Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-339

Proposal Title: Mitigating Soil Salinity in Western Minnesota Landscapes

Project Manager Information

Name: Bo Hu

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

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Project Basic Information

Project Summary: The project proposes to change biomass management practices for sugar beets and sunflowers to remove soil salinity, improve water quality, and enhance ecosystem resilience in salinity area of western Minnesota

ENRTF Funds Requested: $495,000

Proposed Project Completion: June 30, 2030

LCCMR Funding Category: Land (F)

Project Location

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

Region(s): NW, SW,

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

Region(s): NW, SW,

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.

Soil salinity is an emerging threat to Minnesota's soils and water resources, with localized areas in the Red River Valley and irrigated regions such as Paynesville, Belgrade, Brooten, and Morris showing elevated surface salt concentration. Saline soils, enriched primarily with sodium chloride and sometimes sulfates, carbonates, or nitrates, disrupt soil structure, reduce fertility, and contribute to chloride runoff into waterways, threatening aquatic ecosystems. Both natural processes, including geologic weathering, and human activities, such as irrigation mismanagement, climate-driven wet-dry cycles, and long-term manure application, contribute to this problem. Traditional soil remediation techniques, such as leaching or soil replacement, are costly, disruptive, and difficult to implement at scale.

Phytoremediation, using salt-tolerant plants to extract salts from soil, offers a practical, environmentally sustainable solution. Our prior research funded by the Minnesota Environment and Natural Resources Trust Fund demonstrated that sugarbeet and sunflower effectively accumulate sodium chloride in aboveground biomass, leaving roots and key crop components relatively unaffected. Greenhouse trials show sugarbeet foliage can concentrate salts up to 20% of dry weight, suggesting substantial remediation potential. Developing field-scale phytoremediation strategies in Minnesota soils could reduce salinity, improve water quality, and enhance ecosystem health, providing a cost-effective, sustainable approach for protecting the state's natural resources.

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.

We propose to leverage the phytoremediation potential of sugarbeet (Beta vulgaris) and sunflower (Helianthus annuus) to reduce soil salinity in Minnesota's saline-impacted regions. Both species are widely grown in Western Minnesota with elevated soil salinity. Our research demonstrated that sugarbeet and sunflower could accumulate high concentrations of sodium and chloride in their leafy biomass, while roots, seeds, and taproots remain relatively unaffected. Currently, this biomass is returned to the soil, leaving salts returned back to soil. By changing harvesting and processing practices to remove the leafy biomass, we can extract salts from the soil, improving soil health, protecting water quality, and enhancing ecosystem resilience.

The project will demonstrate a field-scale approach to sustainably remove salts while producing usable biomass for energy, industrial products, or safe soil amendments. These additional uses create economic incentives for adoption, enabling an environmentally and economically sustainable solution. While the approach is designed for Minnesota soils, it is scalable and applicable to other saline-affected regions.

This project will provide the first proof-of-concept demonstration of crop-based salt phytoremediation for natural resource protection. Removing soil salinity will yield long-term environmental benefits, while supporting rural communities and offering a model adaptable to global salinity challenges.

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 remove excess salts from Minnesota soils using sugarbeet and sunflower phytoremediation, directly improving soil health and reducing chloride runoff to surface waters. By lowering soil salinity, the project will protect aquatic ecosystems, enhance water quality, and support more resilient plant and stable microbial communities. The harvested biomass can be repurposed for energy or safe soil amendments, promoting sustainable land management. Field-scale demonstrations and outreach will provide practical guidance for adoption, enabling long-term conservation and preservation of natural resources while offering a scalable model for saline-affected areas across the state and beyond.

