EVALUATING THE SUCCESS OF ESTABLISHMENT OF SPECIFIC SALTMARSH VEGETATION IN ENGINEERED SOILS

by

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(Under the Direction of S. Sonny Kim)

ABSTRACT

The purpose of this study is to evaluate the success of establishment of specific saltmarsh vegetation in engineered soils. This identifies efficient and cost-effective procedures to reestablish pre-existing vegetation of saltmarshes after construction, repair, or maintenance in GDOT rights-of-way. The study involved evaluating the growth of four different saltmarsh vegetation types (*Spartina alterniflora, Juncus roemerianus, Schoenoplectus tabernaemontani,* and *Borrichia frutescens*) in eight engineered soil mixtures that approximate the physical and chemical properties of saltmarsh soils, along with two controls providing baselines for growth in potting soil, as well as, growth in the material specified in the current GDOT construction specifications for restoration of disturbed saltmarshes. This study included a greenhouse experiment, in which biological and aqueous chemistry measurements were collected. This study provides recommendations for each vegetation type, including which engineered soil is advised and the best method to measure success within and adjacent to Georgia's estuaries and saltmarshes.

INDEX WORDS: Saltmarsh Restoration, Engineered Soil, Saltmarsh Soils, *Spartina alterniflora, Juncus roemerianus, Schoenoplectus tabernaemontani, Borrichia frutescens*

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DEDICATION

I would like to dedicate my thesis to my beloved family especially my parents, Jeffrey and Christina House.

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1.0 INTRODUCTION

1.1 Saltmarsh Alterations

Construction, reconstruction, repair, or maintenance of road infrastructure in Georgia's coastal counties cause disturbances of coastal marshes and other hydrologically sensitive areas within and adjacent to Georgia's estuaries. These disturbances often result in the alteration of the saltmarsh's geotechnical composition and structure due to heavy equipment and foreign backfill material. The use of foreign backfill material and heavy equipment over saltmarshes destroys vegetation and damages wetlands resulting in compacted surface soil conditions that differ from the naturally occurring saltmarsh soils.

In these Environmentally Sensitive Areas (ESAs), the soil is unique due to the hydrologic transport and deposition processes that create the soil over extended periods (i.e., years to decades). Therefore, once altered, the soil's physical and chemical properties differ from surrounding soils. Because the resulting compacted surface soil properties and conditions vary from the natural marsh soils, native vegetation cannot easily thrive in the disturbed areas. These areas can remain barren for extended periods after the construction activity, leaving them vulnerable to erosion from stormwater runoff and tidal flow, which can cause the loss of structural stability in the geotechnical foundations of adjacent transportation assets such as roads and bridges.

Infrastructure improvements in Georgia's coastal counties without an ecological restoration plan can cause harmful disturbances in coastal marshes and other ESAs, such as loss of vegetation and increased erosion. The Georgia Department of Transportation's (GDOT's) regulatory requirements related to construction activities that occur in wetlands (Supplemental Specifications, Construction of Transportation Systems, 2016 Edition) are generally found throughout Section

107 (Legal Regulations and Responsibility to the Public) and in subsection 107.23.E (Environmental Considerations - Temporary Work in Wetlands Outside of the Construction Limits within the Right-of-Way and Easement Areas). Pursuant to these regulations, guidance for stabilization in ESAs is provided, including the use of construction mats and provisions for matted and compressed soils to be backfilled to the original elevation with a granular material and covered by excelsior or straw. However, this Specification 107.23.E does not explicitly require documentation or restoration of pre-construction soil properties or vegetation. Restoration of pre-construction soil properties will maintain or even improve the functionality and ecologic conditions in the ESAs by aiding in the establishment of the pre-existing or dominant vegetation.

1.2 Study Objective

The primary objective of this study is to evaluate the success of establishment of specific saltmarsh vegetation in engineered soils and identify efficient and cost-effective procedures to reestablish pre-existing or dominant vegetation after construction, repair, or maintenance. These engineered soils are created using inland materials designed to approximate the geotechnical texture and density of native saltmarsh soils. Engineered soils are needed because harvesting native saltmarsh soils from one marsh area to restore another is not permitted, and as such, the unique characteristics can be replicated through this augmentation process. This study focuses on four specific species of saltmarsh vegetation in the engineered soils (*Spartina alterniflora, Juncus roemerianus, Schoenoplectus tabernaemontani,* and *Borrichia frutescens*) because they are the dominant vegetation observed during the field sampling of saltmarshes in Georgia.

Establishing the pre-existing or dominant vegetation will limit erosion and help ensure the structural stability in the geotechnical foundations of adjacent transportation assets, which could decrease the maintenance after construction. While the effects of restoration and the formation of vegetation have been investigated, there is limited existing work on the establishment of vegetation in engineered soils for restoration purposes. Saltmarsh restoration consists of returning an altered marsh or former marsh to its previously existing naturally functioning state and requires preparation, execution, and management. Vegetation specifically assists the adjacent ecosystems by decreasing erosion, storing floodwaters, filtering pollutants, and serving as a carbon sink (USDA 2019). Restoration is important to maintain the ecosystem services provided by saltmarshes when a marsh is damaged or destroyed. If any aspect of the saltmarsh is altered or damaged, then it will not perform properly. The results from this study can be used to aid in the creation of a draft standard construction specification for consideration by GDOT, detailing the means, methods, and materials for use in establishing vegetation.

1.3 Overview of Thesis

This thesis consists of eight chapters that evaluate the potential for engineered soil mixtures to effectively revegetate and reestablish saltmarshes, specifically for GDOT applications. Chapter 2 provides information on the background of the study. Chapter 3 includes information on prior research and literature conducted on the restoration processes of saltmarshes. Chapter 4 discusses the study's objectives and significance. Chapter 5 summarizes the experimental design and methods used to accomplish the research. Chapter 6 provides the results and analysis from the study. Chapter 7 discusses the conclusions and recommendations for the establishment of vegetation based on the study. Chapter 8 offers future work ideas for potential applications.

2.0 BACKGROUND

This research started in order to investigate techniques to ensure the success of natural vegetation. This research will help aid in erosion prevention of disturbed areas after highway construction. This is because highway construction has negative effects on the hydrologic conditions (Mitsch and Gosselink, 2015). Additionally, construction changes the land use and hydrology inputs. Another negative aspect that highway construction causes is hydrologic isolation (Clewell et al., 1967; Evink, 1980; and Adamus, 1983). These hydrologic inputs can increase, which increases runoff and can wash away exposed soils if the disturbed areas are not stabilized. It is well known that vegetation can assist in stabilizing the soil sediments, which helps with erosion control (Feher and Hester, 2018). Therefore, to decrease erosion it is important to investigate techniques to ensure the success of natural vegetation.

This study focused on eight undisturbed saltmarshes in Georgia that were chosen and characterized as reference sites for restoration purposes in Chatham, McIntosh, and Glynn counties (Figure 1). These saltmarshes were chosen due to their location and proximity to current or future GDOT projects to determine the physical and chemical properties. In each of the eight sites, a vegetation survey was conducted to determine the dominant vegetation based on percent cover to use in this study. The vegetation that primarily dominated each site location is shown below (Table 1).

Table 1: Site Vegetation

Site	Vegetation	Percent Cover (%)
1A	Spartina alterniflora	100
1B	Spartina alterniflora	100
1C	Spartina alterniflora	100
2A	Spartina alterniflora	75
	Borrichia frutescens	5
2B	Spartina alterniflora	100
2C	Spartina alterniflora	100
3A	Juncus roemerianus	90
3B	Spartina alterniflora	65
3C	Juncus roemerianus	75
4A	Schoenoplectus tabernaemontani	50
4B	Schoenoplectus tabernaemontani	50
4C	*Bolboschoenus robustus*	75
5A	Schoenoplectus tabernaemontani	55
5B	Schoenoplectus tabernaemontani	65
	Spartina alterniflora	10
5C	Schoenoplectus tabernaemontani	40
	Spartina alterniflora	15
6A	Spartina alterniflora	100
6B	Spartina alterniflora	100
6C	Spartina alterniflora	100
7A	Spartina alterniflora	40
7B	Borrichia frutescens	50
7C	Borrichia frutescens	51
8A	Spartina alterniflora	100
8B	Spartina alterniflora	100
8C	Spartina alterniflora	100

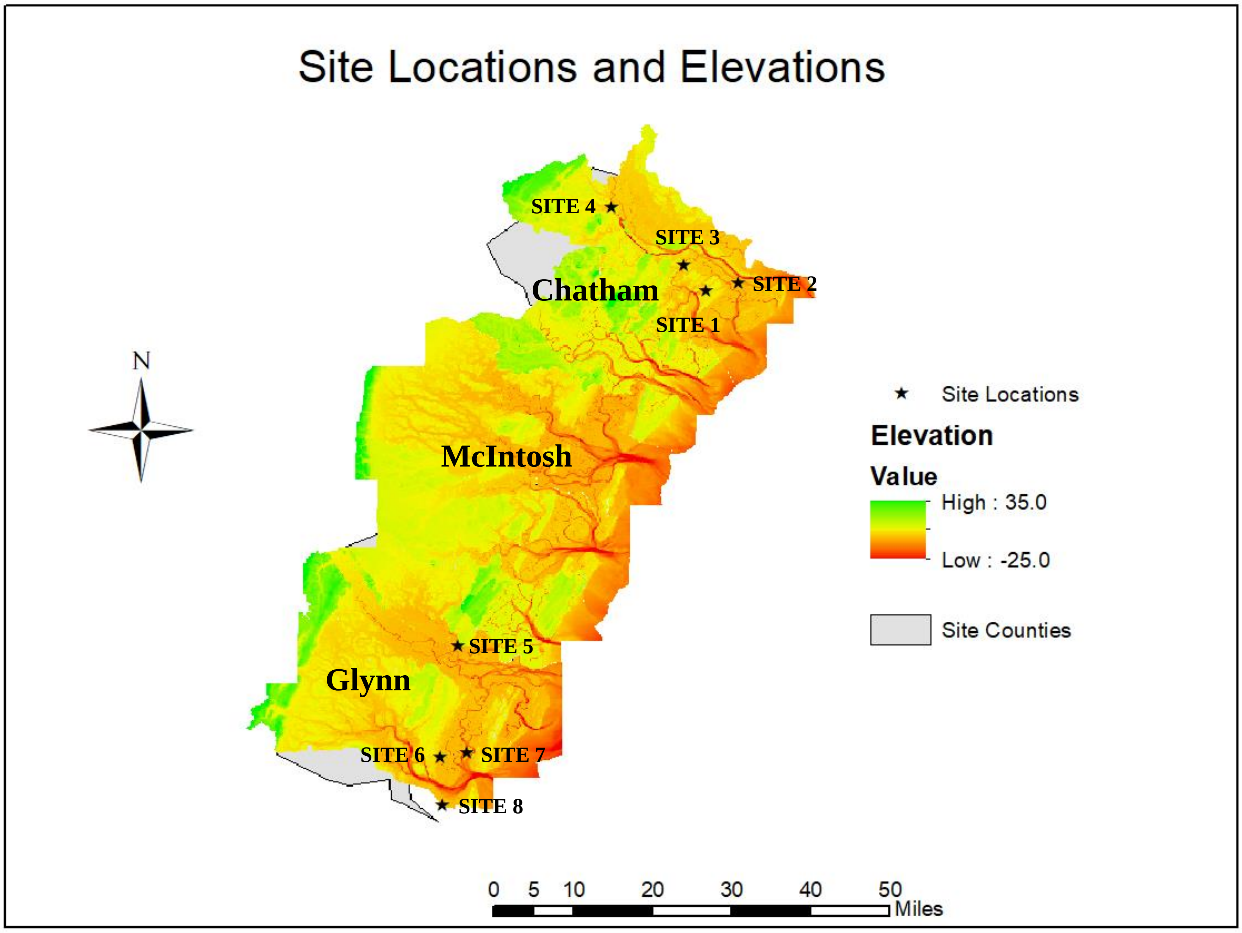


Figure 1: Site Locations

In each of the eight undisturbed saltmarshes, soil was collected from three separate locations (A, B, C) in March 2018. Three locations of each saltmarsh site were selected based on the findings from Crawford and Stone's (2015) study, which found there are considerable differences in soil texture and water retention within marshes, which could possibly influence how the marsh reacts to disturbances. In order to gather the most beneficial soil sample that represents the typical soil texture and nutrient availability, soil was collected by extracting the top twelve inches of the root zone soil and retrieving a soil sample using sealed waterproof containers and a bulk density soil sampling kit. A multiparameter waterproof meter and a pushpoint sampler were used to measure pore water pH, salinity, and redox by collecting a small amount of water at the sample site. Soil samples were then transported to the Geotechnical and Materials Testing (GMAT) laboratory at the University of Georgia where they were analyzed for moisture content, organic matter, bulk density, particle size distribution, and nutrients.

The soil physical properties were determined by following American Society for Testing and Materials (ASTM) standards. In order to create the particle size distributions, the procedures from Standards ASTM D1140 (2017) and ASTM D422 (2007) were followed. Moisture content was determined by ASTM D2216 (2010), and organic matter was determined using ASTM D2974 (1987). Analysis results were utilized to determine the physical and chemical properties of saltmarsh soils for the specific purpose of optimizing the reestablishment of soil properties and functionality after construction has occurred (Salehi Hikouei et al., 2019). These geotechnical soil properties of saltmarsh soils along the Georgia coastline, are summarized in Table 2. Based on the test results, the engineered soil mixtures were designed for this study.

Table 2: Geotechnical Soil Properties in Saltmarshes Along the Georgia Coast (Salehi Hikouei et al., 2019)

Site	Latitude	Longitude	Organic Matter (%)	Moisture Content (%)	Bulk Density (g/cm^3)	Clay (%)	Silt (%)	Sand (%)	Soil Texture
1.A	32.03	-80.93	2.44	35.97	1.44	16.17	34.75	49.08	Loam
1.B	32.03	-80.93	7.22	201.72	0.4	35.25	27.28	37.47	Clay Loam
1.C	32.03	-80.93	10.57	225	0.4	14.96	25.13	59.91	Sandy Loam
2.A	32.01	-80.89	1.46	48.14	1.18	12.1	7.19	80.72	Sandy Loam
2.B	32.01	-80.89	3.59	77.95	0.87	23.06	22.32	54.62	Sandy Clay Loam
2.C	32.01	-80.89	5.99	181.32	0.44	47.09	45.56	7.35	Silty Clay
3.A	32.06	-81.02	3.73	90.65	0.76	44.57	29.28	26.15	Clay
3.B	32.06	-81.02	0.24	25.11	1.5	17.02	11.18	71.8	Sandy Loam
3.C	32.06	-81.02	0.54	38.2	1.31	17.22	11.32	71.46	Sandy Loam
4.A	32.17	-81.16	23.85	428.17	0.18	22.68	70.65	6.67	Silt Loam
4.B	32.17	-81.16	19.54	278.87	0.27	56.46	37.1	6.44	Clay
4.C	32.17	-81.16	28.88	309	0.29	28.27	54.52	17.21	Silt Clay Loam
5.A	31.36	-81.44	8.02	227.01	0.39	38.9	33.15	27.95	Clay Loam
5.B	31.36	-81.44	7.76	215.31	0.37	59.35	34.08	6.57	Clay
5.C	31.36	-81.44	8.54	254.17	0.35	55.15	39.99	4.86	Clay
6.A	31.16	-81.45	0.89	63.82	1.07	16.52	22.01	61.47	Sandy Loam
6.B	31.16	-81.45	7.8	338.3	0.31	22.68	72.52	4.8	Silty Loam
6.C	31.16	-81.45	5.66	261.39	0.37	19.61	73.11	7.28	Silt Loam
7.A	31.17	-81.42	1.47	24.6	1.56	7.52	13.12	79.36	Loamy Sand
7.B	31.17	-81.42	1.59	23.08	1.67	8.55	11.02	80.43	Loamy Sand
7.C	31.17	-81.42	1.09	34.87	1.45	9.7	10.19	80.11	Loamy Sand
8.A	31.07	-81.47	3.81	185.54	0.46	30.48	35.71	33.81	Clay Loam
8.B	31.07	-81.47	1.05	35.64	1.36	17.87	22.31	59.82	Sandy Loam
8.C	31.07	-81.47	5.98	213.95	.40	39.11	55.59	5.30	Silty Clay Loam

The soil textures varied significantly based on the sites. Sites 2A, 7A, 7B, and 7C contained more percent sand compared to other locations. While higher percent clay was found in 4B, 5B, and 5C. Higher percent silt was discovered in 4A, 6B, and 6C. These findings also show that when organic matter decreases or sand content increases, the soil bulk density will increase. If bulk density increases, it can potentially constrict and limit vegetation growth and productivity of certain species in a saltmarsh environment - thereby dictating the favored species for that environment. These discoveries are important to understand what type of soil is found in saltmarshes in Georgia in order to create beneficial soils that support successful restoration.

