Environment and Natural Resources Trust Fund

2023 Request for Proposal

General Information

Proposal ID: 2023-048

Proposal Title: Creating Carbon Sequestration Markets for Minnesota Wood Products

Project Manager Information

Name: Brian Barry

Organization: U of MN - Duluth - NRRI

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Project Basic Information

Project Summary: The biochar industry is poised to bring carbon sequestration and forest health to Minnesota but it will require large-scale deployment demonstrations in order to become a reality.

Funds Requested: $408,000

Proposed Project Completion: June 30, 2025

LCCMR Funding 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?

During the Project and In the Future

Narrative

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

The primary opportunity for this project is demonstrating how Minnesota has the resources, technology and willingness to impactfully combat rising atmospheric greenhouse gas (GHG) concentrations. The current trajectory for Earth's atmospheric GHG concentrations is predicting more frequent and more intense weather events in the decades ahead. In Minnesota we are not insulated from these events, namely wildfires and flooding, and it is incumbent upon us to take action so future generations of Minnesotans get to enjoy our wilderness in the same condition as we have.
To reduce GHG concentrations, carbon dioxide (CO_2) being the dominant culprit, society cannot simply rely on cutting our fossil fuel emissions, we must also develop strategies to transform gaseous CO_2 into long-lasting, stable solids, also referred to as carbon sequestration. The large global demand for demonstrating a carbon sequestration method which is sustainable, scalable and economic is illustrated by the ongoing $100 million dollar XPRIZE Carbon Removal competition. Recently the 15 finalists from 1,100 worldwide entrants were revealed and 3 of these were biochar projects, the most for any technology type among the finalists. Biochar is currently regarded as the most promising carbon sequestration method, the challenge is creating markets that incentivise biochar production.

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

Our project will focus on carbon sequestration through the deployment of biochar as a dewatering agent in efforts to stabilize coal combustion residuals (CCRs)for permanent landfilling. Due to recent changes in regulations (see 2018 EPA CCR Rule), many electric generating units across the country will be closing CCR impoundments over the next 10-15 years. The CCR sludge accumulated in CCR ponds requires a stabilizing, dewatering agent to be mixed in prior to landfilling. Biochars have high water holding capacities making them ideal candidates for stabilizing CCRs.
Minnesota generates a substantial amount of wood waste, whether its industrial waste, EAB infested trees or balsam removed in wildfire mitigation efforts. The fate of the carbon in this wood is to end up as GHGs if left to its own devices. By converting these feedstocks to biochar you are:

-Lowering MN GHG emissions
-Adding value to otherwise unmerchantable wood
-Lowering the cost of fire mitigation efforts
-Creating new carbon markets in MN

Biochar producers are coming to MN (see letter of support) and we are poised to be national leaders in this field, but for sustainable growth of this industry, large scale deployment opportunities for biochar, as proposed here, must be demonstrated.

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?

The biggest threat to Minnesota forestlands are wildfires and tree infestations (EAB e.g.). Wildfire mitigation (fuels removal) is expensive and cannot be performed to the extent it needs to be. Conversion of the removed balsam fir to biochar can generate a valuable product that can be sold to offset forest management costs and ultimately allow for better wildfire prevention. Susceptible ash trees could be converted to biochar and replaced with more resilient tree species, thereby increasing forest health. Additionally, in the process creating healthier, more fire resistant forests you have the added benefit of carbon sequestration.

Activities and Milestones

Activity 1: Laboratory Scale Biochar Production, Characterization and Stability Testing of Biochar/CCR Mixtures

Activity Budget: $245,000

Activity Description:
The laboratory scale assessments will consist of both physical property characterizations of the biochar alone and the stability performance assessments of biochar/CCR mixtures. In concert with Activity 2, the two chosen feedstocks to be used in our large scale field trials will be used to generate a variety of biochar samples on the laboratory scale with the primary variable being the maximum temperature at which the biochar was produced (400-900 °C). These samples will then be analyzed to assess their potential as a CCR dewatering agent and to guide condition choices for large-scale biochar production runs.
The physical property analyses of the biochars will include H:C molar ratio quantifications to determine carbon sequestration potentials and pore size distributions and water holding capacities to assess for potential as a CCR dewatering medium. The biochar/CCR mixtures will be mixed at various weight ratios and moisture contents and resulting mixtures will have their stability assessed by testing for bulk density, compaction, undrained shear stress, flowability and hydraulic conductivity.

