Environment and Natural Resources Trust Fund

2022 Request for Proposal

General Information

Proposal ID: 2022-077

Proposal Title: Biochar Soil Amendment to Improve Urban Tree Survival

Project Manager Information

Name: Eric Singsaas

Organization: U of MN - Duluth - NRRI

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Project Basic Information

Project Summary: We will demonstrate opportunities to turn waste wood from dying trees into biochar to supplement soils for urban tree plantings. Biochar stores carbon and helps to improve sapling establishment.

Funds Requested: $397,000

Proposed Project Completion: June 30 2027

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): Metro, 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.

This proposed project builds upon the City of Minneapolis resolution to incorporate regenerative agriculture and biochar as a climate resilience solution by expanding its application to improve tree planting along streets. Minneapolis has made a city-wide commitment to achieve a low carbon economy. As part of this commitment, the city has adopted a resolution supporting the use of biochar as a carbon negative solution; one that sequesters carbon absorbed by trees and other plants into the soil for the long term. Biochar is a high-carbon material made from waste biomass that can sequester carbon while also improving many properties of soils.

The introduction of invasive pests such as the Emerald Ash Borer is creating a vast surplus of dead and dying trees in Minnesota that could be disposed of by converting into biochar. There is an opportunity to leverage some of the properties of biochar to help improve tree survival in the city. When processed correctly, urban tree biochar can be turned into a soil amendment that increases aeration and water percolation in compacted soils, and also adsorbs pollutants such as lead, road salt, and polycyclic aromatic hydrocarbons, thereby alleviating many stresses on urban trees.

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.

The proposed work will demonstrate the conversion of insect-killed trees into a biochar that improves urban soil properties and then demonstrate its application to improve new tree establishment in the metro area. To understand the influence of biomass input and processing parameters on biochar properties, we will produce a variety of biochars at different temperature and residence time conditions to estimate the yield of char, then measure fixed carbon content, porosity, extractives, and cation exchange capacity of the biochar in the laboratory to understand the relationship between input biomass, processing conditions, and biochar properties.

To assess the impact of biochar on tree survival, we will select 2 biochars and up to 3 tree species that have low establishment success in Minnesota to conduct a common plot study investigating the practical impact of biochar on urban tree establishment and survival.

To demonstrate the impact of biochar in a real urban environment, we will work with the Minneapolis Park and Recreation Board and Hennepin County forestry crews to incorporate biochar into neighborhood tree planting.

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?

This project will:
Provide data on processing conditions and properties to guide small producers on producing biochar from insect-damaged tree wastes.
Provide information on the relationship between biochar properties and performance in urban forestry.
Provide information on how to use biochar to improve establishment and survival of trees that had previously been difficult to establish in Minnesota cities.
Establish biochar incorporation methods for urban tree-planting crews.
Disseminate information on production and use of biochar to other cities around Minnesota to help find markets for waste wood.

Activities and Milestones

Activity 1: Produce, test, and characterize biochar for urban soils experiments

Activity Budget: $158,810

Activity Description:
This activity will focus on first determining the optimal processing conditions for ash trees and then scale-up of biochar production for the plot and field experiments.

The properties of different biochars can vary substantially depending on many factors, including the input biomass, processing temperature, residence time, and post treatment conditions. Since many studies of biochar application in soils provide little information beyond the processing temperature, there is little guidance right now for municipalities and companies interested in producing biochar to develop a biochar industry that suits their needs.

This research activity will address this information gap. We will start with lab-scale processing of sample biomass from invasive species-threatened tree biomass (e.g., black ash, green ash, balsam fir) and use designed experiments to characterize the relationship between processing conditions and physical/chemical properties of the biomass.

Using the bench-scale experiments as guidance, we will decide upon two types of biomass to use for activities 2 and 3, and select conditions to make as much as 5 tons of biochar under each condition at the NRRI Biomass Conversion Laboratory. These biochars will be analyzed to verify their physical/chemical properties and shipped to St. Paul for the plot and field studies.

Activity Milestones:

Description	Completion Date
Complete pilot production of 2 biochar types for pilot study	March 31 2023
Understanding of processing condition impacts on biochar properties	May 31 2023
Complete pilot production of biochar for city tree planting	September 30 2023

Activity 2: Plot study the impact of biochar on new urban tree candidate species survival in Minnesota's climate

Activity Budget: $103,904

Activity Description:
The objective of this activity is to determine the value of biochar to trees planted in Minnesota without the possible confounding factors associated with the urban street-side environment. We will select three species that have low establishment success rates in Minnesota and therefore are not commonly planted today, and study them in research plots on the U of M campus using research plots.