As previously stated, the construction of road infrastructure through a saltmarsh can alter the landscape by changing the elevation and the hydrology, as well as introducing foreign soil as the backfill after construction. An important aspect to note is the location of the site in relationship to the road network of the counties as shown in Figure 2. Figure 2 shows that each of the sites are found near areas where numerous roads are located. It should be noted that the sites may already be altered in some way, such as foreign soil or pollution due to recent new highway construction or maintenance projects. The designed soil mixture implemented in this study is intended to mimic the soil during sampling and not to optimize soil characteristics.

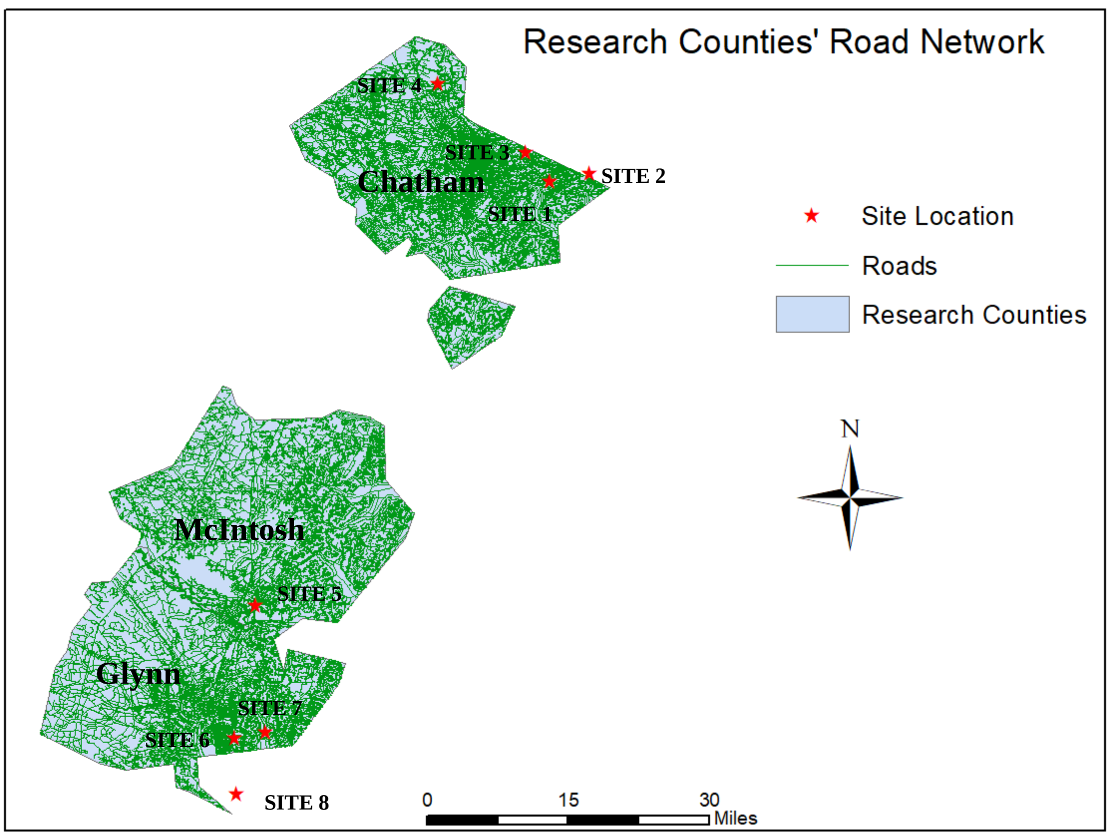


Figure 2: Research Counties’ Road Network

3.0 LITERATURE REVIEW

3.1 Overview

For this study, the literature review specifically evaluated publications that demonstrate case histories and research studies conducted both nationwide and statewide. Special attention was given to the following:

(1) the importance and resilience of saltmarshes;

(2) an evaluation of specific vegetation in saltmarshes and their characteristics;

(3) harmful effects to saltmarshes and other ESAs from infrastructure and disturbances and the need for the reestablishment of prior conditions for sustainability; and

(4) the restoration of saltmarshes, specifically the need after construction, repair, or maintenance of road infrastructure in Georgia's coastal counties.

3.2 Saltmarshes

Saltmarshes are coastal wetlands that are exposed to saline water and inundated regularly by tides, and as such, are unique ecosystems. Saltmarshes provide countless benefits to the environment, as well as to surrounding ecosystems. Saltmarshes have been found to alter and filter potentially catastrophic effects of storms, floods, and droughts due to their vegetative structure, storage capacity, and surface resistance (Beaumont et al., 2007). The vegetation found in saltmarshes provides erosion control, nutrient cycling, and nursery areas for wildlife (De Groot et al., 2002). Therefore, the reestablishment of vegetation in saltmarshes is important due to their many benefits to the ecosystem.

To reestablish vegetation, the proper physical and chemical conditions should be met. A driving factor in saltmarsh structure and function is the hydrologic flow, which is affected by elevation. Elevation influences several abiotic factors, such as soil anaerobiosis, nutrient availability, sediment deposition, and salinity (Kongchum et al., 2017). Therefore, if there is a slight change to the elevation, hydrology shifts and changes the inundation duration. This will cause an alteration of the soil's physical and chemical properties. Berkowitz's el at. (2018) study supports the idea of restoring soil's physical and chemical properties because it was found that if physio-chemical properties are not maintained or restored, vegetation may not reestablish. Therefore, understanding the relationship between vegetation and the soil's physical and chemical properties is essential for saltmarsh restoration purposes.

Evaluating the soil's physical and chemical properties is required to reestablish native vegetation because there are considerable differences in soil that support vegetation compared to unvegetated soil. It is well known that soil composition and chemical properties are important factors correlating to vegetation that can succeed at a particular location. It is expected when organic matter decreases or sand content increases, the soil bulk density will increase. If bulk density increases, it can potentially constrict and limit vegetation growth and productivity of certain common species in a saltmarsh environment. Dieback patches have been found to demonstrate higher bulk density, lower field capacity, and coarser soil textures compared to healthy vegetation patches (Crawford and Stone, 2015). Also, it is known that sandy and coarse textured soils are low in nutrient availability (Kusler and Kentula, 1990). This information suggests there might be more beneficial backfill materials when restoring saltmarshes other than the GDOT typical approach of granular material specified in Section 107.23E of GDOT's Standard Specifications. Providing a more effective material with the appropriate soil texture will help to reestablish the native vegetation. Kirwan's et al. (2008) study concluded that soil texture is one of the main soil properties that affect the health and vigor of native plant species in Atlantic coastal marshes. If the native vegetation is not reestablished, bare patches may expedite erosion.

The soil and vegetation found in saltmarshes determine the productivity of the saltmarsh and of the structural stability in the geotechnical foundations of adjacent transportation assets. Soil shear strength and the resistance of the soil to erode is based on the soil's properties, the vegetation, and their interaction (Howes et al., 2010). Marsh surface erosion increases when vegetation is removed (Sheehan and Ellison, 2015). Establishing vegetation is also important because stems and leaves slow water velocities and thus support sedimentation while roots and rhizomes improve the stabilization of the soil and decrease erosion (Frey and Basan, 1985). This is due to unconsolidated soils that have not fully compacted and are not being stabilized by physical means and are more vulnerable to erosion. Vegetation contributes to soil shear strength through a deep, strong, and complex root system. This idea is supported by the work that Feher and Hester (2018) completed that found vegetation provides a significant soil shear strength advantage by stabilizing newly placed sediments at young restoration sites. Boorman (1999) concluded that vegetation improves stabilization of the soil surface in saltmarshes; for that reason, the survival of saltmarshes can be based on vegetation type. However, it is important to establish the appropriate vegetation because invasive species can arise and negatively alter the prior habitat by out-competing the native vegetation. Therefore, this study focuses on four vegetative species that are native to Georgia's saltmarshes and are good contenders for stabilizing new sediment based on their vegetative structure.

3.3 Specific Vegetation in Saltmarshes

This study focuses on four specific saltmarsh vegetation species: *Spartina alterniflora, Juncus roemerianus, Schoenoplectus tabernaemontani,* and *Borrichia frutescens.* These species were chosen because they represent the pre-existing or dominant vegetation in a sample of the eight Georgia saltmarshes previously described. The vegetation that are successfully established in saltmarshes must be equipped to withstand three main physiological stressors: (1) frequent inundation, (2) presence of saline water, and (3) anaerobic environment (due to the frequent inundation). Much vegetation research focuses on *Spartina alterniflora* and *Juncus roemerianus* for restoration purposes because both types of vegetation have a high absolute net primary production per unit area (Wiegert and Evans, 1967) and are common along the East and Gulf coasts of the US.

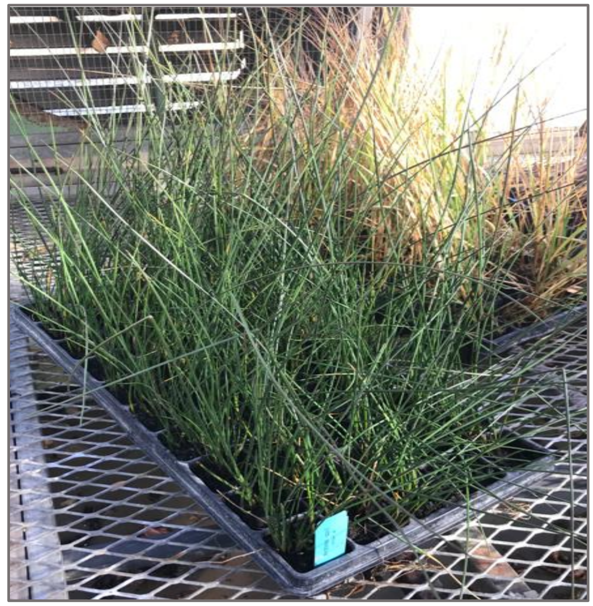
Spartina alterniflora (Figure 3 (a)) is the dominant vegetation along the east coast and comprises roughly 79 percent of the saltmarshes in Georgia and was found to have the greatest rates of production (Reimold, 1977; Spinner, 1969). *Spartina alterniflora* almost entirely dominates low marsh habitats due to its capability to oxygenate its rhizosphere in anoxic soils as well as its high salinity tolerance (Teal and Kanwisher, 1966). However, *Spartina alterniflora* is also capable of great growth in the high marsh habitats when competitors are not present, suggesting it is particularly suited for the low marsh where there are minimal interactions with other vegetation (Bertness, 1991). In the eastern coastal region, *Spartina alterniflora* is usually the first choice for restoration because it establishes relatively quickly and expands rapidly once it is introduced (Mitsch and Gosselink, 2015). This species has been successful in both coarse soils (gravels and sands) and fine textured soils (clays and silts) (USDA, NRCS, 2019) and has a high tolerance to anaerobic conditions and salinity. *Spartina alterniflora* is widely used for restoration purposes because it provides erosion control, sediment trapping, and creates organic matter (USDA, NRCS, 2019) because of its dense root system that reinforces the surrounding soil (See Figure 4(a)).

Juncus roemerianus (Figure 3 (b)) dominates the high marsh, comprising roughly 20.6 percent of the saltmarshes in Georgia (Spinner, 1969). However, it performs poorly in the low marsh indicating that its lower limit was set by physical stressors including depth and duration of inundation and high salinity (Pennings et al., 2005). *Juncus roemerianus* is found in irregularly flooded locations in the high marsh that have lower salinity (Marshall, 1974). *Juncus roemerianus* is an evergreen species, which allows higher annual productivity than other species (Giurgevich and Dunn, 1978), and is adapted to fine textured soils, but not coarse textured soils (USDA, NRCS, 2019). *Juncus roemerianus* also has a tolerance against anaerobic conditions and salinity (USDA, NRCS, 2019). Due to its fibrous root system, it is also successful in restoration projects and erosion control (Figure 4(b)) (USDA, NRCS, 2019).

Borrichia frutescens (Figure 3(c)) is a plant found in higher elevations, which is not usually exposed to inundations along the Atlantic coastline in the United States (Adams, 1963). *Borrichia frutescens* is adapted to both coarse and fine textured soils (USDA, NRCS, 2019). It has a medium tolerance to anaerobic conditions and is tolerant to salinity (USDA, NRCS, 2019). *Borrichia frutescens* has a creeping rhizomatous root system (Figure 4(c)).

Schoenoplectus tabernaemontani (Figure 3(d)) is also successful in both coarse and fine textured soils (USDA, NRCS, 2019). It has a high tolerance to anaerobic conditions and a low tolerance to salinity (USDA, NRCS, 2019). This plant provides food and cover to several saltmarsh animals. *Schoenoplectus tabernaemontani's* root system is also quite fibrous (Figure 4(d)).

(a) Spartina alterniflora



(b) Juncus roemerianus

(c) Borrichia frutescens

(d) Schoenoplectus tabernaemontani

Figure 3: Vegetation (a) *Spartina alterniflora*, (b) *Juncus roemerianus*, (c) *Borrichia frutescens*, (d) *Schoenoplectus tabernaemontani*

(a) (b) (c) (d)

Figure 4: Root Structure for (a) *Spartina alterniflora,* (b) *Juncus roemerianus,* (c) *Borrichia frutescens,* and (d) *Schoenoplectus tabernaemontani*

3.4 Threats to Saltmarshes

There are numerous threats to saltmarshes, primarily due to human impacts that have damaged more than 65% of wetlands, degraded water quality, and accelerated species invasions (Lotze et al., 2006). This is through the changing climate, nutrient inputs, sediment delivery, and subsidence rates that all affect saltmarshes (Kirwan 2013). Another major alteration to the landscape and the environment is attributed to construction activities.

