



Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-044

Proposal Title: Bringing Minnesota Farmers Into The Low-Carbon Economy

Project Manager Information

Name: Brian Barry

Organization: U of MN - Duluth - NRRRI

Office Telephone: (218) 788-2720

Email: barry310@d.umn.edu

Project Basic Information

Project Summary: Residuals from timber mills and the paper and pulp industry will be processed into field-ready, granular biochar products that Minnesota farmers can easily incorporate into conventional no-till systems.

Funds Requested: \$176,000

Proposed Project Completion: 2022-12-31

LCCMR Funding Category: Small Projects (H)

Secondary Category: Air Quality, Climate Change, and Renewable Energy (E)

Project Location

What is the best scale for describing where your work will take place?

Region(s): NE

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

We aim to provide Minnesota-based farmers with opportunities to participate in the low-carbon economy by turning sustainable waste streams from Minnesota forests into engineered biochar products. Biochar is a carbon-rich material which can be produced through the pyrolysis (heating in a low oxygen environment) of biomass such as wood, bark, switchgrass or crop residuals. Biochar offers many economic and environmental benefits, such as improving agricultural soil health, reducing fertilizer runoff into waterways, improving crop drought resistance and sequestering atmospheric carbon which can generate revenue via carbon offset credits.

The scientific evidence supporting biochar's efficacy in improving plant health and its ability to aid soils ability to sequester carbon is compelling. However, there are some practical hurdles to overcome before biochar can be employed by conventional farmers on a wide scale. Biochar made by most current small producers is not suitable for application to agricultural fields due to significant fine dust content and the irregularity of the particle sizes which are both required for mechanized application. We will apply our expertise in fertilizer development, binders, and biomass agglomeration to convert raw biochar into engineered granules that can be practically applied to soils using existing farming infrastructure.

What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.

Processing biochar into consistently sized granules will require the use of a soil-friendly binder. The Natural Resources Research Institute at UMD (NRRI) has extensive experience developing soil amendments, including the Minnesota-based brand Gypsoil® and Onyx(TM), a biodegradable material that is an effective binder for forming briquettes from pyrolyzed biomass. NRRI also has an extensive history of partnering with the supplier on innovating new materials using Onyx. This bio-based binder (Onyx) is produced from the waste stream of the cellulosic ethanol (biofuel) industry. This project will build upon these findings by using Onyx to produce consistent and flowable biochar granules suitable for mechanized application by conventional farmers.

In order to accomplish this, biochar will be milled, bound with OnyxTM, and then processed into granules of consistent size. Two different pathways will be investigated: a) compression using ring die pelletization and b) extrusion followed by spheronization. We will also examine the best processing method, such as biochar feedstock type, pre- vs. post-pyrolysis agglomeration, pyrolysis and agglomeration processing temperatures, and ratio of biochar to Onyx.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

Biochar is well understood to increase rates of both microbial nitrogen fixation and soil fertilizer retention. Incorporating biochar into soils will reduce fertilizer needed for crop growth and will slow leaching of applied fertilizer into Minnesota watersheds. Also, applying biochar as a soil amendment sequesters atmospheric carbon into soils directly via entombing long-lived carbon underground. It also improves soil microbial health, which increases carbon sequestration. Finally, this project utilizes biomass feedstocks which would otherwise become landfill waste, which results in the emission of carbon into the atmosphere.

Activities and Milestones

Activity 1: Granulated biochar production

Activity Budget: \$92,985

Activity Description:

We will produce granulated products using several processes and mixtures of biomass and binder. Processing variables will include biomass milling size, pyrolysis temperature, pre- or post-pyrolysis mixing with Onyx™ and method of granulation. Several different biomass residuals from Minnesota forests will be tested, including but not limited to, bark residues from the paper & pulp industry, sawmill dust from the lumber industry and chipped woods (balsam, ash etc.) from thinning efforts towards forest fire prevention. A systematic design of experiment (DOE) method will be used to assess the products response to changes in isolated variables.

We will test agglomeration techniques such as ring die pelletizing or extrusion followed by spheronization. The targeted granule size will look to mimic that of typical fertilizers (0.09" average diameter, size guide number = ~225) so that existing spreading equipment can be used. Having similarly-sized biochar granules is critical so that there is controlled flowability of granules through the spreading hoppers, allowing for an even and prescribed dosage of biochar application to the field.

