Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2019 ENRTF Work Plan (Main Document)

Today's Date: Feb 5th, 2019

Date of Next Status Update Report: March 1, 2020

Date of Work Plan Approval: June 5, 2019

Project Completion Date: June 30, 2022

Does this submission include an amendment request? __

PROJECT TITLE: Phytoremediation for Extracting Deicing Salt from Roadside Soils

Project Manager: Bo Hu

Organization: University of Minnesota

College/Department/Division: College of Food, Agricultural and Natural Resource Sciences / Department of Bioproducts and Biosystems Engineering

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Location: The experiment will be primarily done at Biological Agricultural Engineering Building (BAE) 320, 1390 Eckles Ave, St Paul, MN, 55108. The impact of the project will be statewide

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Total Project Budget: $360,000

Amount Spent: $0

Balance: $360,000

Legal Citation: M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04i

Appropriation Language: $360,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to collaborate with the Department of Transportation to evaluate potential native plants that can be grown on roadsides to adsorb and remove toxic salts accumulated from deicing roads and assess uses for the harvested material.

I. PROJECT STATEMENT:

The icy conditions of Minnesotan winters require aggressive applications of road salts to melt the snow and ice on sidewalks and roads. It is estimated that 365,000 tons of salt is sprinkled in the Twin Cities Metro Area each year [1]. The continued contamination of salt can negatively affect the health of surrounding ecosystem. It is easy to leach into lakes, rivers, and groundwater, causing significantly increased salinity [2]. Many lakes (for instance, Loring pond and Diamond lake) around Metro have already been reported the chloride concentrations consistently surpassing the environmental standard[3] of 230 mg/L. High salt conditions can also negatively affect both plant growth and soil structure. Contaminated soil can affect up to 10 m off of a road side increasing soil density and alkalinity causing problems with erosion and vegetation [1]. Similar to road salt, improper irrigation can also cause salt contamination. Irrigation waters tend to have high concentrations of calcium, magnesium, and sodium ions. Use of this brackish water, particularly without adequate drainage management, results in the accumulation of salts in the rooting zone of plants due to evapotranspiration. This typically results in substantial global agricultural and economic losses, sustenance issues for subsistence farmers, and ecosystem imbalances [4-5]. Planting salt tolerant species can be one way to address this issue. For instance, Dr. Eric Watkins at the University of Minnesota is currently developing salt tolerant turf grasses so that they can grow better for roadsides [6]. Another approach is to develop technologies to remove salt from the soil. This approach will not only address the challenge for the sustainable urban restoration of roadsides and waterways but also provide an opportunity to regain agricultural croplands, revitalize rural economy and increase global food security [2].

Phytoremediation is an emerging method to extract salts from the soil by utilizing the growth of certain plants and remove salts by harvesting the plant biomass. These plants are typical halophytes, which excrete salt ions through specialized leaf glands[7]. Phytoremediation has numerous advantages over the conventional techniques for salt remediation, such as removing the contaminated soil to landfill while replacing it with clean soil, leaching, chemical amendments, and organic amendments. Phytoremediation is environmental friendly than the landfill of affected soil since this soil will have the opportunity to be re-used. It can also be more easily applied and less costly than the leaching and amendment methods. The harvested halophytic plant biomass may have some industrial applications, for instance, serving as animal feed or energy source.

Glasswort *Salicornia rubra (S. rubra)* is a succulent halophyte which is found growing in Kittson County, Minnesota. It grows on the saline areas such as salt flats, alkaline depressions, exposed shores of alkaline lakes, and saline swales [8]. Despite not being commonly found in central Minnesota, recently *S. rubra* has been observed growing next to major highways in the Twin Cities [8]. It is predicted that this is a result of the increased salinity of roadside soil, which is the ideal growing condition of *S. rubra* in its natural habitat. Since it is a native grass, *S. rubra* is suitable to MN climate and does not pose any economic threat to the local ecosystem. We believe that *S. rubra* has a great potential to be used for phytoremediation to remove and stabilize salts from the soil surrounding MN roads and lakes. *S. rubra* can uptake salts from the soil, bringing it into the above-ground plant tissues, and then reduce salt contamination through grass mowing and collection. This project will study the potential of *S. rubra* and other native species for the phytoremediation to remove salts from roadside soil and farmland [1].