From 1995 to 2000, Georgia experienced one of the highest levels of in-migration in the United States (Franklin, 2003). Consequently, the increase in population resulted in more development and infrastructure. The most recent American Society of Civil Engineers (ASCE) Georgia Infrastructure Report Card indicated that the transportation infrastructure in Georgia received a cumulative grade of a C+ (ASCE, 2019). This indicates that the infrastructure in Georgia is only slightly above average and is in need of attention (ASCE, 2019). GDOT maintains and ensures that the transportation system in Georgia contributes to a productive and efficient economy. In order to maintain this level of efficiency and guarantee that roads and bridges are safe and serviceable, it requires systematic monitoring, preventive maintenance, and preservation. Coastal development, however, was identified in watershed reviews by the Environmental Protective Agency (EPA) as a serious threat to coastal wetlands due to impacts from residential and commercial development, associated recreational development, and infrastructure (EPA, 2010).

The implementation of road infrastructure through a saltmarsh also alters the landscape by changing the hydrology and possibly creating new drainage patterns, which can transport runoff of materials or chemicals (Leopold et al., 1964). The increased runoff of materials and chemicals by placement of an impermeable surface are the main processes that may be harmful to aquatic environments (Forman and Alexander, 1998). The runoff of materials and chemicals can be extensive, such as: litter, debris, oils, and heavy metals. Research has been conducted in exploring ways to limit road infrastructure pollution runoff, therefore, improving the water quality. Leendertse et al. (1996) observed that saltmarsh sediments and vegetation have absorbed and transformed about 50% of deposited metals. This suggests that saltmarshes are effective sinks for metal contamination. If saltmarshes can help reduce harmful pollutants from road infrastructure runoff, then it is also important to restore damaged marshes next to road infrastructure to reduce harmful pollutants from entering nearby water bodies.

3.5 Restoration

Saltmarsh restoration is the practice of returning a saltmarsh to its original or previous state after it has been altered - usually through human impacts. Long-term establishment of marsh ecological productivity is the ultimate goal of restoration. Restoration goals are determined based on the purpose of the project and could include plant biomass production or water quality improvement goals. Borja (2010) found that restoration projects that aim to restore the original biotic composition, diversity, and complete functionality may take as long as five years, and full recovery of coastal marine ecosystems can take a minimum of 15 to 25 years, which is an important indicator that restoration practices need to start as soon as possible with sustainable and efficient applications.

Moreover, the application of dredged materials has the potential for restoring damaged marshes which have become shallow open water areas (Ford et al., 1999). The dredged material could elevate the saltmarsh, and this could improve the hydrologic conditions. Dredged material is similar to the soil composition found in saltmarshes, therefore, the use of dredged material in damaged marshes could be a useful supplement for plant reestablishment and erosion control.

Reestablishing the soil and vegetation in saltmarshes will benefit several aquatic and terrestrial animals (Wiegert and Freeman, 1990), including spiders, fiddler crabs, and birds. For birds, saltmarshes are important for feeding, roosting and nesting sites, and mainly through their position at the base of estuarine food webs (Hughes, 2004). In order to provide a healthy and efficient environment steps need to be made towards restoration.

4.0 PROBLEM STATEMENT

This problem statement will clarify the research significance to society, as well as discuss the research objectives and issues that need to be resolved. The problem statement will serve as an overview of the purpose of this research.

4.1 Research Significance

Because of the unknowns about the restoration and success of vegetation in engineered soils, the goal of this research was to develop best management practices (BMPs) for post-construction restoration of right-of-way that bridge the gap between engineering applications and ecological processes that occur in saltmarshes. BMPs can be applied in saltmarshes to identify efficient and cost-effective procedures to improve the reestablishment of vegetation in post-construction saltmarshes and other tidally influenced areas to imitate prior conditions and reduce the potential for erosion. The procedures included the development of engineered soils to support the pre-construction vegetation at any location. These engineered soils are significant because they provide very similar characteristics to native saltmarsh soils.

4.2 Research Objectives and Hypothesis

The purpose of this study is to evaluate the success of establishment of specific saltmarsh vegetation in engineered soils and compare it to the success of a GDOT standard matrix. The study involved evaluating the growth of *Spartina alterniflora*, *Juncus roemerianus*, *Schoenoplectus tabernaemontani*, and *Borrichia frutescens* in eight engineered soil mixtures that approximate the physical and chemical properties of in situ saltmarsh soils, along with two control groups providing baselines for growth in potting soil, as well as, growth in the material specified in the current GDOT construction specifications for restoration of disturbed saltmarshes. This study provides recommendations for each vegetation type, including which engineered soil is optimal for supporting plant growth and the best method to measure success in hydrologically sensitive areas within and adjacent to Georgia's estuaries and saltmarshes.

The target species grown in the designed soil mixtures are expected to outperform the two controls in the experiment. Soils that mimic the natural physical and chemical conditions found in saltmarshes are hypothesized to be more beneficial to the species existing prior to construction.

5.0 RESEARCH METHODOLOGY

This study evaluated the success of establishment of specific saltmarsh vegetation in engineered soils and included a greenhouse mesocosm. This mesocosm, a controlled experiment that represents the natural environment, mimicked the physical and chemical conditions (e.g., water pH and salinity, soil redox, bulk density, and organic matter content, and inundation frequency, depth and duration) found at each of the coastal sites under evaluation. Biological and aqueous chemistry measurements including plant height, number of leaves, number of stems, plant cover, leaf color, tub and pore water redox (mV), pH, and salinity (PSU) were collected at the beginning and end of the experiment. Plant height, number of leaves, number of stems, plant cover, and leaf color were used to determine the growth of each species. Biomass is a primary indicator of the success of the vegetation; therefore, it was harvested at the end of the experiment to verify the method to determine success of establishment.

5.1 Experimental Design

In the greenhouse experimental design, five replicated tubs contained 50 vegetative plugs each, to test growth viability of the four target vegetative species. Engineered soils were designed based on in situ soils at eight sites along the Georgia coast. Two controls were established: potting soil and sand (GDOT standard). Each species and one unvegetated blank were planted in each of the 10 matrices for a total of 200 vegetated plugs and 50 blank deepots (See Figure 5). Diurnal tides with surface inundation of approximately 6-hours were simulated in each of the experimental tubs as shown in Figure 6. This was done by utilizing tubes and pumps to allow for water to flow to and from the reservoir tubs to the tubs with vegetation. The pumps were connected to timers to ensure the 6-hour tides. The depth of submergence for each vegetation type was determined based on the vegetation's salinity tolerance and shown in Figure 7. As stated previously in Chapter 3, *Spartina alterniflora* entirely dominates low marsh habitats and has a high tolerance to anaerobic conditions. Whereas, *Juncus roemerianus* dominates the high marsh and has a tolerance for anaerobic conditions. *Schoenoplectus* tabernaemontani is found in brackish marshes and has a high tolerance to anaerobic conditions. While, *Borrichia frutescens* is found in higher elevations and has a medium tolerance to anaerobic conditions. Therefore, *Spartina alterniflora* was placed at the low marsh location where it would get inundated at daily high tide. *Juncus roemerianus* and *Schoenoplectus tabernaemontani* were placed at the high marsh location where the species would not get inundated at hightide but experience anaerobic conditions for a short period of time. *Borrichia frutescens* was placed at a higher location in the high marsh where it would not get inundated at high tide and does not experience anaerobic conditions. Once the experiment was designed, the greenhouse was set up with the tubs and tidal simulators and the soil mixtures were created.

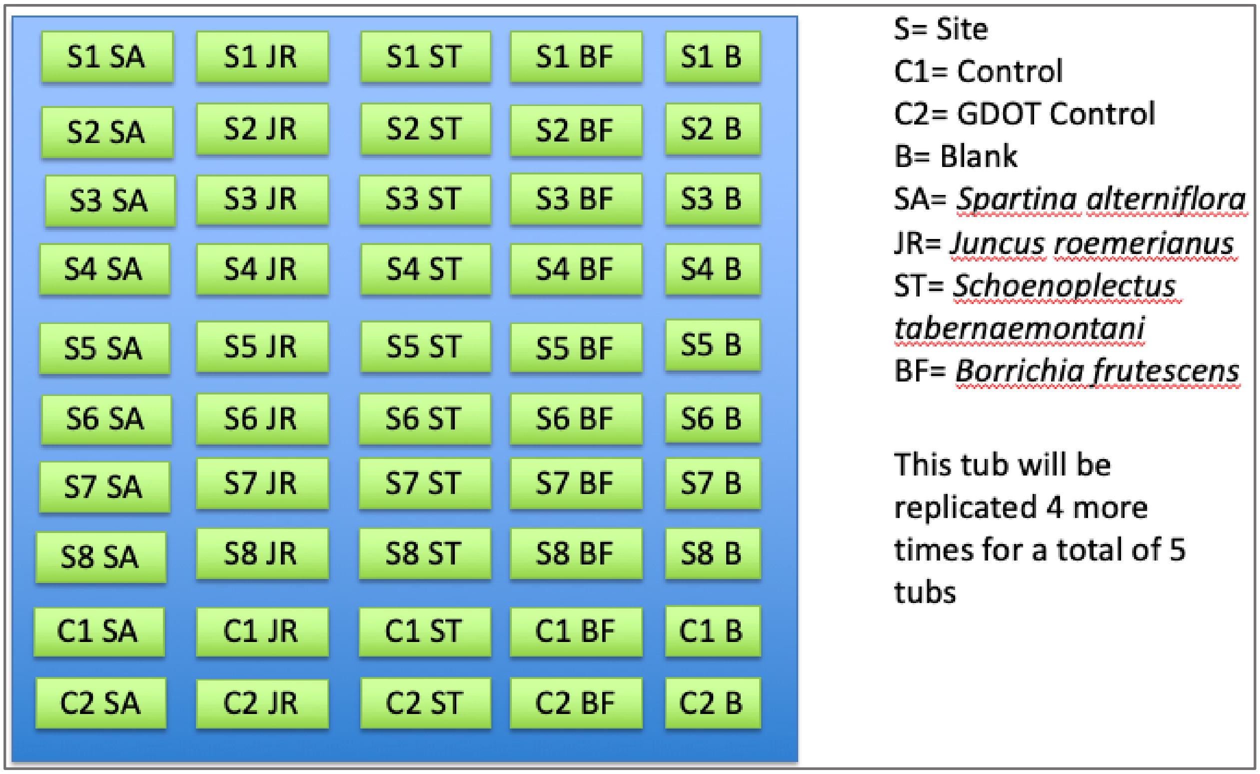


Figure 5: Illustration of Experimental Plan

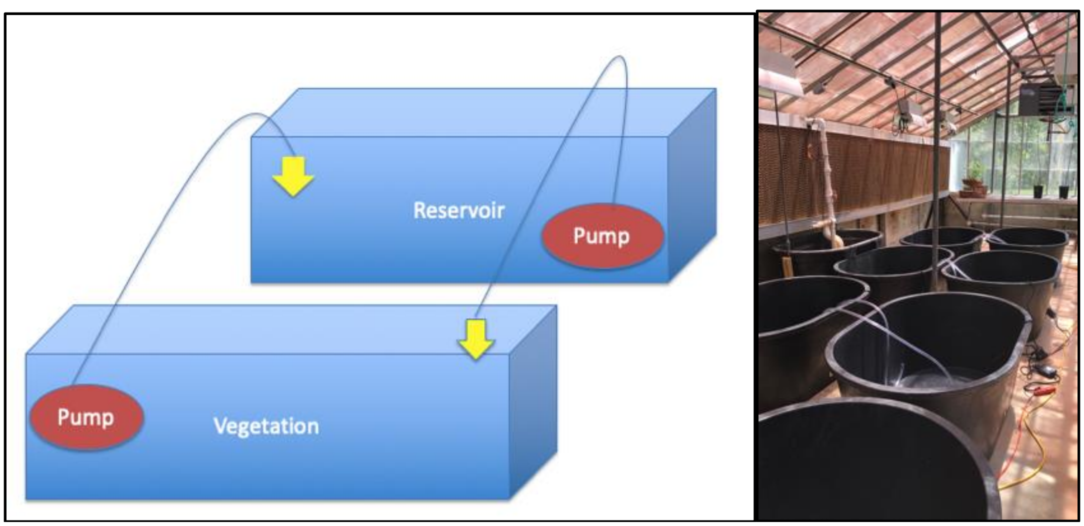


Figure 6: Tidal Simulator

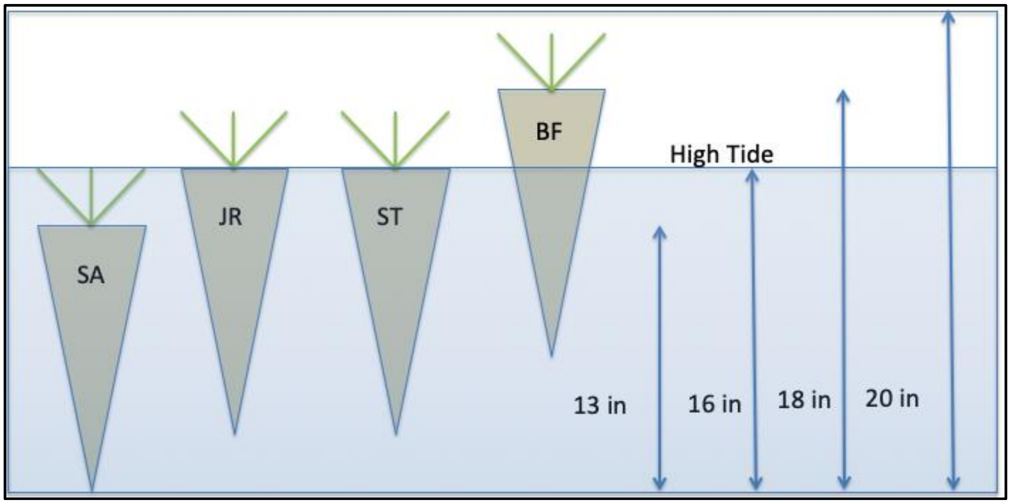


Figure 7: Vegetation Heights

5.1.1 Greenhouse Setup and Materials

As shown in Figure 6, five 110-Gallon Tuff Stuff Heavy-Duty Oval Stock Tanks (with vegetation) were placed adjacent to another to serve as water reservoirs. In each tank, one submersible Little Giant 170 GPH 36W Energy Efficient Direct Drive Submersible Pond Pump was placed with a ball valve attached, allowing a six-hour tidal cycle. The pumps were attached to one PRIME 15-Amp 2-Outlet Mechanical Residential Plug-in Countdown Lighting Timer to automatically control the times of the tide. The pumps were also attached to an EASTMAN 5/8-in x 5-ft PVC Clear Vinyl Tubing to allow for the flow from one tank into another. Figure 8 shows trays and deepots that were sterilized with bleach and placed in the tub. The greenhouse was checked four times each week to ensure the equipment/materials were functioning properly.

Figure 8: Trays and Deepots

5.1.2 Soil Matrix Mixture Procedure

Engineered soils were created to mimic the original soils found in the field based upon the particle size distributions (ASTM D1140 and ASTM D422), moisture content (ASTM D2216), and organic matter (ASTM D2974). This information was utilized to determine the distribution of clay, silt, sand, and organic matter for the new engineered soil mixtures. However, it was found that as organic matter concentration in sediments increases, bulk density decreases. Therefore, when designing the engineered soil mixtures, the organic matter content of 10% was a target value of sites with less than 10% to help limit the bulk density.

The design mixtures with the percentage of sand, dredged material, and organic matter used can be found in Table 3. A sieve analysis was conducted on the sand used in the study and the results are presented in Appendix A. Appendix A also shows the particle size distribution for the dredged material. The particle size distribution curves for the two design mixtures and the particle size distribution curves of the engineered design mixture plotted next to the original soil are also found in Appendix A. These curves demonstrate that the engineered soil mixtures mimic the original soils.