Activity Milestones:

Description	Completion Date
2. Completion of DOE.	2021-08-31
1. Identification and acquisition of biomass	2021-08-31
3. Completion of experiments to form biochar granules.	2022-08-31

Activity 2: Characterize granule spreading properties

Activity Budget: \$36,555

Activity Description:

Agglomerations (granules) can be described as the unification of particulate solids through physical and/or chemical forces. We will use two methods to test the mechanical strength of an agglomerate. We will first measure a granule's resistance to impact and abrasion through a tumbling durability test. Biochar samples will be tumbled and then screened to separate the fine particles to calculate percent weight loss. We will then use a Chatillon force measurement instrument to test the strength at break of biochar granules. In these experiments, a piston is forced downward onto a granule and the force applied at the point of granule breakage is recorded. Typical fertilizers, such as granular urea, have a strength at break of 3 pounds of force.

In addition to the mechanical strength testing, other physical properties will be assessed which affect granule performance in spreading equipment. These characterizations will include particle size, particle shape, particle density, flowability and coefficient of friction.

Activity Milestones:

Description	Completion Date
1. Development and implementation of methodology for experimental testing.	2021-12-31
2. Completion of physical property testing for selected granular products.	2022-10-31
3. Completion of a report communicating the properties and performance of generated biochar granules.	2022-12-31

Activity 3: Characterize agronomic properties of biochar granules

Activity Budget: \$46,460

Activity Description:

The biomass feedstock, the pyrolysis temperature and the residence time (duration of exposure to highest pyrolysis temperature) all affect the properties of the resulting biochar. The elemental composition (ratio of atom types) of biochars, according to the international Biochar Initiative (IBI), must have a H to C ratio less than 0.7 and an O to C ratio less than 0.4. It is critical that these values are achieved to ensure adequate graphitization of carbon which renders the biochar unsusceptible to degradation, locking the carbon in the soil.

In addition to elemental composition (ultimate analysis), the biochars will be extracted with various solvents to determine the amount of mobile material contained within the biochar. Improper handling of generated volatiles during pyrolysis can lead to the deposition of soot on the surface of the biochar. These chemicals have the potential to be detrimental to soils if the levels are high enough and therefore it is critical to quantify the amount of these mobile species. Several additional, relevant characteristics will be quantified as well including surface area, pore size distribution, cation exchange capacity, pH, field capacity (water retention) and liming equivalence.

Activity Milestones:

Description	Completion Date
1. Development and implementation of standard methodology for experimental testing.	2021-12-31
3. Completion of report communicating the physicochemical properties of generated biochar and biochar agglomerations.	2022-10-31
2. Completion of physicochemical property testing of selected biochar samples.	2022-10-31

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this be funded?

We will identify amenable feedstock type(s) and processing conditions necessary to produce targeted biochar specifications. We will then work with collaborators from both the soil sciences and the agricultural industry as well as identifying funding sources to fund these scaled-up efforts. The NRRI has the capability of scaling up production and agglomeration of biochar through the pilot-scale Biomass Conversion Lab located at the NRRI Coleraine industrial site. It also has a proven track record of attracting funding from resources such as the USDA, DOE and others.

Project Manager and Organization Qualifications

Project Manager Name: Brian Barry

Job Title: Chemistry and Materials Science Program Leader

Provide description of the project manager's qualifications to manage the proposed project.

Dr. Barry has a history as principal investigator of funding from various granting agencies over his career thus far. As such, he has ample experience managing experimental design, personnel and budgets. His background in chemistry & materials science is particularly critical for analyzing the physiochemical properties of the produced biochar agglomerates. He also has a proven track record of fruitful collaborations, which is particularly relevant to this proposal as various expertises (agglomeration e.g.) will need to be pulled together in order to produce quality results.

Organization: U of MN - Duluth - NRRI

Organization Description:

The Natural Resources Research Institute (NRRI) is an applied research organization that works to develop and deliver the understanding and tools needed to utilize our mineral, forest, energy and water resources in a balanced and environmentally responsible manner. NRRI is a unique, multidisciplinary, applied research institute focused on Minnesota's many natural resources. Associated with the University of Minnesota Duluth with research facilities in Duluth and Coleraine, NRRI is a leading research arm of the greater University of Minnesota community. The Institute was created to be an economic development engine for the state. NRRI delivers solutions to allow responsible use of Minnesota's resources, provides information and tools for sound environmental decisions and assists existing and entrepreneurial business and industry evolve and prosper. Ultimately, NRRI is here to collaborate broadly in creating resilient, vital Minnesota communities.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Brian Barry (Research Project Specialist 3)		Principal Investigator			26.7%	0.3		\$37,295
Timothy Hagen (Research Project Specialist 2)		Co-Principal Investigator			26.7%	0.3		\$40,525
Eric Singsaas (Research Director 1)		Scientific advisor			26.7%	0.08		\$14,136
Matthew Young (Researcher 3)		Biochar production			24.1%	0.3		\$24,885
Oksana Kolomitsyna (Researcher 5)		Biochar characterization			26.7%	0.15		\$11,282
Sergiy Yemets (Researcher 6)		Biochar characterization			26.7%	0.15		\$11,902
Oleksiy Kacharov (Researcher 5)		Biochar characterization			26.7%	0.15		\$10,925
							Sub Total	\$150,950
Contracts and Services								
Twin Ports Testing	Professional or Technical	Will perform Ultimate, Proximate and Ash analysis of biochar samples				0		\$8,000

