
Materials for modifications gas chromatographic system in Spokas lab to improve sample efficency (Permapure moisture traps)	$1,000
Laboratory Incubation Supplies (septa, syringes, support gases)	$5,000
Field supplies for gas sampling probes	$1,000
Flux boxes for field measurements	$41,000
Weather Stations and soil monitor equipment for 3 field sites	$7,000
Biochar supplies, equipment development and testing, analysis	$35,000
Travel: All in-state travel: 1) travel to acquire biomass feeedstocks (10 different feedstocks at 100 miles avg) and (2) Travel to in-state scientific conference to present	$10,000
Additional Budget Items:	
TOTAL PROJECT BUDGET REQUEST TO LCCMR	$768,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
In-kind Services During Project Period: Kurt Spokas's salary is paid by USDA. The 1% cost share for his salary will be manually tracked by the department.	$7,000	*Secured*
In-kind Services During Project Period: 1% of Roger Ruan's salary will be cost shared by his department for this project	$7,300	*Secured*
Funding History: Adding value to ethanol production byproducts (dried distillers grain) through production of biochar and bio-oil. Funded by Minnesota Corn Research and Promotion Council and the Minnesota Corn Growers Association	$ 60,000	*Secured; start 7/1/2010*

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April 9, 2010

In 2009, Dr. Morrison took a sabbatical leave with a firm working in the carbon aggregation space. During this time, he became involved with researchers and interested parties working around the country on aspects of methane capture, soil carbon sequestration and biochar production. He assembled this research team and brings inspired leadership to the project.

Dr. Robert Morrison is a professor in the College of Veterinary Medicine, University of Minnesota. He works with farmers and practicing veterinarians with emphasis on health and productivity of swine farms. In addition, Dr. Morrison has an MBA and is part owner of a family business. Through his efforts at the university, he is an accomplished researcher, educator and communicator. He will combine these skills with his organizational abilities to coordinate this project.

During his career, Dr. Morrison has trained 17 PhD and Masters graduate students who occupy leadership positions around the world. He has participated in research projects valued at over five million. And, through his research and outreach efforts, he has co-authored over 300 publications and over 500 presentations.

Some of his recent publications are as follows:

1. Larriestra A, Maes D, Deen J, Morrison RB. Mixed models applied to the study of variation of grower-finisher mortality and culling rates of a large swine production system. Canadian J Vet Research 2005; Vol 69, No 1. 26-32.

2. Tiranti KI, Morrison RB. Association between conformation at selection and retention through P2. Am J Vet Res 2006 Mar; 67(3):505-509.

3. Mondaca-Fernández E, Morrison RB, Murtaugh M. Association of distance between pig sites with PRRSV sequence homology, Can J Vet Res 2006:70;3 257-259.

4. Schaefer N, Morrison RB. Effect on total pigs weaned of herd closure for elimination of porcine reproductive and respiratory virus. J Swine Health & Production 2007; Vol 15 No 3, 152-155.

5. Mondaca-Fernández E, Morrison RB. Applying spatial analysis for a PRRSV regional control program. Vet Rec 2007, vol. 161, n°4, pp. 137-138.

6. Morrison RB. Regional elimination of PRRS in Stevens County. International PRRS Symposium. Chicago, IL. 2008.

7. Bents A, Kerkaert B, Morrison RB. Analysis of marketing data to identify economic opportunities for producers. Conference of American Association of Swine veterinarians 2009.
8. Morrison RB. Climate change, carbon credits and agriculture. Illinois Pork producers annual conference, 2010.