The engineered soils were created by mixing different amounts of dredged material for fine mineral substrate, sand for coarse material substrate, and shredded hay for the organic matter, which varied by site. Two different dredged material sources, D-12 and D-13, were collected from the Savannah Dredge Material Containment Area in Savannah, Georgia. Two sources of dredged material were collected to ensure a more representative sample and an appropriate amount of material. The first design mixture was created using the dredged material from D-13 and the second design mixture was created using the dredged material of D-12 from the Savannah Dredge Material Containment Area. Using both D-13 and D-12 material ensured that the 200 vegetation plugs would be filled while maintaining the physical properties. Both engineered soil mixtures were within around 10% of one another to ensure that they did not vary significantly.

Table 3. Design Mixtures

Site ID	Mixture 1					Mixture 2				
	Total Sand (%)	Total Clay (%)	Total Silt (%)	Total Organic Matter	Soil Texture	Total Sand (%)	Total Clay (%)	Total Silt (%)	Total Organic Matter	Soil Texture
1	23.37	33.37	43.26	18.57	Clay Loam	28.77	29.33	41.90	14.59	Clay Loam
2	50.39	21.60	28.01	14.14	Sandy Clay Loam	52.52	19.56	27.93	12.66	Loam
3	62.79	16.20	21.00	13.39	Sandy Loam	71.51	11.73	16.76	10.95	Sandy Loam
4	29.13	30.86	40.01	28.04	Clay Loam	24.02	31.29	44.69	28.11	Clay Loam
5	11.41	38.58	50.01	18.11	Silty Clay Loam	5.03	39.11	55.86	17.48	Silty Clay Loam
6	11.41	38.58	50.01	17.88	Silty Clay Loam	5.03	39.11	55.86	17.06	Silty Clay Loam
7	84.05	6.94	9.00	10.96	Loamy Sand	90.50	3.91	5.59	9.84	Sand
8	64.56	15.43	20.00	13.82	Sandy Loam	62.01	15.64	22.34	12.49	Sandy Loam

Engineered design soils were mixed in the Geomaterials Engineering (GMAT) laboratory at the University of Georgia. The engineered design mixtures were then transported to the Whitehall Head House at the University of Georgia for the washing and planting process.

5.2 Design Implementation

The target vegetation was delivered in early February 2019 from Legare Farms Inc., South Carolina. Afterwards, the plants were gently washed to remove the nursery soil (Figure 9).

Figure 9: Before and After Washing Roots

Next, the vegetation was centered and planted in the applicable tubes, filled with appropriate soil matrix, and placed inside the racks with appropriate spacing in one of the two design mixtures as shown in Figure 10. The vegetation and soil matrix were planted a few centimeters below the deepots to ensure no soil material would be lost.

Figure 10: Planting Process

Plants were placed at different heights in the tubs based on elevations found in the field and then immersed (Figure 11). The target salinity for the project was 20 Practical Salinity Units (PSU) based on the different species' salinity tolerance and the mean salinity found in all eight sites of the saltmarshes sampled (Table 4). The target salinity was reached by adding Instant Ocean Sea Salt to the tap water in the tanks.

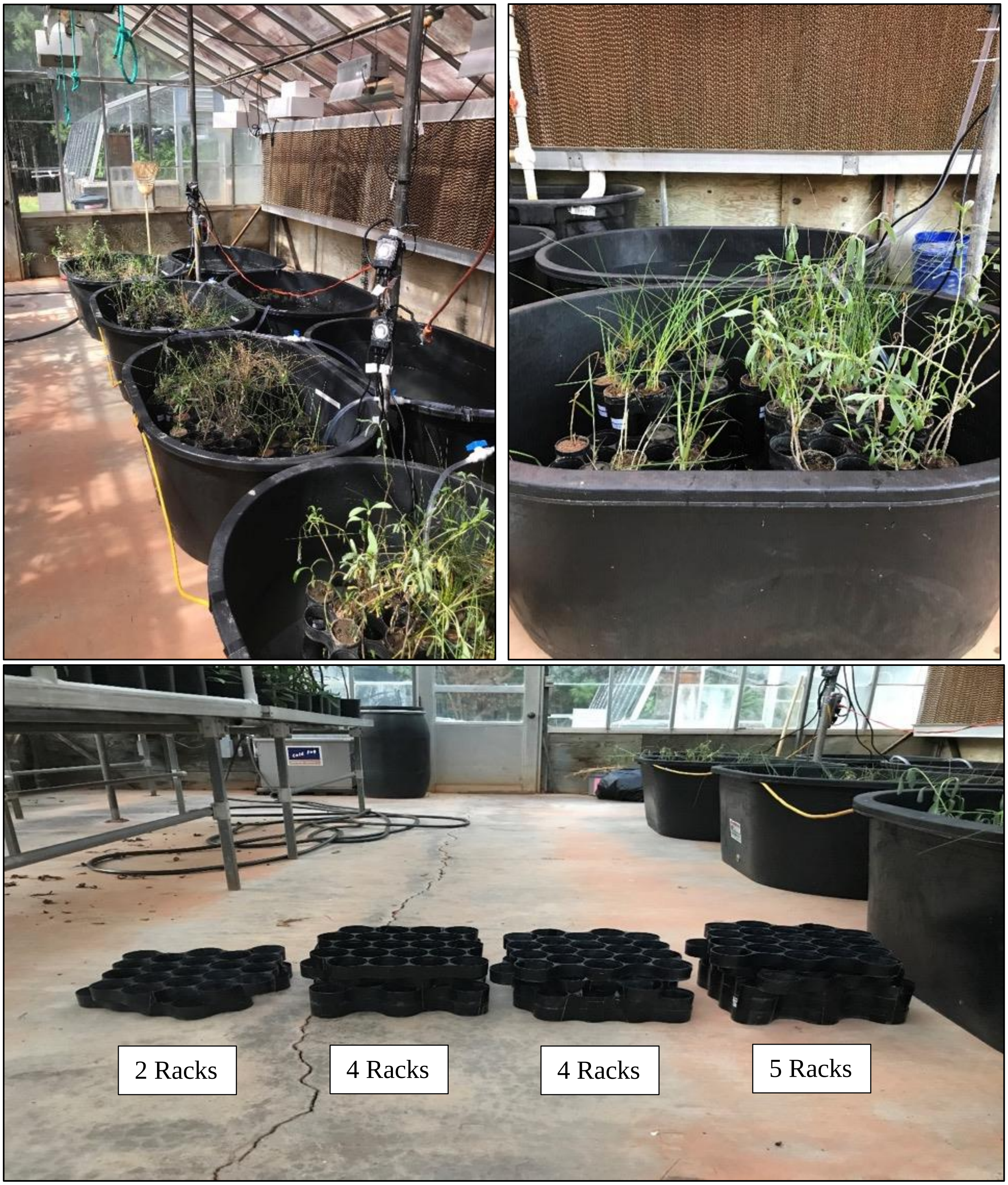


Figure 11: Pumping System

Table 4: Sample pH, Salinity, and Redox Conditions (Salehi Hikouei et al., 2019)

Sample	pH	Salinity (PSU)	Redox (mV)
1.A	6.79	27.03	-325.6
1.B	6.81	26.39	-337.4
1.C	6.57	25	-279.9
2.A	6.86	22.5	-357.2
2.B	6.62	31.22	-320.9
2.C	6.83	26.65	-360.7
3.A	6.51	20.29	-16.6
3.B	6.6	5.56	-86.2
3.C	6.39	14.88	-12.1
4.A	6.46	4.04	-38.5
4.B	6.43	4.26	-19.4
4.C	6.4	4.84	-54.4
5.A	6.49	3.38	-106.5
5.B	6.54	1.94	-146
5.C	6.44	2.46	-184
6.A	6.8	25.79	-332
6.B	6.89	28.76	-373.5
6.C	6.78	28.95	-353
7.A	6.64	52.19	-313.3
7.B	6.89	12.09	-144.4
7.C	6.8	25.93	-188.7
8.A	6.8	20.57	-303.7
8.B	6.74	23.02	-308.2
8.C	6.83	24.28	-339.8

5.3 Data Collection

The data collection for determining the optimum engineered soil mixture to support growth of target species by mimicking the physical and chemical conditions of the studied marshes began on May 1st, 2019 and concluded October 9th, 2019. Initially, the target species were introduced to 5 PSU saline water. Minor dieback was recorded after the planting process, but these were slowly regenerated in three weeks. Within three weeks the vegetation was inundated with 20 PSU saline water, which was the target salinity.

Measurements were collected at the beginning (week 3) and end (week 21) of the experiment, which included plant height, number of leaves, number of stems, plant cover, leaf color, tub and pore water redox (mV), pH, and salinity (PSU). The number of live leaves and live stems were each physically counted. However, for *Borrichia frutescens* the number of branches were counted to accurately determine growth since this species is not a graminoid. Plant height was determined by measuring the top three tallest stems with a meter stick. If the vegetation had less than three stems, only the live stems that where present were measured for plant height. If the vegetation was dead, then a value of zero was recorded for the plant measurements. Plant cover estimates were calibrated using diagrams from Munsell Soil Color Charts. Leaf color was determined from the newest growth of the plant using the Munsell Plant Tissue Charts, which identified hue, value, and chroma of the plant tissue color.

Salinity, redox, and pH were determined by using a HANNA HI 98194 pH/EC/DO Multiparameter instrument (Figure 12) for both the tub water and pore water. Along with the initial and final measurements for pore water salinity, redox, and pH, twice a week the tub water salinity, redox, and pH were measured to ensure the tubs were relatively similar to one another. If the salinity was not close to 20 PSU, then Instant Ocean Sea Salt was added or more water was added to the tubs. Once every week the porewater salinity, redox, and pH for tub 2 was measured to observe how the pore water was affected over time.

Figure 12: HANNA HI 98194 pH/EC/DO Multiparameter Instrument

5.3.1 Measurements for Biomass

Once final measurements were recorded, biomass was determined. Plants were harvested, and rinsed in deionized water to remove the soil, and separated between dead and alive aboveground and belowground biomass. The tissue was dried at 65 C for 48 hours until constant mass was achieved (<5% decrease over 24 hours) and then weighed and recorded. Figure 13 shows the biomass for each species and illustrates the root systems.

(a) (b) (c)

Figure 13: Root Structure and Biomass at Final Measurements for (a) *Spartina alterniflora*, (b) *Juncus roemerianus*, (c) *Borrichia frutescens*

5.4 Statistical Analysis Methodology

In this study, a statistical software, JMP 14.0 was used to analyze the data collected. The statistical tests were (1) one-way Analysis of Variance (ANOVA), (2) Tukey-Kramer HSD ("Honestly Significant Difference") tests, (3) paired t-tests, (4) generalized regression models. These tests were chosen to determine if there was a significant difference in the means being tested and if so, which group means were different from one another with corresponding p-values. These tests aided in the understanding of how well specific saltmarsh vegetation establishes in different soil types.

To ensure that the replicated data from the five tubs were valid, it was important to determine there was no significant difference in salinity, redox, and pH in the five replicate tubs. Further, it was important to ensure if the vegetation was exposed to the same environment, by testing there was not a significant difference in salinity, redox, and pH in the eight engineered soils' and the two controls' pore water for each vegetation type. Therefore, two ANOVA tests were used. ANOVA assumptions of independence, normality, and equal variance were satisfied for all vegetative species and can be found in Appendix B. These two tests determined if the replicates were treated as true replicates. It also allowed for relationships to be established from the initial and final measurements. This was also done by using a blocking design with the tubs.

For each vegetative species, it was important to determine if the eight engineered soils or the two controls had a statistically significant difference in the growth of plant height, number of leaves, number of stems, percent cover, and total biomass. The soil mixtures were a categorical variable while the plant height, number of leaves, number of stems, percent cover, and total biomass were quantitative variables, therefore, an ANOVA was utilized to test each growth factor. ANOVA assumptions of independence, normality, and equal variance were satisfied for all vegetative species and can be found in Appendix B. Therefore, this test was performed, and accurate conclusions were made from the results. If the ANOVA test proved to be statistically significant, the Tukey-Kramer HSD test and paired t-test were examined. These tests determined the recommendation for which engineered soil was advised for each vegetation type.

Lastly, a generalized regression model was generated to establish important parameters to accurately estimate biomass. Live aboveground biomass, live and dead aboveground biomass, belowground biomass, and the total biomass for all four vegetative species were analyzed. These parameters were plant height, number of leaves, number of stems, and percent cover. While the sample size was small, the residuals for live aboveground biomass, live and dead aboveground biomass, belowground biomass, and the total biomass provided little-to-no evidence against the normality assumption. Therefore, this test was performed, and accurate conclusions were made from the results. The models were evaluated based on the adjusted coefficient of determination

(R^2adj), the Root Mean Square Error (RMSE), and the corrected Akaike's Information Criterion (AICc).

5.5 Design Summary

This experimental design allowed for the investigation of engineered soil mixtures. The engineered soil mixtures are thought to aid in the establishment and growth of several saltmarsh vegetative species. The data collection and analysis of the results will provide significant recommendations for each vegetation type, including which engineered soil is advised and the best method to measure success in hydrologically sensitive areas within and adjacent to Georgia's estuaries and saltwater marshes.

6.0 EXPERIMENTAL RESULTS AND ANALYSIS

6.1 Salinity, Redox, and pH in Tub Water and Pore Water

During the study, a salinity of 20 PSU was sought, and a range of 16.1 PSU-25.28 PSU was achieved, with a standard error mean of 0.0839 and standard deviation of 1.126. The salinity was maintained for the duration of the study. The tub and pore water salinities throughout the study are shown in Figure 14, which suggests that throughout the study the average tub water salinity was consistent with the average salinity of tub 2. This implies that the replicated tubs were true replicates and that there is not a significant difference in salinity. Figure 14 also shows that the tub water is consistently lower than the pore water salinity, which is to be expected because the deepots could retain the saltwater for a period of time and when the water evaporates, the salts accumulate over several tidal cycles.