Activity Milestones:

Description	Completion Date
Identification and acquisition of biomass feedstock and subsequent benchtop conversion to biochar for lab scale testing.	September 30, 2023
Complete full pore size distribution analyses and water holding capacity testing for select biochar samples.	December 31, 2023
Complete mechanical stability testing and determination of methods to be employed for field scale demonstrations.	March 31, 2024

Activity 2: Feedstock Identification/Acquisition and Biochar Production

Activity Budget: $134,000

Activity Description:
In consultation with regional woody biomass purveyors (paper mills e.g.), public lands stewards (United States Forest Service e.g.) and with guidance from the results of Activity 1, we will identify feedstocks with high potential for meeting project demands. These feedstocks must be capable of generating biochar that meets identified physical property specifications (water holding capacity e.g.) and is generated at a volume, frequency and consistency capable of meeting the needs of CCR generators. Once feedstock(s) have been chosen, arrangements will be made to have this material prepped (debarked, delimbed and chipped) and trucked to the biochar production location (ARTi-Char, Prairie City, IA) and then delivered back to the CCR holding pond site once converted to biochar (Boswell Energy Center, Cohasset, MN). We anticipate 4-5 tons of biochar to be produced from each of the two identified feedstocks to meet the demands of our planned field trials.

Activity Milestones:

Description	Completion Date
Secure biomass feedstocks which have been appropriately processed for compatibility with producer's biochar kiln.	January 31, 2024
Finalize arrangements for delivery of biomass feedstocks to biochar production site.	March 31, 2024
Confirm quality of produced biochar and arrange for transportation of biochar to CCR impoundment site.	June 30, 2024

Activity 3: Field Scale Trials: Design and Construction of On-Site Landfill Test Cells for Assessment of Biochar as a Dewatering Agent.

Activity Budget: $29,000

Activity Description:

A series of test cells and treatment areas will be constructed inside the Boswell Energy Center's existing impoundments. Earth moving equipment (dozers, excavators, haul trucks, etc) will be used to create the test cells and treatment areas and liner material will be applied to ensure sufficient separation between cells. Once test cell construction is completed, biochar produced in Activity 2 will be added to the CCR materials at a range of ratios determined to be most effective during the bench scale testing (Activity 1). A control cell with no biochar will also be included for comparison purposes. The resulting controls and biochar/CCR mixtures will then be monitored and tested (compaction, stability, sloughing, etc) over the course of a construction season to verify that the structural properties have potential for long-term stability. After stabilization mixing, the different mixtures will be sculpted into scale models of a closed ash impoundment at the appropriate slope grades and monitored during the construction season to determine potential for long-term CCR storage.

Activity Milestones:

Description	Completion Date
Complete construction of testing cells at Boswell Energy Center CCR impoundment.	June 30, 2024
Complete demonstration-scale biochar/CCR sludge mixing and compaction and sculpting of material in test cells.	March 31, 2025
Complete an executive summary and technical report at the conclusion of the project.	June 30, 2025

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Kurt Anderson	Minnesota Power	Landfill Demonstration Manager	No

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 work be funded?

Results from laboratory scale stability testing of biochar/CCR mixtures will inform the protocol adopted for the large-scale demonstration component of the project. Isolated testing cells containing ~3 tons of CCR sludge will be constructed on-site at an active CCR impoundment. The biochar/CCR mixtures will be sculpted into scale models of a closed ash impoundment at the appropriate slope grades and if the stability persists, this protocol stands a good chance for widespread implementation. The successful outcome of a viable CCR/biochar mixture protocol is high and so we don't anticipate the need for future funding.