	Service Contract							
							Sub Total	\$8,000
Equipment, Tools, and Supplies								
	Tools and Supplies	Biomass feedstock	Material for biochar production					\$1,500
	Tools and Supplies	Onyx binder	Used for agglomeration of biochar					\$1,000
	Tools and Supplies	Solvents and lab disposables	lab supplies needed for biochar characterizations					\$1,707
	Tools and Supplies	Condensers for tube furnace	condensers to catch combustible volatiles produced during biochar production					\$3,600
							Sub Total	\$7,807
Capital Expenditures								
		Tube Furnace	Furnace used to pyrolyze biomass to form biochar					\$9,043
							Sub Total	\$9,043
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
							Sub Total	-
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								

							Sub Total	-
Other Expenses								
		Shipping of samples	Sending samples to external analytical laboratory					\$200
							Sub Total	\$200
							Grand Total	\$176,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
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Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	-
Non-State				
In-Kind	UMN unrecovered indirect costs are calculated at the UMN negotiated rate for research of 55% modified total direct costs.	Indirect costs are those costs incurred for common or joint objectives that cannot be readily identified with a specific sponsored program or institutional activity. Examples include utilities, building maintenance, clerical salaries, and general supplies. (https://research.umn.edu/units/oca/fa-costs/direct-indirect-costs)	Secured	\$91,826
			Non State Sub Total	\$91,826
			Funds Total	\$91,826

Attachments

Required Attachments

Visual Component

File: [65705a7f-317.pdf](#)

Alternate Text for Visual Component

This visual aid shows the various stages of atmospheric carbon transitioning to a sequestered state in agricultural soils. Residuals from paper/timber mills can be converted to biochar via pyrolysis, followed by agglomeration into biochar granules and finally these granules are spread on agricultural fields adding many environmental benefits including soil microbial health, reduction in fertilizer runoff, drought resistance and carbon sequestration. It also highlights the fact that this practice could generate revenue through selling of carbon offset credits.

Optional Attachments

Support Letter or Other

Title	File
Sponsored Projects Authorization Letter	f0fc5151-abf.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

Yes,

- Patent, Copyright, or Royalty Potential
- Potential revenue generated or net income from the sale of products or assets developed or acquired with ENRTF funding

Does your project include research?

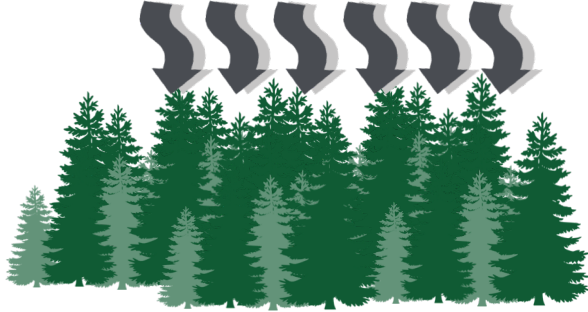
Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

PROJECT NAME:
Bringing Minnesota Farmers into the Low-Carbon Economy

Atmospheric Carbon (CO₂) is stored in Minnesota forests



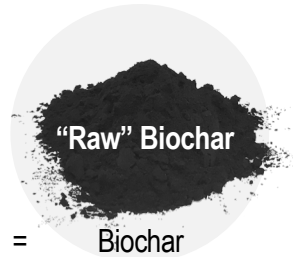
Biochar created from paper/timber mill residuals through a process called pyrolysis



Residuals



+ Pyrolysis (300-700 °C) =



"Raw" Biochar

Biochar

Through agglomeration, NRRI can create hopper-friendly biochar granules sized to be compatible with current farming machinery



Granular
Biochar

OPPORTUNITY: Implementation of biochar into farming practices would have substantial environmental and economic benefits.

CHALLENGE: Production (agglomeration) of purposefully-sized granules of biochar using a soil-friendly binder must be accomplished before implementation on meaningful scale.

OUTCOMES: Improved soil health, drought-resistance, reduction in fertilizer runoff, sequestration of carbon (eligibility for carbon offset credits)



Biochar creates a favorable habitat, increasing microbial community abundance in soils.