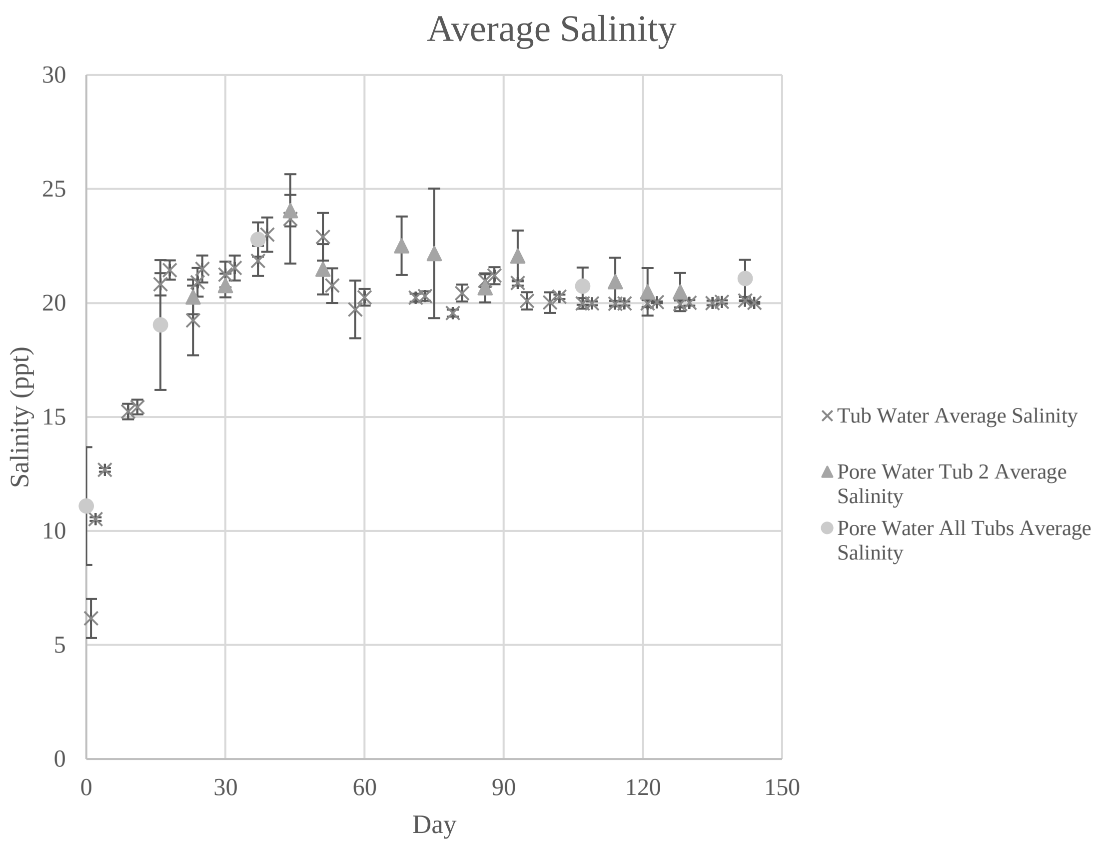


Figure 14: Salinity Ranges

In order to verify if the replicated tubs are true replicates, an ANOVA test was completed. This test indicated whether a difference occurred among the means of the groups. The one-way ANOVA was completed to test there was not a significant difference in salinity, redox, and pH in the five replicate tubs. The results for this test are presented in Appendix B. Because the salinity had been controlled for all the tubs and there was not a statistically significant difference, it was concluded that the replicates will be treated as true replicates.

To determine if the vegetation was exposed to the same environment, a one-way ANOVA was completed to confirm there was not a significant difference of salinity, redox, and pH in the eight engineered soils and the two controls by testing the pore water for each vegetation type. The results for this test are presented in Appendix B. The mean salinity of the soil matrixes ranged from 20.51 PSU to 22.84 PSU as shown in Appendix B. Because the engineered soil matrixes and the GDOT control (C2) were not significantly different from one another, relationships were made from the initial and final measurements. The following sections present the results of the four species studied.

6.2 *Spartina alterniflora*

To determine if the eight engineered soils or the two controls had a statistically significant difference in the growth of *Spartina alterniflora,* four ANOVA tests were completed for plant height, number of leaves, number of stems, and percent cover. The results for this test are presented in Appendix B. The p-value resulting from this test indicated there was not a significant difference (p-value >.05) in the growth of the plant height (Figure 79), number of leaves (Figure 80), and number of stems (Figure 81) of *Spartina alterniflora* and the soil matrixes (See Table 5). However, there was a statistically significant difference (p-value <.05) in the growth of the percent cover (Figure 82) of *Spartina alterniflora.* This significant difference occurs among the potting soil (C1), the GDOT control (C2), and S8. C2 and S8 had significantly lower cover compared to C1. While there is not a statistically significant difference between the engineered soil mixtures and C2 in plant height, number of leaves, number of stems, and percent cover, there were engineered soil mixtures that demonstrated improved growth compared to C2.

To enumerate, the engineered soil mixtures that demonstrated improved growth compared to the GDOT control based on growth and total biomass were S6, S3, S1, and S2. The biomass results for *Spartina alterniflora* can be seen in Figure 15 below. To further support this claim, another ANOVA test was completed to determine if the eight engineered soils or the two controls had a statistically significant difference in the total biomass of *Spartina alterniflora*. The p-value resulting from this test indicated there was a significant difference (p-value <.05) in the soil matrices and total biomass of *Spartina alterniflora* (Figure 83). To determine which pairs of means were different, the Tukey-Kramer HSD test was performed. The Tukey-Kramer HSD test was used to help conclude that S6 had a significantly higher total biomass compared to C2. The soil composition of S6, S3, and S2 all mimicked geotechnical soil properties of saltmarsh soils in which *Spartina alterniflora* was established. This suggests that it is beneficial to replicate soil properties for the reestablishment of specific vegetation at sites with *Spartina alternaflora* as the target species.

Table 5: Summary Statistics of *Spartina alterniflora*

Test	p-value	Top Means		
		1	2	3
One-way ANOVA for Growth in Plant Height by Matrix	.2257	S6	S2	S4
One-way ANOVA for Growth in Leaves by Matrix	.8470	S2	S6	S3/S1
One-way ANOVA for Growth in Stems by Matrix	.3856	S2	S6	S8
One-way ANOVA for Growth in Percent Cover by Matrix	.0279	S6	S2	S3
One-way ANOVA of Total Biomass by Matrix	.0142	S6	S3	S1

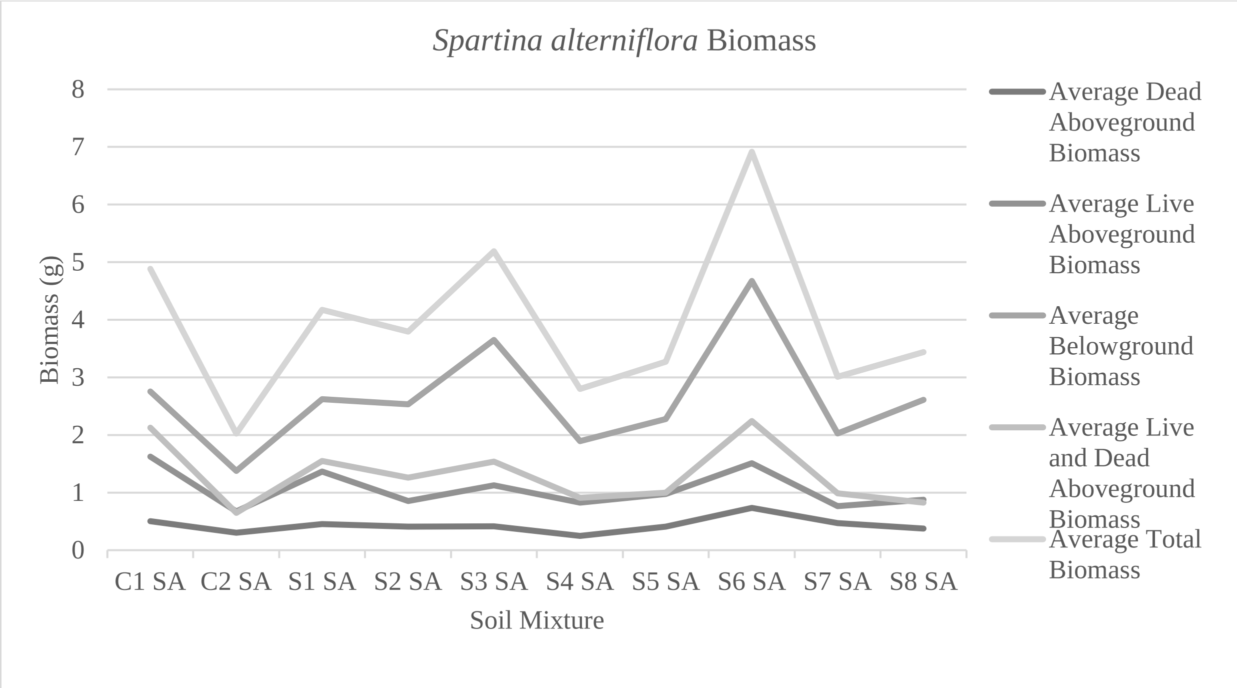


Figure 15: Biomass Results for *Spartina alterniflora*

As stated previously, *Spartina alterniflora* is adapted to both coarse and fine textured soils. Additionally, it has high tolerance to anaerobic conditions and salinity. These results support that *Spartina alterniflora* is an effective vegetative species to establish in a range of environments, while establishing the best in silty clay loam, clay loam, and sandy loam soils.

To propose the best method to measure success in recently restored saltmarshes a generalized regression model was generated. The model predicting live aboveground biomass with the parameters height and percent cover demonstrated a strong capacity to predict biomass (smallest AICc and largest R^2adj). Therefore, these parameters are effective field indicators to estimate biomass (Table 6). The model and more detailed statistical analyses are found in Appendix B.

Table 6: Summary Statistics for the Generalized Regression Model of *Spartina alterniflora*

	Spartina alterniflora				
			Fit Statistics		
Model	Model Category	Model	R2adj	RMSE	AICc
1	Live Aboveground Biomass	Height	0.4763	0.4239	51.53
1	Live Aboveground Biomass	Leaves	0.3086	0.5211	68.04
1	Live Aboveground Biomass	Stems	0.0193	0.5801	76.62
1	Live Aboveground Biomass	Cover	0.4612	0.43	52.66
1	Live Aboveground Biomass	Height and Leaves	0.5733	0.3775	44.74
1	Live Aboveground Biomass	Height and Stems	0.5066	0.406	50.55
1	Live Aboveground Biomass	Height and Cover	0.6498	0.342	36.83
1	Live Aboveground Biomass	Leaves and Stems	0.4293	0.4367	56.37
1	Live Aboveground Biomass	Leaves and Cover	0.4515	0.4281	54.79
1	Live Aboveground Biomass	Stems and Cover	0.4504	0.4285	54.87
1	Live Aboveground Biomass	Height, Leaves, and Stems	0.6184	0.3522	41.8
1	Live Aboveground Biomass	Height, Leaves, and Cover	0.6497	0.3374	38.38
1	Live Aboveground Biomass	Height, Stems, and Cover	0.641	0.3416	39.36
1	Live Aboveground Biomass	Leaves, Stems, and Cover	0.5197	0.3951	51
1	Live Aboveground Biomass	Height, Leaves, Stems, and Cover	0.6608	0.3274	38.74
2	Live and Dead Aboveground Biomass	Height	0.3118	0.5808	78.44
2	Live and Dead Aboveground Biomass	Leaves	0.2353	0.6122	82.76
2	Live and Dead Aboveground Biomass	Stems	0.0669	0.6762	90.92
2	Live and Dead Aboveground Biomass	Cover	0.4459	0.5211	69.55
2	Live and Dead Aboveground Biomass	Height and Leaves	0.4399	0.5171	71.39
2	Live and Dead Aboveground Biomass	Height and Stems	0.3803	0.544	75.54
2	Live and Dead Aboveground Biomass	Height and Cover	0.5219	0.4778	64.9
2	Live and Dead Aboveground Biomass	Leaves and Stems	0.3312	0.5651	78.66
2	Live and Dead Aboveground Biomass	Leaves and Cover	0.4428	0.5158	71.18
2	Live and Dead Aboveground Biomass	Stems and Cover	0.4329	0.5204	71.9
2	Live and Dead Aboveground Biomass	Height, Leaves, and Stems	0.4448	0.5081	72.55
2	Live and Dead Aboveground Biomass	Height, Leaves, and Cover	0.5248	0.47	66.16
2	Live and Dead Aboveground Biomass	Height, Stems, and Cover	0.5191	0.4728	66.65
2	Live and Dead Aboveground Biomass	Leaves, Stems, and Cover	0.4457	0.5077	72.48
2	Live and Dead Aboveground Biomass	Height, Leaves, Stems, and Cover	0.5127	0.4695	68.83
3	Belowground Biomass	Height	0.0511	1.585	160.77
3	Belowground Biomass	Leaves	0.3744	1.286	143.68
3	Belowground Biomass	Stems	0.1569	1.494	155.92
3	Belowground Biomass	Cover	0.565	1.073	128.78
3	Belowground Biomass	Height and Leaves	0.3734	1.271	145.15
3	Belowground Biomass	Height and Stems	0.2079	1.429	154.76
3	Belowground Biomass	Height and Cover	0.5616	1.063	130.51
3	Belowground Biomass	Leaves and Stems	0.4531	1.187	139.57
3	Belowground Biomass	Leaves and Cover	0.5931	1.024	127.44
3	Belowground Biomass	Stems and Cover	0.5731	1.049	129.41
3	Belowground Biomass	Height, Leaves, and Stems	0.4387	1.187	142.15
3	Belowground Biomass	Height, Leaves, and Cover	0.5885	1.016	129.42
3	Belowground Biomass	Height, Stems, and Cover	0.5658	1.044	131.62
3	Belowground Biomass	Leaves, Stems, and Cover	0.5907	1.013	129.2
3	Belowground Biomass	Height, Leaves, Stems, and Cover	0.5933	0.9968	130.56
4	Total Biomass	Height	0.1468	1.907	175.94
4	Total Biomass	Leaves	0.4255	1.565	159.72
4	Total Biomass	Stems	0.1679	1.883	174.91
4	Total Biomass	Cover	0.6774	1.172	136.06
4	Total Biomass	Height and Leaves	0.4773	1.473	157.25
4	Total Biomass	Height and Stems	0.3142	1.687	168.38
4	Total Biomass	Height and Cover	0.6699	1.17	138.39
4	Total Biomass	Leaves and Stems	0.539	1.383	152.1
4	Total Biomass	Leaves and Cover	0.7062	1.104	133.62
4	Total Biomass	Stems and Cover	0.6842	1.145	136.58
4	Total Biomass	Height, Leaves, and Stems	0.5382	1.366	153.68
4	Total Biomass	Height, Leaves, and Cover	0.7	1.101	135.97
4	Total Biomass	Height, Stems, and Cover	0.679	1.139	138.77
4	Total Biomass	Leaves, Stems, and Cover	0.7123	1.078	134.28
4	Total Biomass	Height, Leaves, Stems, and Cover	0.7043	1.078	137.03

6.3 *Juncus roemerianus*

Another five ANOVA tests were completed for plant height, number of leaves, number of stems, percent cover, and total biomass to determine if the eight engineered soils or the two controls had a statistically significant difference in the growth of *Juncus roemerianus.* The results for this test are presented in Appendix B. The p-value resulting from this test indicated there was not a significant difference (p-value $>.05$) in the growth of the plant height (Figure 85), number of leaves (Figure 86), number of stems (Figure 87), percent cover (Figure 88), and total biomass (Figure 89) of *Juncus roemerianus* and the soil matrixes (See Table 7). While there is not a statistically significant difference between the engineered soil mixtures and C2 in plant height, number of leaves, number of stems, percent cover, and total biomass, there were engineered soil mixtures that demonstrated improved growth based on the growth of the parameters and total biomass compared to the GDOT control. The biomass results for *Juncus roemerianus* can be seen in Figure 16 below.

Specifically, the engineered soil mixtures that demonstrated improved growth compared to the GDOT standard were S5, S4, S1, and S3. S5 mimicked geotechnical soil properties of saltmarsh soils in which *Spartina alterniflora* and *Schoenoplectus tabernaemontani* were established. Whereas S4 mimicked geotechnical soil properties of saltmarsh soils in which *Schoenoplectus tabernaemontani* was established and S1 mimicked geotechnical soil properties of saltmarsh soils in which *Spartina alterniflora* was found. S3 mimicked geotechnical soil properties of saltmarsh soils in which *Juncus roemerianus* was established. Not only does this indicate that it is beneficial to replicate soil properties for the reestablishment of specific vegetation, it also suggests that using the engineered soil mixture could potentially support non-invasive species, such as *Juncus roemerianus*. This will allow for multiple vegetative species to be used in the restoration depending on the site's elevation, which will lead to a more diversified environment.