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 earned his Ph.D. in Inorganic Chemistry from the University of Iowa in 2010 and has dedicated his efforts towards environmentally impactful research at every stop along the way. His Ph.D. thesis was on developing novel electrode materials for next-generation batteries, his post-doctoral work at Sandia National Laboratories looked at developing catalysts capable of activating carbon dioxide (CO2) and during his time spent as an Assistant Prof. of Chemistry (St. Mary's in Halifax Nova Scotia & UW-Platteville) he researched ways to chemically modify natural chemicals found in wood. Currently Dr. Barry is the manager of the chemistry labs at NRRI and is responsible for managing operations, delivering research solutions and fundraising through grant applications to keep his labs operational. Dr. Barry has a long history of managing research and demonstration projects funded at both the state and federal levels and is well suited to manage the program detailed here.

Organization: U of MN - Duluth - NRRI

Organization Description:

The Natural Resources Research Institute (NRRI) is a part of the University of Minnesota research enterprise and employs over 130 scientists, engineers and technicians. Its mission is to deliver integrated research solutions that value our resources, environment and economy for a sustainable and resilient future.

NRRI collaborates broadly across the University system, the state and the region to address the challenges of a natural resource-based economy.

By partnering with industry, business leaders, agency decision-makers and many others, NRRI researchers frame and deliver on real-world solutions. NRRI scientists have extensive experience in managing large, interdisciplinary projects. Major objectives include the development of tools for environmental assessment and resource management. NRRI's role is as an impartial, science-based resource that develops and translates knowledge by characterizing and defining value-resource opportunities, minimizing waste and environmental impact, maximizing value from natural resource utilization and maintaining/restoring ecosystem function.

Major outcomes from NRRI projects include informing environmental management and policy and assisting industry and communities in defining and maintaining the social license to operate in natural systems. NRRI has established mechanisms for sharing outcomes through press releases, publication in peer-reviewed journals, technical reports, annual reports, periodicals, and through social media channels.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Brian Barry		In addition to being the principal investigator, Brian will be serving as project manager and will be responsible for design of experiment, data analysis and reporting.			25.1%	0.4		$49,608
Eric Singsaas		Eric will be in charge of the design of experiment for ash/biochar mixture stability assessments			25.1%	0.1		$18,804
Sergiy Yemets		Sergiy will be in charge of developing a method for determining the water holding capacity and subsequent experiments to quantify this property on all biochar samples to be investigated.			25.1%	0.4		$31,664
Oksana Kolomitsyna		Oksana will be in charge of performing and reporting the pore size distributions of all biochar samples via Hg intrusion porosimetry			25.1%	0.4		$30,017
Oleksiy (Alex) Kacharov		Oleksiy (Alex) will be in charge of performing all gas adsorption experiments (N2/CO2) for all biochar samples to determine pore volumes, pore size distribution and surface area.			25.1%	0.4		$29,067
Matthew Young		Matt will be managing the team conducting all of the mechanical stability testing and responsible for onboarding any new methods not performed previously at NRRI.			22.3%	0.4		$38,810
Sam Firoozi		Sam will be performing density, Procter compaction, undrained shear stress, flowability and hydraulic conductivity of generated ash/biochar samples.			22.3%	0.36		$24,435
Cally Hunt		Cally will be performing density, Procter compaction, undrained shear stress, flowability and hydraulic conductivity of generated ash/biochar samples.			22.3%	0.36		$27,521
							Sub Total	**$249,926**
Contracts and Services								
Twin Ports Testing	Professional or Technical Service Contract	This is for expenses associated with sending samples out for Proximate and Ultimate Analysis.				0.01		$3,000