II. OVERALL PROJECT STATUS UPDATES:

First Update March 1, 2020

Second Update September 1, 2020

Third Update March 1, 2021

Fourth Update September 1, 2021

Fifth Update March 1, 2022

Final Report between project end (June 30) and August 15, 2022

III. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1 Title: Screening of native Minnesota halophytic plants
Description:
We first want to study the halophytic plant inventory and screen more native species *via* lab growth tests for phytoremediation purpose. Around 200 distinct halophytic species are reported in the U.S., growing in coastal and inland regions [9]. Several studies have been done on these plant species, covering wide ranges of topics including halophyte ecology and physiology, and their utilization in farming systems. MNDNR publishes on their website about all the plant species living in the state of MN and we will compare with the reference to identify more halophytic species [8] suitable for MN conditions. We will grow some plants in the lab to screen more species that are native in MN and suitable to grow on the roadside. Potential species may include two halophytic plants *S. rubra* and *Suaeda maritima*; two crop plants: sugar beet and alfalfa; and two grass plants: wild barley and turf grass. Detailed plant species may change as we obtain more detailed information on the literature search. These potential specimen will be planted under varying salt concentrations to study optimal growing conditions. The plants will be kept in the same room with lights placed over the pots to simulate day and night. Plant height and leaf chlorophyll will be measured every 10 days. Salt content of the biomass will be measured after two month of growth at each conditions to determine the best candidate for road salt removal from soil.

ACTIVITY 1 ENRTF BUDGET: $ 116,000

Outcome	Completion Date
1. Select two halophyte, two crop and two grass plants with the ability to grow in MN	Year 1 - 01/2020
2. Screen these plants with lab growth for salt removal capability	Year 1 - 05/2020

First Update March 1, 2020

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ACTIVITY 2 Title: Plant growth test on salt-affected soil
Description:
We will consult with MNDOT to identify a slot of area for some pilot plant growing tests. The selected specimen from the lab tests will be planted in the spring on this pilot testing lot and monitored for the entire growing season. Based on the literature, it will take *S. rubra* 2-3 weeks before they grow to the market height and it is expected the plants can keep removing salts when the grass is mowed and collected. We will measure the plant biomass, nitrogen (TN), phosphorus (TP and PO_4-P), and the salt concentration in the shoots, roots, and soil. We will use this information to develop an implementation plan for how this species will be added into current regional seed mixtures for plantation diversity and how to maintain their growth. The plan will also consider effects of this species on the roadside stabilization and safety, a better outcome for NPDES permit compliance for obtaining a uniform, perennial cover, changes to standard specification for construction activities, structural root system enhancement that increase the shear resistance for reducing soil slides, flood overtopping stability, etc.

ACTIVITY 2 ENRTF BUDGET: $ 120,000

Outcome	Completion Date
1. Pilot plant growth in a field	*Year 2 – 12/2020*
2. Evaluation and analysis of samples for pilot growth study	*Year 2 – 05/2021*

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Third Update March 1, 2021

Fourth Update September 1, 2021

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ACTIVITY 3 Title: Develop possible utilization of harvested plant biomass
Description:
It is important to find a utilization of the biomass in order to cover the cost of harvest, and provide an economically sustainable solution. We will study the utilization of the biomass for animal feed supplement, energy source, and for recycled road salts after ashing. *S. rubra* has been reported as the ingredient supplement to improve the flavor and nutrition of the animal feed. The plant biomass will be analyzed for its feed value, including the following parameters: gross energy, fiber, total protein and amino acid profile, phosphate, lipids, and possible accumulation of heavy metals. The plant biomass can also be combusted for heat and power, meanwhile the ash can be recycled as the road salts.

ACTIVITY 3 ENRTF BUDGET: $ 124,000

Outcome	Completion Date
1. Biomass characterization for possible applications	*Year 3 - 10/2022*
2. Business strategies for how to adopt this plant for road side applications	*Year 3 - 06/2022*

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Third Update March 1, 2021

Fourth Update September 1, 2021

Fifth Update March 1, 2022

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IV. DISSEMINATION:

Description:
We will publish two to three peer-reviewed manuscripts in the related journals to disseminate our results to the general public. We will also use the university extension website www.extension.umn.edu as well as PI's academic website http://bohu.cfans.umn.edu/ for dissemination of the research. A teaching module will be developed to teach students the concept of phytoremediation, lab plant cultivation, as well as basic analytical techniques on how to measure sodium and chloride concentration via the ion chromatography. The teaching module will be primarily targeting to the new coming freshmen students as well as potential undergraduate candidates to stimulate their interests in the STEM related field. We will also explore the possibilities to add this module to the UMN Summer Camp program or CFANS booth at MN State Fair to showcase the general public about our mission toward the overall environmental protection.

