Reference SON: *Strategic R&D*

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Growth Enhancing Bio-Polymer Use in Ecosystem Restoration[1]

Research Need

Sea level rise due to climate change is predicted to impact nearly all coastal wetlands, with continued losses causing negative impacts to tourism, the fishing industry, wildlife habitats, protective barrier islands, and residential areas. For example, data from past hurricanes indicates that the loss of every one-mile strip of wetlands along the coast corresponds to an estimated $5.8M average annual increase in property damage (Restore or Retreat.org).

Grasses and grass-like plants of tidal salt marshes on the coasts of the United States, as well as mangrove and tupelo gum swamps, are important to sustainability of wetland and marsh areas and critical to restoration efforts in these low lying areas. However, it is often difficult to re-establish this native vegetation because soil loss can be more rapid than root development. This effect is particularly acute in tidal wetlands and salt marshes, where establishment of salt-tolerant species is slow compared to grasses. A method of soil amendment, particularly for use in increasingly saline environments, is needed to improve success of wetland restoration, reduce sediment losses, increase slope stability, improve soil germination rates, increase drought resistance and improve revegetation rates on disturbed lands.

Exopolysaccharides (EPS) are produced by numerous Rhizobium species, symbiotic bacteria that nodulate plant roots using plant sugars to produce a biopolymer (BP) film. The functions of this film include surface adhesion, water retention and nutrient accumulation. In field demonstrations, a single application of concentrated EPS to soil at the beginning of the growing season has resulted in plants with larger root masses. In regions with saline soils, EPS can also increase the salt tolerance of some plants which improves plant growth and reproduction. These biopolymers have potential to fill a unique niche in ecological restoration by facilitating more rapid and successful vegetation establishment.

Project Objectives & Plan

Rhizobia will be isolated from saline tolerant legumes, cultured, and grown in batch – and subsequently pilot scale – reactors, and effects on plant growth in saline environment tested in lab and field scale.

The production of soil amendments using monocultures in bioreactors, developed using *Rhizobium tropici*, has been patented to the US Army and licensed to industrial partners (Newman et al. 2010). The same industrial process will be used to produce a novel rhysobially based material, to geoengineer soil systems such that plants are better protected from salt stress. In the laboratory, the rhizobia will be isolated from the soil around this saline tolerant legume, cultured, and grown in batch reactors, where the microbes are stimulated to produce large quantities of this biopolymer.

Laboratory, mesoscale (lysimeter), and field-scale soil tests will be conducted employing grasses used for wetlands restoration, to assess benefit to plant growth in a saline environment. Metrics, compared to plants grown in non-amended (control) soil, will include:

- Root mass and shoot length
- Root architecture
- Total suspended solids (TSS) in leachate and runoff water
- Nutrient concentration (TKN, nitrate, phosphate) in leachate and runoff water
- Changes in total organic carbon (TOC) in soil over time

Payoff

This research constitutes an important leveraging opportunity to adapt biopolymer technology developed for military applications to ecological restoration, and levee and coastal management needs. By combining modern bioengineering with an understanding of the natural symbiotic relationship between plants and soil microbial communities, soils can be rapidly adapted for enhanced re-vegetation during wetland and restoration efforts. The biopolymer can be used as a soil amendment to induce rapid root and shoot development. This root development can facilitate soil stabilization to encourage both stability of current wetlands and development of new or restored wetlands, as well as dunes, levees or other areas. Imparting salt tolerance in brackish wetlands is key to rapid establishment of vegetation in brackish and saline environments.

Products

Technical Reports (TRs)

Larson, S.L., Martin, W.A., Wade, R., Hudson, R. and Nestler, C. (2016). Technology transfer of biopolymer soil amendment for rapid re-vegetation and erosion control at Fort A. P. Hill, Virginia (ERDC/EL TN-16-2), Technical Report. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Larson, S. L., Nijak, G., Corcoran, M., Lord, E. and Nestler, C. (2016). Evaluation of rhizobium tropic-derived biopolymer for erosion control of protective berms. Field Study: Iowa Army Ammunition Plant (ERDC TR-16-5), Technical Report. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Larson, S. L., Busby, R., Martin, W. A., Medina, V. F., Seman, P., Hiemstra, C. A., Mishra, U. and Larson, T. (2017). Sustainable carbon dioxide sequestration as soil carbon to achieve carbon neutral status for DoD lands (ERDC TR-17-13), Technical Report. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Larson, S.L., Corcoran, M.K., Gent, D.B., Butler, A.D. and Nestler, C.C. (2019). Improved levee resilience through soil application of a natural organic polymer – field study Kaufman Levee No. 1. (ERDC TR-19-6), Technical Report. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Larson, Steve et al. (in preparation) Revegetation of Saline Levee Soil with Application of Specific Biopolymers, ERDC TR-17-DRAFT (Demo funded under Flood and Coastal Risk Reduction, applying results of laboratory studies supported by EMRRP program)

White Papers

Larson, S. L. (2017). Levee resilience or “getting the grass to grow”. *Flood Risk Management (FRM) Newsletter*, 10(3).

Conference Presentations/Webinars/Workshops

(2016). Biopolymer levee field test and revegetation under saline conditions, Webinar.

(2016). Soil as a sink for atmospheric carbon sequestration, Webinar. Center for the Advancement of Sustainable Innovations (CASI), Seven Webinar Series.

(2017). Evaluation of biopolymer for erosion control of protective berms”, Webinar. SERDP-ESTCP Webinar Series.

[1]Project Alias – Work Unit Documentation Title: *Improved Plant Survival and Wetland Stability* ERDCwiki Title: *Revegetation of Coastal Wetlands using Biopolymer and Salt Tolerant Plants*