It was stated previously, that *Juncus roemerianus* is adapted to fine textured soils, but not to coarse textured soils. However, the results suggest that *Juncus roemerianus* can be established best in soils that are silty clay loam, clay loam, and sandy loam. These results support that *Juncus roemerianus* is an effective vegetative species to establish in a range of environments.

Table 7: Summary Statistics of *Juncus roemerianus*

Test	p-value	Top Means		
		1	2	3
One-way ANOVA for Growth in Plant Height by Matrix	.0612	S5	S7	S1
One-way ANOVA for Growth in Leaves by Matrix	.4855	S4	S1	S2
One-way ANOVA for Growth in Stems by Matrix	.1255	S5	S3	S4/S8
One-way ANOVA for Growth in Percent Cover by Matrix	.7171	S5	S7	S1
One-way ANOVA of Total Biomass by Matrix	.3656	S6	S8	S5

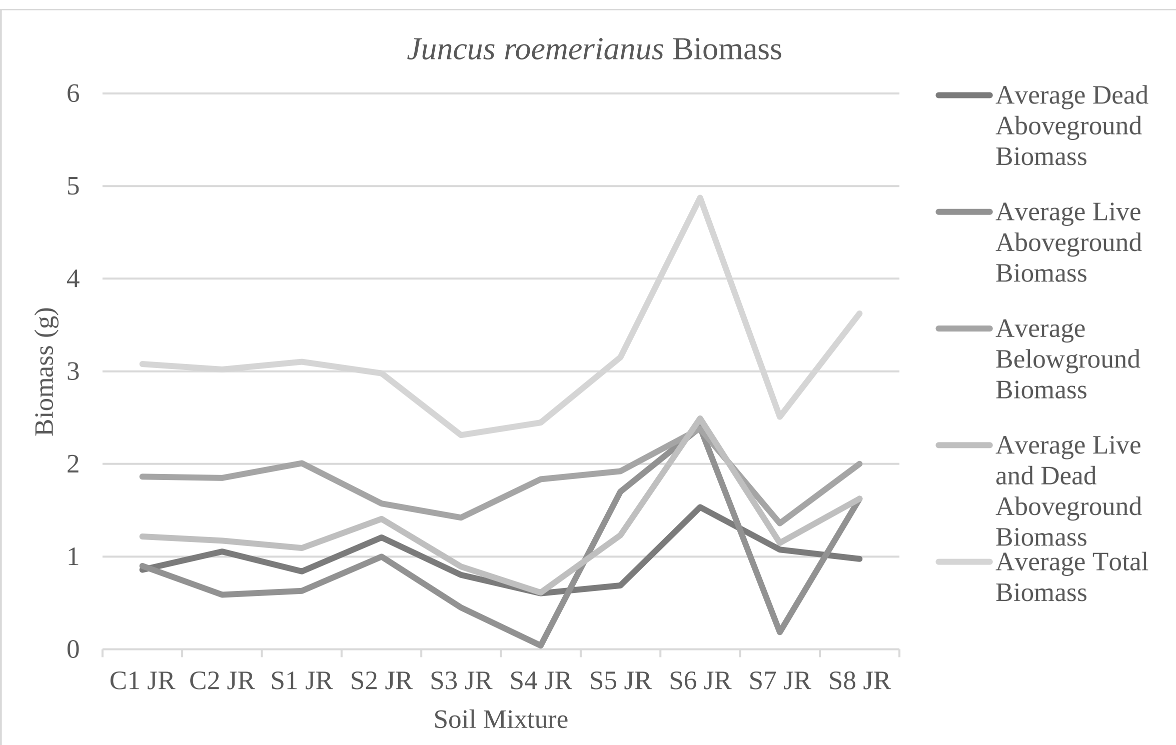


Figure 16: Biomass Results for *Juncus roemerianus*

Additionally, biomass of this species was determined in order to propose the best method to measure success in recently restored saltmarshes. A generalized regression model was generated to establish important parameters to accurately estimate biomass. The same models and combinations were tested for *Juncus roemerianus* (See Table 8). The model predicting live aboveground biomass with the parameters height and number of stems demonstrated strong capacity to predict biomass (smallest AICc and largest R^2adj). Therefore, these parameters are reliable indicators in the field to estimate biomass (Figure 90).

However, for ease of application in the field, the number of stems can be solely measured (Figure 91). This can be done because the model that predicts live aboveground biomass with the factor of number of stems is within 10% (AICc and R^2adj) of the model that factors in both height and number of stems. This will also be a more cost-effective procedure.

Table 8: Summary Statistics for the Generalized Regression Model of *Juncus roemerianus*

	Juncus roemerianus				
			Fit Statistics		
Model	Model Category	Model	R2adj	RMSE	AICc
1	Live Aboveground Biomass	Height	0.0627	0.8653	46.41
1	Live Aboveground Biomass	Leaves	0.0985	0.8483	43.52
1	Live Aboveground Biomass	Stems	0.8678	0.3249	17.03
1	Live Aboveground Biomass	Cover	0.7028	0.4873	29.18
1	Live Aboveground Biomass	Height and Leaves	0.0169	0.8481	47.56
1	Live Aboveground Biomass	Height and Stems	0.8982	0.2739	15.72
1	Live Aboveground Biomass	Height and Cover	0.7031	0.4679	31.78
1	Live Aboveground Biomass	Leaves and Stems	0.8776	0.2992	18.39
1	Live Aboveground Biomass	Leaves and Cover	0.6803	0.4837	31.83
1	Live Aboveground Biomass	Stems and Cover	0.8571	0.3246	20.81
1	Live Aboveground Biomass	Height, Leaves, and Stems	0.8818	0.2803	21.61
1	Live Aboveground Biomass	Height, Leaves, and Cover	0.6497	0.4827	36.83
1	Live Aboveground Biomass	Height, Stems, and Cover	0.8896	0.2731	20.3
1	Live Aboveground Biomass	Leaves, Stems, and Cover	0.8654	0.299	23.44
1	Live Aboveground Biomass	Height, Leaves, Stems, and Cover	0.8694	0.2795	28.04
2	Live and Dead Aboveground Biomass	Height	-0.07	1.223	56.79
2	Live and Dead Aboveground Biomass	Leaves	-0.068	1.214	53.56
2	Live and Dead Aboveground Biomass	Stems	0.7867	0.545	32.54
2	Live and Dead Aboveground Biomass	Cover	0.5891	0.7565	42.37
2	Live and Dead Aboveground Biomass	Height and Leaves	-0.142	1.201	57.32
2	Live and Dead Aboveground Biomass	Height and Stems	0.7849	0.5259	35.28
2	Live and Dead Aboveground Biomass	Height and Cover	0.5828	0.7324	45.22
2	Live and Dead Aboveground Biomass	Leaves and Stems	0.7683	0.5413	34.99
2	Live and Dead Aboveground Biomass	Leaves and Cover	0.5373	0.765	44.67
2	Live and Dead Aboveground Biomass	Stems and Cover	0.7714	0.542	36.19
2	Live and Dead Aboveground Biomass	Height, Leaves, and Stems	0.7452	0.5412	40.04
2	Live and Dead Aboveground Biomass	Height, Leaves, and Cover	0.5012	0.7573	49.44
2	Live and Dead Aboveground Biomass	Height, Stems, and Cover	0.766	0.5251	39.91
2	Live and Dead Aboveground Biomass	Leaves, Stems, and Cover	0.746	0.5404	39.99
2	Live and Dead Aboveground Biomass	Height, Leaves, Stems, and Cover	0.7178	0.5404	46.49
3	Belowground Biomass	Height	0.0803	0.8348	45.33
3	Belowground Biomass	Leaves	-0.014	0.845	43.41
3	Belowground Biomass	Stems	0.2664	0.7456	41.94
3	Belowground Biomass	Cover	0.113	0.8198	44.79
3	Belowground Biomass	Height and Leaves	0.1458	0.7422	43.82
3	Belowground Biomass	Height and Stems	0.4928	0.5956	39.02
3	Belowground Biomass	Height and Cover	0.339	0.6799	42.99
3	Belowground Biomass	Leaves and Stems	0.3252	0.6597	40.52
3	Belowground Biomass	Leaves and Cover	0.1263	0.7507	44.14
3	Belowground Biomass	Stems and Cover	0.2538	0.7224	44.81
3	Belowground Biomass	Height, Leaves, and Stems	0.4403	0.5729	41.63
3	Belowground Biomass	Height, Leaves, and Cover	0.2825	0.6486	45.1
3	Belowground Biomass	Height, Stems, and Cover	0.4603	0.5882	43.31
3	Belowground Biomass	Leaves, Stems, and Cover	0.3033	0.6391	44.69
3	Belowground Biomass	Height, Leaves, Stems, and Cover	0.4049	0.5603	47.51
4	Total Biomass	Height	-0.0537	1.8928	69.89
4	Total Biomass	Leaves	-0.0814	1.862	65.54
4	Total Biomass	Stems	0.6824	1.039	51.89
4	Total Biomass	Cover	0.4532	1.363	60.05
4	Total Biomass	Height and Leaves	-0.0664	1.77	68.17
4	Total Biomass	Height and Stems	0.7675	0.8541	49.83
4	Total Biomass	Height and Cover	0.5412	1.199	60.03
4	Total Biomass	Leaves and Stems	0.7074	0.9273	50.06
4	Total Biomass	Leaves and Cover	0.4228	1.302	59.57
4	Total Biomass	Stems and Cover	0.6745	1.01	54.88
4	Total Biomass	Height, Leaves, and Stems	0.7201	0.8649	53.16
4	Total Biomass	Height, Leaves, and Cover	0.4535	1.208	62.53
4	Total Biomass	Height, Stems, and Cover	0.7515	0.8454	54.19
4	Total Biomass	Leaves, Stems, and Cover	0.6924	0.9066	54.48
4	Total Biomass	Height, Leaves, Stems, and Cover	0.6983	0.8518	59.24

6.4 *Schoenoplectus tabernaemontani*

After the completion of the study, it was found that *Schoenoplectus tabernaemontani* experienced extremely high rates of mortality. As stated previously, this vegetative species has a low tolerance to salinity and was present in the sites with the lowest salinity. Therefore, it probably did not survive because of the environment having a salinity of 20 PSU. Due to the high mortality and small sample size, there was an inability to accurately analyze *Schoenoplectus tabernaemontani* in the eight engineered soils and the two controls.

6.5 *Borrichia frutescens*

Another five ANOVA tests were completed for plant height, number of leaves, number of stems, percent cover, and total biomass to determine if the eight engineered soils or the two controls had a statistically significant difference in the growth of *Borrichia frutescens.* The results for this test are presented in Appendix B. The p-value resulting from this test indicated there was not a significant difference (p-value >.05) in the growth of the plant height (Figure 92), number of leaves (Figure 93), number of stems (Figure 94), percent cover (Figure 95), and total biomass (Figure 96) of *Juncus roemerianus* and the soil matrixes (Table 9). While there is not a statistically significant difference between the engineered soil mixtures and C2 in plant height, number of leaves, number of stems, and percent cover, there were engineered soil mixtures that demonstrated improved growth based on the growth of the parameters and total biomass compared to the GDOT control. The biomass results for *Borrichia frutescens* can be seen in Figure 17 below.

The engineered soil mixtures that demonstrated improved growth compared to the GDOT standard were S2, S6, and S4. S2 mimicked geotechnical soil properties of saltmarsh soils in which *Borrichia frutescens* and *Spartina alterniflora* were established. Whereas S6 solely supported *Spartina alterniflora*, while S4 supported Schoenoplectus tabernaemontani. Again, this demonstrated that it is beneficial to replicate soil properties for the reestablishment of a range of specific vegetation, which will lead to a more diversified environment.

As stated previously, *Borrichia frutescens* is adapted in fine and coarse textured soils. Additionally, this species has a tolerance to salinity and a medium tolerance to anaerobic conditions. The test results confirm that *Borrichia frutescens* is found and can be establish in soils that are sandy clay loam, silty clay loam, and clay loam.

Table 9: Summary Statistics of *Borrichia frutescens*

Test	p-value	Top Means		
		1	2	3
One-way ANOVA for Growth in Plant Height by Matrix	.2695	S2	S3	S6
One-way ANOVA for Growth in Leaves by Matrix	.2601	S6	S5	S4
One-way ANOVA for Growth in Stems by Matrix	.2257	S6	S1	S7
One-way ANOVA for Growth in Percent Cover by Matrix	.6812	S2	S4	S7
One-way ANOVA of Total Biomass by Matrix	.5610	S2	S6	S4

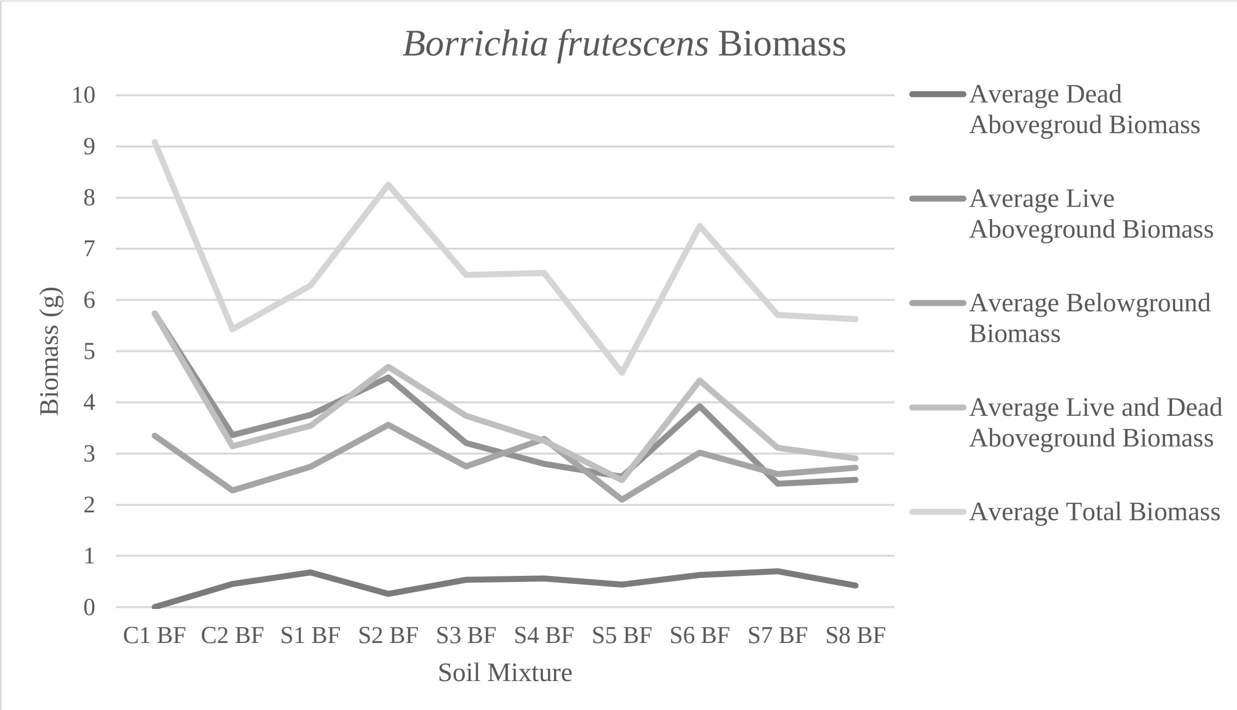


Figure 17: Biomass Results for *Borrichia frutescens*

Furthermore, biomass of this species was determined in order to propose the best method to measure success. Another generalized regression model was generated to establish important parameters to accurately estimate biomass. The same models and combinations were tested for *Borrichia frutescens* (See Table 10). The model predicting below ground biomass with the parameters branches and cover demonstrated strong capacity to predict biomass (smallest AICc and largest R^2adj) (Figure 97). However, the model predicting live above ground biomass with the parameters number of branches and height demonstrated strong capacity to predict biomass (smallest AICc and largest R^2adj) (Figure 98). Therefore, these parameters are useful indicators in the field to estimate biomass and can be found in Appendix B.