ARTi-Char	Professional or Technical Service Contract	This is for hiring ARTi-Char (biochar production company) to pick up our feedstock, haul it back to their site for subsequent conversion of the biomass to biochar and then shipping it back to the miller for size reduction efforts.				0.05		$89,100
Entity TBD	Professional or Technical Service Contract	Up to 9 tons of unmilled biochar will need to be milled to reduce particle size. This company will accept unmilled material from ARTi-char, process it and ship it to Boswell Energy Center.				0.01		$20,000
							Sub Total	**$112,100**
Equipment, Tools, and Supplies								
	Equipment	Soil density equipment ($500), Procter testing equipment ($1,000), Flowability testing equipment ($700), Fallcone testing equipment ($1,400), Hydraulic conductivity testing equipment ($1,600)	Soil density equipment for performing density measurements; Procter equipment allows for the determination of which moisture level in ash/biochar mixtures allows for maximum compaction; Flowability equipment allows for the determination of the flowability of ash/biochar mixtures; Fallcone testing equipment allows for the determination of the undrained shear strength of ash/biochar mixtures to assess walkability of material mixtures; Hydraulic conductivity testing equipment will allow for the determination of hydraulic conductivities of ash/biochar samples					$5,200
	Tools and Supplies	Chemistry lab general consumables ($1,701), Materials Engineering Lab general consumables ($1,634), Liquid Nitrogen for gas adsorption analysis ($530), Triple Distilled Mercury ($1,009)	Chemistry supplies is to cover costs associated with everyday consumable to be used for the project (glassware cleaning chemicals, kimwipes, scintillation vials etc.); Material Engineering lab consumable expenses will cover costs associated with everyday consumables used in the materials testing lab at NRRI; Samples must be cooled down with liquid nitrogen for extended periods of time					$4,874

			for gas adsorption analysis experiments; When performing Hg intrusion penetrometry experiments, each sample consumes ~60g of mercury which cannot be recovered. This will cover the purchase of this reagent.					
	Tools and Supplies	Biochar feedstock	This is the budget for the purchase (includes shipping if necessary) of biomass feedstock (hybrid poplar, beetle-infested ash etc.)					$25,000
							Sub Total	**$35,074**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Travel for NRRI employees to Boswell Energy Center	Covers mileage and gas costs for 5 visits per period to landfill testing site (160 mile round trip). 5 x 160 miles x $0.585/mile = $468 x 2 = $936/period					$1,900
							Sub Total	**$1,900**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								

		Shipping samples to Twin Ports Testing	Shipping expenses associated with sending samples to Twin Ports Testing for analytical services.					$200
		Shipping milled biochar (multi-tons) to Boswell Energy Center	Expenses associated with shipping multi-ton quantities of biochar in semis from miller to Boswell Energy Center					$8,800
							Sub Total	**$9,000**
							Grand Total	**$408,000**

Classified Staff or Generally Ineligible Expenses

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

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	$224,400
In-Kind	Minnesota Power	Minnesota Power will contribute $20,300 of in-kind support. They are contributing site access, engineering and regulatory support, and financial contributions to construct and monitor test sites at the Boswell Energy Center in Cohasset, MN	Secured	$20,300
			Non State Sub Total	**$244,700**
			Funds Total	**$244,700**

Attachments

Required Attachments

Visual Component

File: e6437982-18b.pdf

Alternate Text for Visual Component

Overview showing the opportunity to address MN's carbon footprint and create low-carbon market opportunities through the development of deployment opportunities (dewatering agent for coal ash impoundment) for Mn biochar...

Optional Attachments

Support Letter or Other

Title	File
UMD Sponsored Projects Administration approval letter	c9b608d7-b54.pdf
Letter of Support (Iron Range State Legislature)	f95c9891-bff.pdf
Letter of Support (Carbon Alliance)	ba87410b-f00.pdf
Letter of Support (Minnesota Power)	1fa05739-e3f.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have potential for royalties, copyrights, patents, or sale of products and assets?