We will plant 90 trees from three selected species purchased from a nursery that supplies trees to Minnesota's cities. These will be planted in outdoor plots with two types of biochar produced at the NRRI Biomass Conversion Laboratory (activity 1) and control (no biochar) using a nested factorial experimental design. After tree establishment, we will monitor them over the course of the study period for survival, growth in diameter, height, and general health.

The outcome of this activity will be a report on the relationship between biochar properties and species on the survival and growth of trees in Minnesota's climate.

Activity Milestones:

Description	Completion Date
Complete planting of plot study on St. Paul campus	June 30 2023
Complete growth and survival measurements	December 31 2026

Activity 3: Demonstrate biochar soil supplementation to improve survival of new tree varieties in neighborhoods

Activity Budget: $134,286

Activity Description:
The objective of this activity is to demonstrate the application of biochar to street tree planting in urban environments, and to assess the impact of biochar on tree survival and vigor.

We will select three species of trees in consultation with the municipal and county urban foresters , and apply two types of biochar with controls. The experimental trees will be planted at sites selected randomly throughout the city of Minneapolis in coordination with city tree planting crews. University students will be present to mix biochar into the soil for backfill with the planting crews. Trees will be GPS tagged for monitoring over the course of the study. Twice per year, student crews will measure the GPS tagged trees for survival and vigor, as well as record growth in diameter and height.

The main outcome of this activity will be a report on the relationship between biochar properties and species on the survival and growth of trees. A secondary outcome of this work will be to familiarize city tree planting crews and neighbors with biochar and its role in carbon sequestration as part of the city's climate strategy.

Activity Milestones:

Description	Completion Date
Complete installation of neighborhood trees in Minneapolis	October 31 2023
Complete field measurements on city trees	May 31 2027
Communication and dissemination of information to municipal leadership and citizens	June 30 2027
Final report	June 30 2027

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Eric North	University of Minnesota Twin Cities	Co-PI	Yes
James Doten	City of Minneapolis - Health	Supervisor of urban biochar applications.	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 be funded?

This project will run for five years in order for crews to get sufficient data on urban tree establishment and survival that is relevant and actionable by cities and biochar producers alike. At the end of the project per open we will have both experimental and field demonstration results that are sufficient to encourage cities to budget for biochar incorporation into their tree planting plans. This will allow cities to work with private industry to produce biochar from municipal tree wastes for the urban forestry markets.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Expand Materials Reuse and Recycling Jobs Program	M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 05k	$800,000
Forest and Bioeconomy Research	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 03q	$2,200,000

Project Manager and Organization Qualifications

Project Manager Name: Eric Singsaas

Job Title: Research Director

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

Dr. Singsaas is the Director for Materials and Bioeconomy at the University of Minnesota's Natural Resources Research Institute. He is a plant physiologist and biochemist who studies biological hydrocarbon production and forest product utilization. He has a B.A. in Biology and Chemistry from Concordia College, Moorhead, MN and a Ph.D. in Botany and Plant Biochemistry from the University of Wisconsin – Madison. From 2001-2015 Eric was professor of biology at the University of Wisconsin – Stevens Point, where he co-developed the Wisconsin Institute for Sustainable Technology to foster the development of a bioeconomy based around use of renewable natural resources. Since 2016 he has led development of bioeconomy programs at the University of Minnesota's NRRI. He has published research in the fields of plant stress physiology and plant-environment interactions, as well as biomass processing and biofuels technology development. He holds several patents in biorefinery and biofuels technology.

Organization: U of MN - Duluth - NRRI

Organization Description:

The Natural Resources Research Institute (NRRI) is an applied research and economic development engine for the University of Minnesota research enterprise. NRRI employs over 130 scientists, engineers and technicians to deliver on