Table 10: Summary Statistics for the Generalized Regression Model of *Borrichia frutescens*

	Borrichia frutescens				
			Fit Statistics		
Model	Model Category	Model	R2adj	RMSE	AICc
1	Live Aboveground Biomass	Height	0.2664	1.832	196.86
1	Live Aboveground Biomass	Leaves	0.4638	1.566	182.12
1	Live Aboveground Biomass	Stems	0.4311	1.613	184.9
1	Live Aboveground Biomass	Cover	0.1442	1.978	204.1
1	Live Aboveground Biomass	Height and Leaves	0.6335	1.28	165.57
1	Live Aboveground Biomass	Height and Stems	0.6534	1.245	162.95
1	Live Aboveground Biomass	Height and Cover	0.3189	1.745	194.71
1	Live Aboveground Biomass	Leaves and Stems	0.4564	1.559	184.1
1	Live Aboveground Biomass	Leaves and Cover	0.4579	1.557	183.97
1	Live Aboveground Biomass	Stems and Cover	0.4568	1.559	184.07
1	Live Aboveground Biomass	Height, Leaves, and Stems	0.6512	1.235	164.68
1	Live Aboveground Biomass	Height, Leaves, and Cover	0.6257	1.279	167.99
1	Live Aboveground Biomass	Height, Stems, and Cover	0.6491	1.238	164.96
1	Live Aboveground Biomass	Leaves, Stems, and Cover	0.4568	1.541	185.5
1	Live Aboveground Biomass	Height, Leaves, Stems, and Cover	0.6437	1.233	167.21
2	Live and Dead Aboveground Biomass	Height	0.259	1.767	193.49
2	Live and Dead Aboveground Biomass	Leaves	0.47	1.495	177.74
2	Live and Dead Aboveground Biomass	Stems	0.4296	1.551	181.19
2	Live and Dead Aboveground Biomass	Cover	0.1561	1.886	199.6
2	Live and Dead Aboveground Biomass	Height and Leaves	0.6332	1.229	161.78
2	Live and Dead Aboveground Biomass	Height and Stems	0.6451	1.209	160.23
2	Live and Dead Aboveground Biomass	Height and Cover	0.3207	1.673	190.74
2	Live and Dead Aboveground Biomass	Leaves and Stems	0.461	1.49	179.87
2	Live and Dead Aboveground Biomass	Leaves and Cover	0.4667	1.482	179.37
2	Live and Dead Aboveground Biomass	Stems and Cover	0.4617	1.489	179.81
2	Live and Dead Aboveground Biomass	Height, Leaves, and Stems	0.6457	1.194	161.58
2	Live and Dead Aboveground Biomass	Height, Leaves, and Cover	0.6247	1.229	164.28
2	Live and Dead Aboveground Biomass	Height, Stems, and Cover	0.6433	1.199	161.9
2	Live and Dead Aboveground Biomass	Leaves, Stems, and Cover	0.4637	1.47	181.06
2	Live and Dead Aboveground Biomass	Height, Leaves, Stems, and Cover	0.639	1.192	164
3	Belowground Biomass	Height	0.0402	1.201	157.16
3	Belowground Biomass	Leaves	0.3536	0.9856	138.57
3	Belowground Biomass	Stems	0.3482	0.9897	138.97
3	Belowground Biomass	Cover	0.2002	1.096	148.58
3	Belowground Biomass	Height and Leaves	0.3604	0.9695	139.42
3	Belowground Biomass	Height and Stems	0.373	0.9599	138.48
3	Belowground Biomass	Height and Cover	0.1955	1.087	150.2
3	Belowground Biomass	Leaves and Stems	0.3502	0.9771	140.16
3	Belowground Biomass	Leaves and Cover	0.3791	0.9552	138.02
3	Belowground Biomass	Stems and Cover	0.4163	0.9261	135.12
3	Belowground Biomass	Height, Leaves, and Stems	0.3653	0.9547	140.48
3	Belowground Biomass	Height, Leaves, and Cover	0.3749	0.9474	139.77
3	Belowground Biomass	Height, Stems, and Cover	0.418	0.9142	136.42
3	Belowground Biomass	Leaves, Stems, and Cover	0.4031	0.9258	137.6
3	Belowground Biomass	Height, Leaves, Stems, and Cover	0.4054	0.9132	138.95
4	Total Biomass	Height	0.1872	2.749	234.99
4	Total Biomass	Leaves	0.4948	2.167	212.64
4	Total Biomass	Stems	0.4642	2.231	215.41
4	Total Biomass	Cover	0.2025	2.722	234.1
4	Total Biomass	Height and Leaves	0.5995	1.908	203.07
4	Total Biomass	Height and Stems	0.6136	1.874	201.38
4	Total Biomass	Height and Cover	0.2969	2.528	229.51
4	Total Biomass	Leaves and Stems	0.4897	2.153	214.45
4	Total Biomass	Leaves and Cover	0.5039	2.123	213.12
4	Total Biomass	Stems and Cover	0.519	2.091	211.67
4	Total Biomass	Height, Leaves, and Stems	0.614	1.851	202.76
4	Total Biomass	Height, Leaves, and Cover	0.594	1.899	205.13
4	Total Biomass	Height, Stems, and Cover	0.6277	1.818	201.06
4	Total Biomass	Leaves, Stems, and Cover	0.5132	2.079	213.66
4	Total Biomass	Height, Leaves, Stems, and Cover	0.6197	1.816	203.59

6.6 Summary

Overall, the results of the greenhouse experiment for all four vegetation species showed improved growth in specific engineered soil mixtures. This suggests that it is beneficial to replicate the geotechnical soil properties for the reestablishment of specific vegetation, which in turn will aid in environmental sustainability through erosion control. Notably, it was found that S6 performed relatively well in *Spartina alterniflora* and *Borrichia frutescens*. This engineered soil (S6) was created using 100% dredged material, suggesting that the use of dredged material (S6) for restoration purposes will support the growth of *Spartina alterniflora* and *Borrichia frutescens*. It was found that live aboveground biomass can be determined by the stems and cover in the field for all vegetation types for ease of application.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The primary objective of this study is to evaluate the success of establishment of specific saltmarsh vegetation in engineered soils in order to identify efficient and cost-effective procedures to reestablishing pre-existing or dominant vegetation after construction, repair, or maintenance, specifically for GDOT applications. The following conclusions were drawn from the results:

1. The results suggest the proposed engineered soils outperform the current GDOT standard which specifies using a granular backfill soil. Therefore, it is beneficial to replicate soil properties for the reestablishment of specific vegetation. Using engineered soil mixtures will assist the target vegetation to successfully establish, which will aid in erosion control measures. Providing erosion control through vegetation will lead to a more sustainable ecosystem.
2. Based on statistical analyses, the following outcomes are drawn:
    a. For saltmarshes with *Spartina alterniflora* present, it is recommended that engineered soils S6, S3, S1, and S2 be used in the restoration of the saltmarsh. These soils yielded greater growth compared to the current standard. Once established, it is advised that monitoring take place in the field to examine growth. For *Spartina alterniflora* the best way to monitor the live aboveground biomass is through measurements of its height and percent cover.
    b. *Juncus roemerianus* is recommended to be planted in engineered soils S5, S4, S1, and S3. Again, these soils yielded greater growth compared to the current standard for this vegetative species. Once established, it is advised that the monitoring of

Juncus roemerianus' live aboveground biomass take place in the form of number of leaves and number of stems.

   c. It is recommended that *Schoenoplectus tabernaemontani* not be used in saltmarsh restoration due to its relatively low tolerance for salinity similar to that found in saltmarshes.

   d. For saltmarshes with *Borrichia frutescens* present, it is recommended that engineered soils S2, S6, and S4 be used in the restoration on the saltmarsh. Once established, it is advised that the monitoring of this species' belowground biomass take place in the form of number of stems and percent cover.

3. Notably, it was found that S6 performed relatively well in *Spartina alterniflora* and *Borrichia frutescens*. This engineered soil (S6) was created using 100% dredged material, which suggests that the use of dredged material (S6) for restoration purposes will support the growth of *Spartina alterniflora* and *Borrichia frutescens*.

4. While the greenhouse study provided meaningful results, it is recommended that future investigations should allow for more time in the growing season, as well as, greater replications.

8.0 FUTURE WORK

Further investigations of the potential for engineered soil mixtures to effectively revegetate and reestablish saltmarshes is recommended:

1. Future pilot-scale field work in Georgia's saltmarshes should examine the establishment of the vegetation in the engineered soil mixtures. This future study will confirm the restoration of pre-construction soil properties and vegetation maintains and can even improve the functionality and ecologic conditions in the saltmarsh. A detailed record of the process of the restoration and establishment of the vegetation should be kept.
2. During the pilot-scale field work in Georgia's saltmarshes a water quality study and an erosion study should be conducted in parallel. This will examine the water quality and erosion rates of saltmarshes that have been restored with the engineered soils and vegetation and compare the results to sites that have not been restored.
3. It could also be beneficial to further investigate these vegetative species in engineered soil with sea level rise and see if it affects the establishment.
4. While the environmental performance of the mixtures is significant, their economic value should also be considered. Item and material unit cost should be collected and used to compare the cost of the current standard to the proposed method of reestablishing the geotechnical soil properties and vegetation. This comparison should be evaluated over time to include further maintenance costs.

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APPENDICES

Appendix A: Mix Designs

The following sections align with the sections in Chapter 5. Figure 17 show the sieve analysis on the sand that was used for additional sand in the design mixtures. Figure 18 illustrates the particle size distribution curves for the two sources of dredge material, while, Figure 19 and Figure 20 show the particle size distribution curves for the first and second mix designs

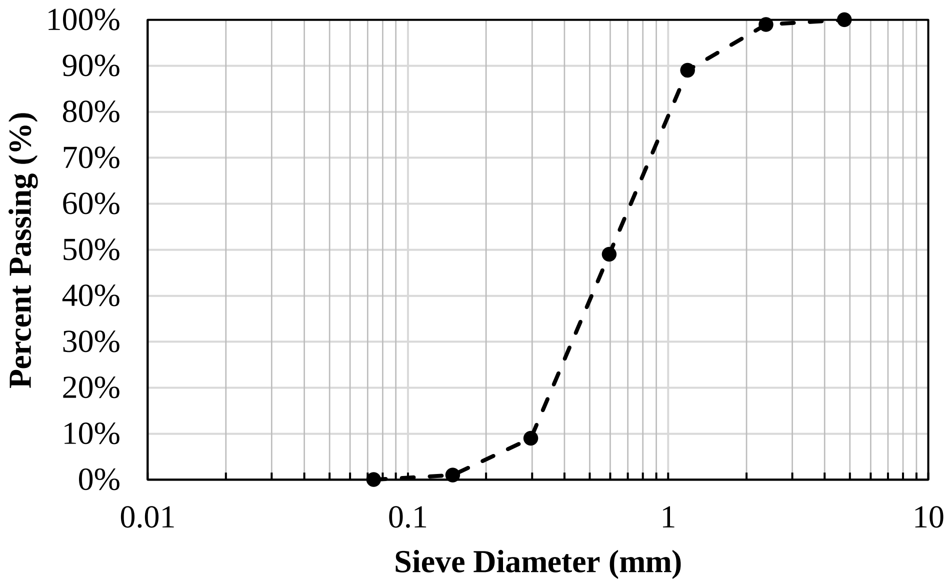


Figure 18: Particle Size Distribution for Sand

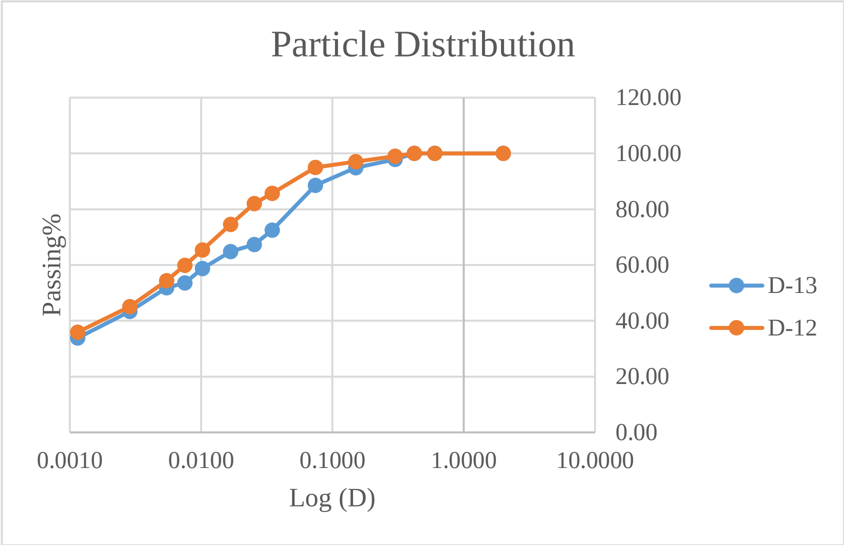
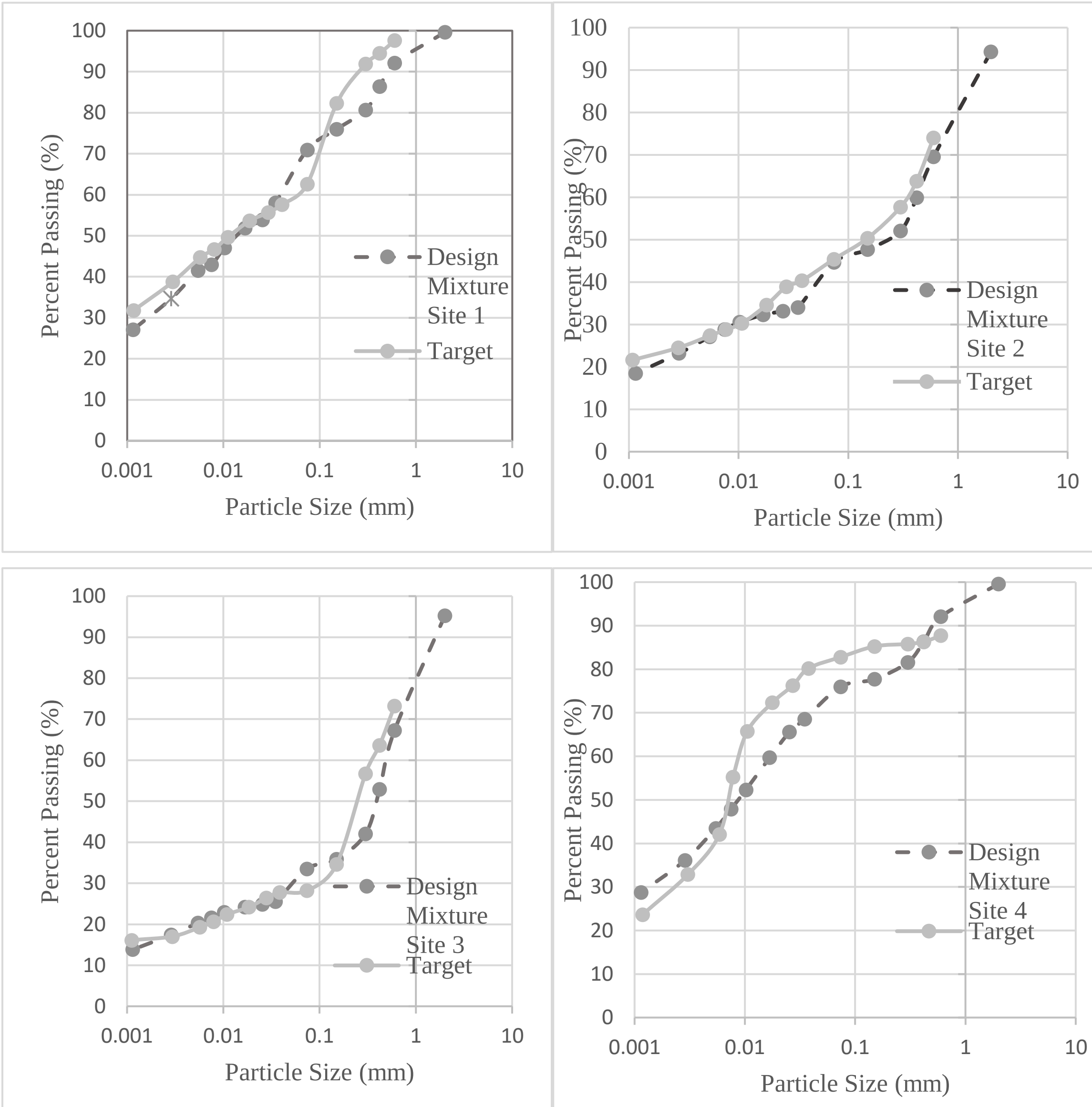