Activities and Milestones

Activity 1: Study the salt phytoremediation potential of sugarbeet and sunflower in the field soil from Western Minnesota

Activity Budget: $157,125

Activity Description:
This activity will evaluate the capability of sugarbeet and common sunflower to remove salts from soil and reduce salinity under controlled and field conditions mimicking western MN soils. In greenhouse experiments, both crops will be grown for 25 weeks to examine how soil salinity, soil source, and fertilization affect plant growth and salt accumulation. Four salinity levels will be simulated using NaCl, $MgCl_2$, and $CaCl_2$ to represent non-saline, slightly saline, moderately saline, and highly saline soils. Four field soil sampled at different locations will be tested with three fertilization levels. Plant height, chlorophyll content, and biomass will be monitored, and salt concentrations in shoots and roots will be measured using ion chromatography. These data will allow calculation of salt uptake rates and removal efficiencies to identify optimal conditions for phytoremediation. Field trials will be conducted at Morris Outreach Center to validate greenhouse results under real local conditions. Soil and plant samples will be collected throughout the growing season to measure soil salinity, electrical conductivity, and salt accumulation in plant tissues. Mass balance analyses will quantify the amount of salt removed through harvested biomass. Results will demonstrate the feasibility of crop-based phytoremediation for reducing soil salinity and improving local soil health.

Activity Milestones:

Description	Approximate Completion Date
Greenhouse study for the salt phytoremediation potential of sugarbeet and common sunflower	June 30, 2028
Field practice of sugarbeet and common sunflower for salt phytoremediation	June 30, 2028

Activity 2: Develop processing techniques for sugarbeet and sunflower biomass after salt accumulation

Activity Budget: $171,659

Activity Description:
This activity will evaluate technologies for processing salt-rich biomass harvested from sugarbeet and sunflower used in soil phytoremediation. Biomass collected from field trials will be tested for conversion into value-added products, including animal feed, renewable energy, and de-icing agents. For feed production, harvested biomass will be chopped and preserved through anaerobic ensiling. Fermentation conditions, including moisture content and microbial inoculation, will be optimized to assess how salt accumulation affects silage quality. The resulting silage will be analyzed for dry matter, crude protein, amino acid composition, fiber fractions, minerals, and digestibility to determine its value as a ruminant feed supplement. The biomass will also be evaluated as a bioenergy feedstock through combustion to generate heat and power using combined heat and power systems. Elemental composition, ash yield, and energy content will be measured to estimate potential energy production. Ash produced during combustion will be analyzed to determine its suitability as a road de-icing agent. In addition, a techno-economic analysis will estimate capital costs, operational expenses, and potential revenues associated with biomass utilization. Life cycle assessment will compare energy use and greenhouse gas emissions with conventional practices to identify the most sustainable and economically viable biomass processing strategy.

Activity Milestones:

Description	Approximate Completion Date
Study conversion techniques for processing the biomass accumulated with salt	March 31, 2029

Techno-economic analysis	March 31, 2030
Comparison of energy balance and greenhouse gas emissions between this system and conventional practice	June 30, 2030

Activity 3: Extension and education

Activity Budget: $166,216

Activity Description:

This activity integrates research and extension to promote sustainable biomass harvesting and processing of sugarbeet and sunflower on saline soils. A stakeholder advisory board, including growers, processors, equipment specialists, soil health experts, and government representatives, will guide research, evaluate progress, and ensure outcomes meet practical needs. Stakeholders will provide feedback on research design, outreach strategies, and educational materials through regular meetings. An online Best Management Practices (BMP) toolbox will be developed via UMN Extension, offering guidance on biomass harvesting logistics, processing technologies, equipment needs, and economic considerations. The toolbox will include an interactive module for farmers to assess feasibility and receive recommendations based on farm size, soil salinity, and available markets. A professional version will allow technical directors to model customized scenarios and evaluate economic outcomes. Educational workshops will disseminate project findings to three audiences: farmers, biomass processors, and policymakers. Workshops will cover soil salinity management, biomass utilization technologies, and economic implications, including animal feed, bioenergy, and de-icing products. Surveys at the end of events and six months later will assess knowledge gain, changes in attitudes, and adoption of recommended practices. Together, these activities will support informed decision-making, encourage adoption of sustainable biomass practices, and improve soil health management.