its mission 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. NRRI researchers have extensive experience in managing large, interdisciplinary projects. NRRI's role is as an impartial, science-based resource that develops and translates knowledge. Projects include characterizing and defining resource opportunities, minimizing waste and environmental impact, maximizing value from natural resources and maintaining/restoring ecosystem function. The NRRI's Materials & Bioeconomy research group is focused on developing new and innovative uses of Minnesota's ag and forest biomass, residuals, and other waste products to create new opportunities for the state through applications of chemical, biological, and materials science principles. We work closely with the NRRI Biomass Conversion Laboratory to scale-up process technologies for pilot and demonstration-scale projects.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Eric Singsaas		Principal Investigator			26.7%	0.25		$49,539
Eric North		Co-Principal Investigator			26.7%	0.4		$72,607
Brian Barry		Materials Scientist to lead characterization			26.7%	0.25		$32,670
Sergiy Yemets		Chemist			26.7%	0.1		$7,164
Oleksiy Kacharov		Chemist - biochar analysis			26.7%	0.1		$6,575
Oksana Kolomitsyna		Chemist - Biochar characterization			26.7%	0.1		$6,791
Matthew Young		Research Engineer - Biochar production and applications			24.1%	0.25		$21,797
Jeff Kinkel		Engineer - Biomass conversion			26.7%	0.08		$11,640
Patrick Casey		Technical staff - biomass conversion			24.1%	0.08		$6,969
Robert Hietala		Technical staff - Biomass conversion			24.1%	0.08		$5,254
Student Researcher - Undergraduate		Field research assistant			0%	1.25		$39,000
Student Researcher - Undergraduate		Field research assistant			0%	1.25		$39,000
Temp Casual		Environmental Intern			7.4%	0.2		$7,113
Temp Casual		Environmental Intern			7.4%	0.2		$7,113
							Sub Total	**$313,232**
Contracts and Services								
Twin Ports Testing	Professional or Technical Service Contract	Ultimate and Proximate analysis of biochar made for this project.				-		$11,165
Trailer rental	Professional or Technical Service Contract	Rental of live bottom trailer to deliver wood chips from Minnesota timber company to Biomass Conversion Laboratory				-		$8,120

University of Minnesota Plot Fees	Internal services or fees (uncommon)	Plot rental on St. Paul campus for outdoor tree experiments.				-		$4,246
Data plan	Professional or Technical Service Contract	Annual data plan for tablet computers used to log and locate experimental trees across the city.				-		$901
							Sub Total	**$24,432**
Equipment, Tools, and Supplies								
	Tools and Supplies	Nursery trees, 270	Trees as experimental subjects; for 90 for plot experiment (St Paul campus) and 180 for field (Minneapolis city streets) experiments.					$33,750
	Tools and Supplies	Biomass - wood chips, approx. 50 tons	Obtain chipped wood from ash or other tree species threatened by invasive pests from local tree harvest company.					$5,075
	Tools and Supplies	Laboratory chemicals and supplies	Chemicals and consumables needed for physical and chemical analysis of biochar samples.					$963
							Sub Total	**$39,788**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Day trips between Duluth and Minneapolis - 9 trips annually for periods 1-2 and 3 trips annually for periods 3-5.	Duluth personnel to supervise research, meet with staff, and disseminate results. Minneapolis					$5,773

			personnel to supervise biochar production.					
	Other	Travel within Minneapolis - based on motor pool vehicle rate of $58/day for local use, average of 30 days per summer.	Student and technical staff for tree planting, data collection and monitoring.					$8,700
							Sub Total	**$14,473**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		Costs for shipping biochar	Costs for shipping biochar from Coleraine to Minneapolis using a trucking or freight service.					$5,075
							Sub Total	**$5,075**
							Grand Total	**$397,000**

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	$218,350
			Non State Sub Total	**$218,350**
			Funds Total	**$218,350**

Attachments

Required Attachments

Visual Component

File: 6e979e76-a16.pdf

Alternate Text for Visual Component

Visual depiction of converting dead or dying trees to biochar for soil amendment and its benefits to soil and trees: Increased soil carbon, improved soil physical properties, improved soil chemical properties, improved biological properties....

Optional Attachments

Support Letter or Other

Title	File
UMD Sponsored Projects Transmittal Letter	5c1c6fbb-b00.pdf
Letter of Support – Minneapolis	17d475ec-598.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?

No

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

N/A

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

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Natural Resources Research Institute
University of Minnesota Duluth
Driven to Discover

PROJECT TITLE:

Biochar Soil Amendment to Improve Urban Tree Survival

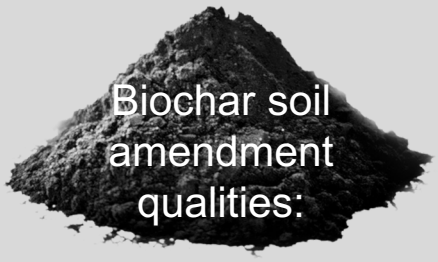
Problem: Urban trees are hard to grow because the street environment is stressful. Relatively few species are planted resulting in low urban tree diversity which can lead to rapid pest (e.g., Emerald Ash Borer) spread.

Innovation: Turn dead and dying trees into biochar to improve urban soils and help more tree species to survive the city

Remove dead and dying green ash monoculture.

Produce **biochar** as soil amendment.

Plant new tree species. Increase street tree survival in urban environments.



- +Soil carbon
- + Soil physical properties
- + Soil chemical properties
- + Soil biological properties

Improved survival of more tree species

Project Outcomes: Biochar amended soils allow for more species to survive in the urban environment. Diverse species increases value of urban forests, and addresses climate by storing soil carbon and moderating summer heat in city neighborhoods.

Natural Resources Research Institute
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