Yes

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

Yes

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

No

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration (UMD)

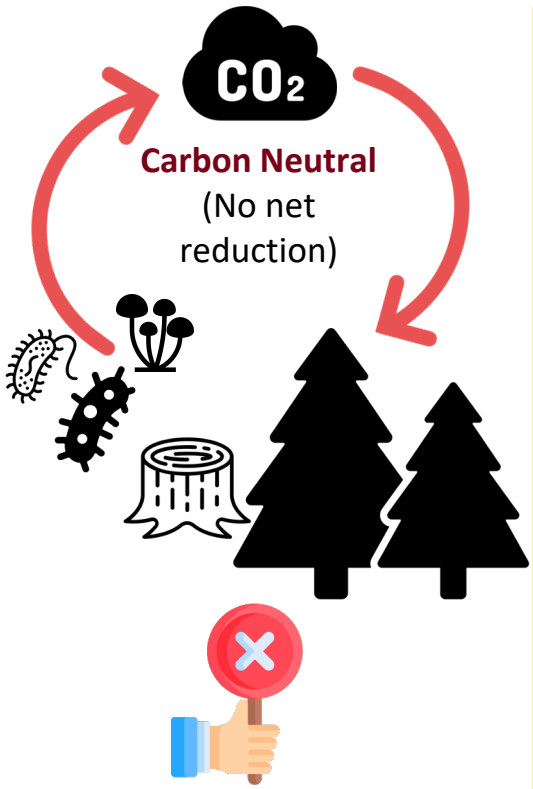
Natural Resources Research Institute
University of Minnesota Duluth
Driven to Discover

Creating Carbon Sequestration Markets for Minnesota Wood Products

Did you know? The amount of carbon on earth is constant. The only way to reduce atmospheric greenhouse gas concentrations is to transform gaseous CO_2 into solids. Biochar, a solid, stable carbon made from biomass, is the focus of our research.

MN BIOMASS RESOURCE OPTIONS

OPTION A



Carbon Neutral
(No net reduction)

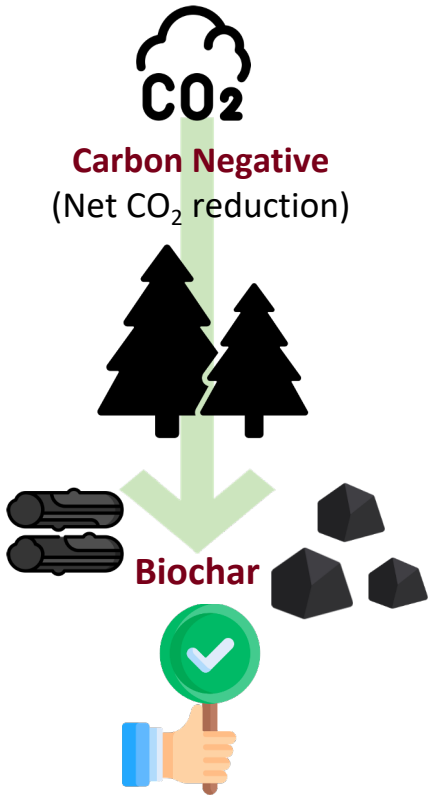
If nothing is done, carbon in fallen trees is converted back to gaseous carbon dioxide by microorganisms in soil.

Biochar feedstocks are **waste** streams:

-EAB infested trees
-Trees removed in fire mitigation efforts
-Industrial waste (mill sawdust e.g.)

Q: How much carbon can MN biochar sequester?
A: Conservative estimates suggest 10% of annual MN emissions can be offset.
Q: Why aren't we doing it already?
A: Reluctance to invest in industrial-scale biochar production due to limited market opportunities.

OPTION B



Carbon Negative
(Net CO_2 reduction)

Carbon in trees is transformed into biochar which is stable and unsusceptible to microbial decomposition.

Market Opportunity: Biochar as a dewatering (stabilizing) agent for permanent landfilling of coal combustion residuals (CCRs).

-Minnesota Power (just in Northern MN) needs to permanently landfill ~1 million cubic yards of CCR sludge over next 10 years.

-This amount of sludge would require ~500,000 TONS of biochar (≈ 1.6 million tons CO_2 sequestered)

-500,000 tons of biochar has a value of ~$75 million

PROBLEM STATEMENT: Atmospheric CO_2 concentrations need to be reduced but carbon sequestration industry needs to grow for this to happen.

PROJECT OUTCOMES: Demonstration of large-scale biochar deployment opportunity creating customers for MN biochar producers all while reducing MN's carbon footprint.

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