Activity Milestones:

Description	Approximate Completion Date
Engage a stakeholder group and form an advisory board for this project	June 30, 2028
An online best management practices toolbox for biomass harvest and processing of sugarbeet and sunflower	June 30, 2029
Develop and deliver educational events focused on biomass harvest and processing through UMN Extension	June 30, 2030

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
This research will be shared through a variety of venues once completed. The results will be published in peer-reviewed journal articles, and acknowledgments and credit to the funding agencies are required for all possible dissemination. The proposed research results will also be presented at local conferences like sugarbeet and sunflower associations. The workshop presentation will be recorded and will be available online on the BBE research website and the University of Minnesota Extension Service. The research-based BMP toolbox will be hosted on the UMN Extension website, which has recently been revamped to improve usability and accessibility and has a wide audience within Minnesota (and beyond!). The BMP toolbox will also be promoted via social and traditional media outlets as well as at Extension events.

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?
The project's results will be implemented through partnerships with local farmers, conservation organizations, and natural resource agencies to demonstrate field-scale salt removal and biomass utilization. Findings will be shared via scientific publications, extension workshops, conferences, and an online resource toolbox to promote adoption of sustainable phytoremediation practices. Future funding will be pursued through USDA programs and industry collaborations to support broader deployment and biomass processing initiatives. These efforts will provide a scalable, environmentally and economically sustainable approach to managing saline soils in Minnesota and beyond.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Phytoremediation for Extracting Deicing Salt	M.L. 2022, , Chp. 94, Art. , Sec. 2, Subd. 08g	$451,000

Project Manager and Organization Qualifications

Project Manager Name: Bo Hu

Job Title: Professor

Provide description of the project manager's qualifications to manage the proposed project.
Dr. Bo Hu is a Professor and Director of Undergraduate Studies in the Department of Bioproducts and Biosystems Engineering at the University of Minnesota, where he has played a pivotal role in enhancing undergraduate education, particularly in the area of sustainability. With his innovative teaching methods, Dr. Hu integrates sustainability concepts across various courses, providing students with both theoretical knowledge and practical, real-world applications. His focus on critical thinking and hands-on learning ensures that students are well-prepared to address global environmental challenges in their future careers.

In addition to his commitment to education, Dr. Hu has over 20 years of active research experience, specializing in biomass utilization, fermentative conversion, and phytoremediation. His research projects include innovative solutions for removing phosphorus from manure and wastewater, using plants to clean polluted soil and water, and exploring synthetic ecology through the co-cultivation of microalgae and fungi in lichen biofilms. His team is also working on upcycling low-quality agricultural byproducts into nutritious animal feeds.

Dr. Hu's research team at the University of Minnesota has developed cutting-edge techniques, such as 16s rDNA-based microbial analysis using high-throughput pyrosequencing to study microbial species in waste treatment, and ITS sequencing to identify fungal species. Additionally, his team is advancing several conversion platforms, including fungal and microalgae co-cultivation, pelletized fungal fermentation, and solid-state fermentation of filamentous fungi, to produce biofuels and bioproducts from agricultural waste while addressing nutrient removal and pollution in contaminated water.

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

Organization Description:
In the College of Food, Agricultural and Natural Resources Sciences (CFANS) at the University of Minnesota, we look at the bigger picture. When we envision a better tomorrow, it includes disease-resistant crops, products that protect our health, lakes free from invasive species, and so much more. We use science to find answers to Minnesota and the world's grand challenges and solve tomorrow's problems. Almost 93 percent of students who earn CFANS undergraduate degrees find jobs in their
career field or enter graduate school within six months of graduation.

The Department of Bioproducts and Biosystems Engineering, in CFANS, discovers and teaches solutions for the sustainable use of renewable resources and the enhancement of the environment. We discover innovative solutions to address challenges in the sustainable production and consumption of food, feed, fiber, materials, and chemicals by integrating engineering, science, technology, and management into all degree programs.