The primary target to disseminate our research results will be the scientific community, MNDOT as well as local community concerned with the road salt pollution. Information obtained from the plant cultivation experiments will be directly applied to establish possible implementations and business models in order to develop a sustainable solution for the road salt remediation. The research results will be fully disseminated to the public and we are not anticipating any patents or revenues from the project. However, any possible royalty, copyright, patent, and sales of products and assets resulting from this project will be subject to revenue sharing requirements with ENRTF according to Minnesota Statutes, section 116P.10.

The Minnesota Environment and Natural Resources Trust Fund (ENRTF) will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the ENRTF Acknowledgement Guidelines.

First Update March 1, 2020

Second Update September 1, 2020

Third Update March 1, 2021

Fourth Update September 1, 2021

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Final Report between project end (June 30) and August 15, 2022

V. ADDITIONAL BUDGET INFORMATION:
A. Personnel and Capital Expenditures

Explanation of Capital Expenditures Greater Than $5,000: N/A

Explanation of Use of Classified Staff: N/A

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:

Enter Total Estimated Personnel Hours for entire duration of project: 7960	Divide total personnel hours by 2,080 hours in 1 yr = TOTAL FTE: 1.3

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:

Enter Total Estimated Contract Personnel Hours for entire duration of project: 0	Divide total contract hours by 2,080 hours in 1 yr = TOTAL FTE: 0

VI. PROJECT PARTNERS:

A. Partners outside of project manager's organization receiving ENRTF funding: N/A

B. Partners outside of project manager's organization NOT receiving ENRTF funding
We are partnering with the MN Department of Transportation for our field study.

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

The project will have a broad impact on both academia and industry. The results will provide fundamental knowledge on how these native plants mobilize and excrete salt in the soil. The possible applications will lead to sustainable developments in road salt management and agricultural practices, and alleviate the deteriorating conditions related to road salt application and improper irrigation.

VIII. REPORTING REQUIREMENTS:

- Project status update reports will be submitted March 1 and September 1 each year of the project
- A final report and associated products will be submitted between June 30 and August 15, 2022

IX. SEE ADDITIONAL WORK PLAN COMPONENTS: N/A

A. Budget Spreadsheet
B. Visual Component or Map
C. Parcel List Spreadsheet
D. Acquisition, Easements, and Restoration Requirements
E. Research Addendum

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2019 Budget Spreadsheet
Legal Citation: M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04i
Project Manager: Bo Hu
Project Title: Phytoremediation for Extracting Deicing Salt from Roadside Soils
Organization: University of Minnesota
Project Budget: $360,000
Project Length and Completion Date: 3 years, June 30th, 2022
Today's Date: August 27th, 2018

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 311,847	$ -	$ 311,847
Bo Hu, Project Manager (74.5% Salary, 25.5% Benefits), 10% FTE per year for three years			
Research Associate (74.5% Salary, 25.5% Benefits), 50% FTE for 3 years			
Graduate student, Research assistant, 50% FTE			
Undergraduate student researcher, 400 hours			
Professional/Technical/Service Contracts			
Professional analysis service for water and solid samples at other UMN analytical labs	$ 9,365	$ -	$ 9,365
Equipment/Tools/Supplies			
Supplies for the lab experiments to purchase necessary chemicals, test kits, culture medium, and other	$ 31,215	$ -	$ 31,215
Capital Expenditures Over $5,000			
	$ -	$ -	$ -
Fee Title Acquisition			
	$ -	$ -	$ -
Easement Acquisition			
	$ -	$ -	$ -
Professional Services for Acquisition			
	$ -	$ -	$ -
Printing			
Publication costs for two/three papers, page charges	$ 3,122	$ -	$ 3,122
Travel expenses in Minnesota			
In-state travel (Mileage, lodging, and meals) to the site for collecting water samples	$ 4,451	$ -	$ 4,451
Other			
	$ -	$ -	$ -
COLUMN TOTAL	$ 360,000	$ -	$ 360,000

OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: UM F&A		$ 169,254	$ -	$ 169,254

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation:		$ -	$ -	$ -
Past appropriations:		$ -	$ -	$ -