We have a public impact through community engagement and extension efforts. We develop and deliver high quality, regionally and nationally-recognized research-based programs to meet current and emerging needs of industry and communities. We also have a long-standing tradition of close partnerships with alumni, industry professionals, organizations, government agencies, donors and community members.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
research faculty Hu/9 month appointment seeking summer salary		Lead Investigator/ oversee all lab components and personnel			26%	0.3		$74,648
Extension and Field Scientist		Overseeing all field components including data collection and personnel			26%	0.3		$42,222
professional researcher - appointment dependent on project funds		conducting experiments			26%	3		$320,879
							Sub Total	**$437,749**
Contracts and Services								
U of M lab services	Internal services or fees (uncommon)	analysis that cannot be done in Hu's lab				0		$6,000
							Sub Total	**$6,000**
Equipment, Tools, and Supplies								
	Tools and Supplies	Greenhouse cultivation supplies such as pots, trays, potting media, irrigation tubing, and plant labels for growing sugar beet and sunflower under controlled conditions. Fertilizers and salinity-adjusted nutrient solutions will also be used to simulate saline soil environments. Soil and plant sampling supplies will include soil corers, sample bags, gloves, field	to accurate and safely conduct proposed research					$24,615

		notebooks, and coolers for collecting and transporting soil and plant tissue samples from field sites in western Minnesota to the laboratory. Laboratory consumables will include centrifuge tubes, pipette tips, filter papers, reagents, and standards needed for measuring soil electrical conductivity, ion concentrations (e.g., sodium, chloride), and other indicators of salinity stress. Supplies for plant tissue processing, such as grinding materials, extraction reagents, and storage vials, will also be required.						
							Sub Total	**$24,615**
Capital Equipment								
		Purchase of a harvesting equipment to collect shoots of the sugar beet and sun flowers for the field trials. The small scale shoot harvester can be good options to start with and we may need some refinement to meet our needs.	This will be used to collect the top part of the sugar beets and sun flowers, which are currently shred back to soil. We want to collect this part for the removal of salt instead of returning back to the soil	X				$10,000
							Sub Total	**$10,000**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	We are planning five travels per year to western MN from St Paul campus, and requesting $300 each travel to cover the mileage.	$1500 for trips to gather soil samples around the saline land in western MN					$1,500
	Conference Registration Miles/ Meals/ Lodging	Two local trips to regional ag-expo to disseminate the practice change for addressing soil salinity issues in western MN	disseminate results and learn from peers					$3,136
							Sub Total	**$4,636**
Travel Outside Minnesota								

							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		Participant stipends/ 3 years @ $4k/year	Advisory council members will be invited to join our research group meeting to provide feedback and suggestions on how to design experiments and how to implement this technology on the real-world applications. The initial advisory council members include the following members: Paul Sproule, sugarbeet and sunflower farmer near Grand Folks, ND; Naeem Kalwar, Crop irrigation, Extension Soil Health Specialist, North Dakota State University, Langdon Research Extension Center; Vidyasagar Sunkavalli, Corporate EHS Director, Southern Minnesota Beet Sugar Cooperative; ROPA North America LLC, an agricultural machinery company covering sugar beet harvesting instrument. More members may be invited depending on different stage of the project.					$12,000
							Sub Total	**$12,000**
							Grand Total	**$495,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Equipment		Purchase of a harvesting equipment to collect shoots of the sugar beet and sun flowers for the field trials. The small scale shoot harvester can be good options to start with and we may need some refinement to meet our needs.	required to work on the research **Additional Explanation :** This will serve as an equipment to work on other phytoremediation type of research where the top part of the biomass needs to be harvested

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**-**

Total Project Cost: $495,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: debb9007-674.pdf

Alternate Text for Visual Component

Conceptual Visual of Saline Soil Mitigation via Sugar Beet and Sunflower Shoot Harvest...

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Authorization to submit	2ecd2001-476.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

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

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?

No

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

Wendy Moylan, Finance Professional, University of Minnesota

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A