Figure 19: Particle Size Distribution for Dredged Material


Percent Passing (%)
Particle Size (mm)
Design Mixture Site 1
Target
Design Mixture Site 2
Target
Design Mixture Site 3
Target
Design Mixture Site 4
Target

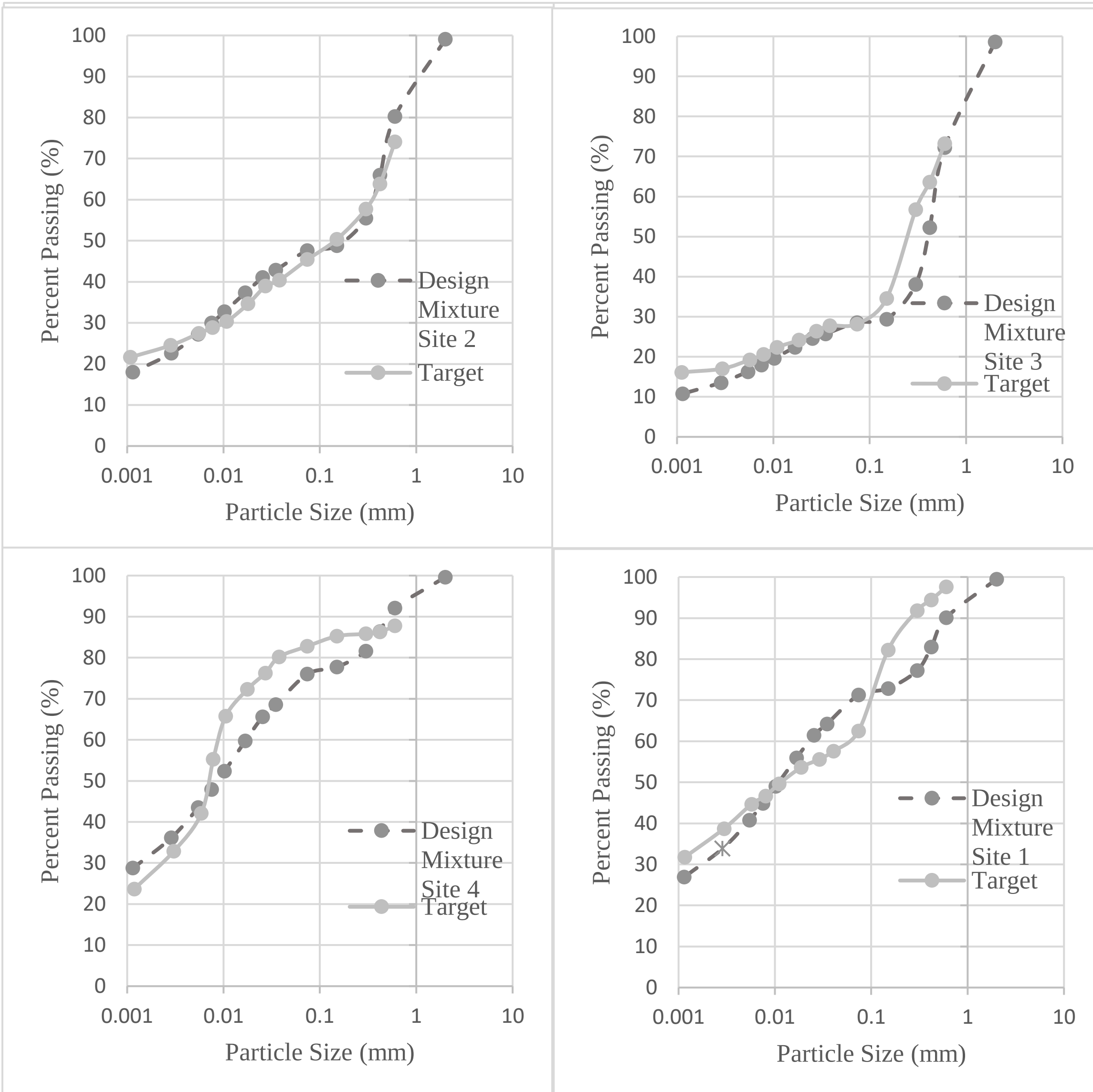


Figure 20:Particle Size Distribution Curves for First Mixture Designs

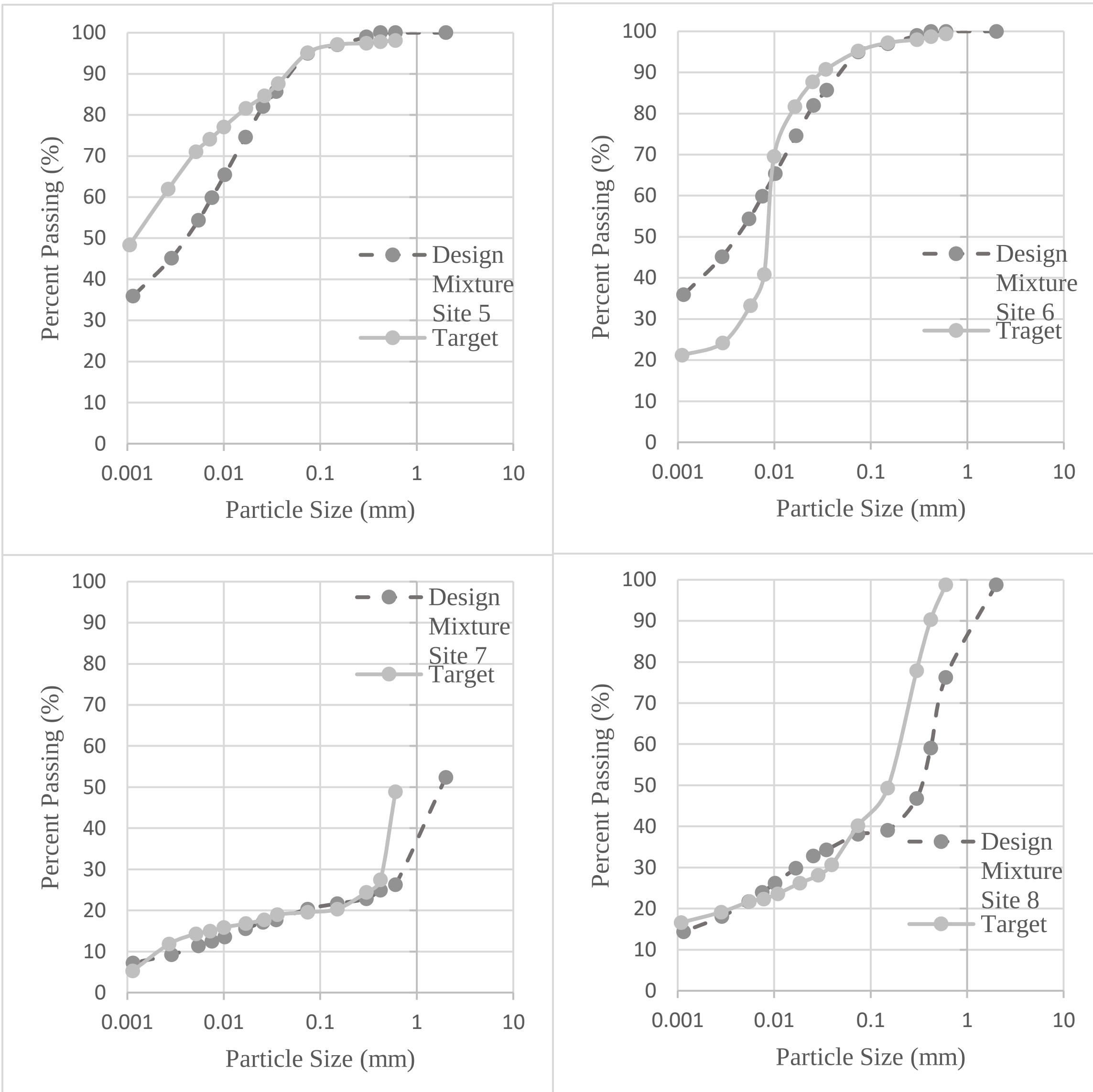


Figure 21:Particle Size Distribution Curves for Second Mix Designs

Appendix B: Experimental Results and Analysis

The following sections align with the sections in Chapter 6. Each section presents the entire procedure and of the tests performed in the study.

Table 11: Data for *Spartina alterniflora*

Tub	Matrix	Height 3 (cm)	Height 21 (cm)	Height Growth (cm)	Leaves 5	Leaves 21	Leaves Growth	Cover 3 (%)	Cover 21 (%)	Cover Growth (%)	Stem 5	Stem 21	Stem Growth	Final Color	Live Above Biomass (g)	Below Biomass (g)	Live and Dead Biomass (g)	Total Biomass (g)
1	S1	30.67	48.33	17.67	10	19	9	20	35	15	8	4	-4	Olive Green	1.6	3.23	2.26	5.49
1	S2	29.00	52.00	23.00	2	2	0	5	25	20	1	1	0	Olive Green	0.78	1.16	1.2	2.36
1	S3	39.50	51.67	12.17	6	15	9	15	30	15	3	3	0	Olive Green	1.7	4.01	2.06	6.07
1	S4	33.67	55.00	21.33	5	24	19	20	40	20	3	5	2	Olive Green	1.72	3.1	1.95	5.05
1	S5	46.50	43.50	-3.00	7	9	2	15	25	10	2	2	0	Olive Green	1.45	1.87	1.97	3.84
1	S6	38.00	66.00	28.00	13	19	6	20	45	25	5	4	-1	Olive Green		6.58	0.72	7.3
1	S7	33.33	53.67	20.33	9	18	9	10	30	20	4	4	0	Olive Green	1.14	2.23	1.55	3.78
1	S8	25.00	37.33	12.33	8	17	9	15	40	25	2	5	3	Olive Green	0.8	4.11	1.48	5.59
1	C1	23.50	61.50	38.00	7	10	3	10	25	15	2	2	0	Olive Green	1.37	1.36	1.74	3.1
1	C2	34.33	33.00	-1.33	12	29	17	25	30	5	10	9	-1	Olive Green	0.88	3.13	1.65	4.78
2	S1	32.00	47.67	15.67	8	11	3	20	30	10	1	3	2	Olive Green	1.04	1.09	1.67	2.76
2	S2	16.67	53.67	37.00	10	20	10	20	30	10	2	6	4	Olive Green	0.72	1.73	1.06	2.79
2	S3	24.00	34.33	10.33	12	13	1	15	35	20	2	3	1	Olive Green	0.71	2.7	1.15	3.85
2	S4	9.50	37.00	27.50	4	5	1	5	25	20	2	1	-1	Olive Green	0.35	1.02	0.47	1.49
2	S5			0.00			0			0			0	Moderate Yellow Green		1.12	0.07	1.19
2	S6	35.67	59.33	23.67	17	28	11	20	60	40	3	7	4	Olive Green	2.36	4.81	3.43	8.24
2	S7	24.33	39.33	15.00	8	11	3	20	35	15	2	3	1	Olive Green	0.56	3.26	1.35	4.61
2	S8	24.67	28.00	3.33	9	20	11	20	35	15	3	5	2	Olive Green	0.47	1.76	0.75	2.51
2	C1	15.50	45.00	29.50	6	7	1	5	30	25	2	1	-1	Olive Green	0.67	0.98	1.04	2.02
2	C2			0.00			0			0			0	Moderate Yellow Green		0.42	0.06	0.48
3	S1	22.33	47.00	24.67	8	22	14	15	50	35	1	4	3	Strong Yellow Green	1.81	4.33	2.16	6.49
3	S2	55.00	64.67	9.67	6	25	19	10	60	50	1	5	4	Strong Yellow Green	1.6	5.46	2.14	7.6
3	S3	33.00	62.00	29.00	10	17	7	20	45	25	3	4	1	Strong Yellow Green	1.53	3.84	2.06	5.9
3	S4	24.67	47.67	23.00	10	16	6	10	30	20	3	4	1	Strong Yellow Green	0.83	1.96	1.15	3.11
3	S5			0.00			0			0			0	Moderate Yellow Green		0.53	0.12	0.65
3	S6	21.00	51.33	30.33	9	20	11	20	50	30	2	4	2	Strong Yellow Green	1.93	7.65	2.59	10.24
3	S7	37.50	42.00	4.50	7	10	3	5	40	35	2	2	0	Strong Yellow Green	1.14	2.75	1.5	4.25
3	S8	29.67	57.00	27.33	17	19	2	35	40	5	5	4	-1	Strong Yellow Green	1.36	6.1	1.69	7.79
3	C1	38.50	60.50	22.00	7	14	7	10	60	50	2	2	0	Strong Yellow Green	2.07	5.72	2.86	8.58
3	C2	24.50	50.50	26.00	3	9	6	5	30	25	1	2	1	Strong Yellow Green	0.64	1.42	0.78	2.2
4	S1	35.00	45.00	10.00	6	11	5	15	35	20	2	2	0	Grayish Olive Green	1	2.64	1.41	4.05
4	S2	24.67	38.33	13.67	7	17	10	15	30	15	2	4	2	Grayish Olive Green	1.13	3.27	1.8	5.07
4	S3	33.00	28.00	-5.00	16	18	2	20	35	15	4	4	0	Grayish Olive Green	0.96	4.5	1.56	6.06
4	S4	26.33	25.00	-1.33	11	9	-2	10	25	15	4	3	-1	Grayish Olive Green	0.4	3.01	0.76	3.77
4	S5	31.50	42.00	10.50	7	13	6	15	35	20	2	3	1	Grayish Olive Green	0.11	3.25	1.157	4.407
4	S6	35.50	50.67	15.17	9	17	8	15	30	15	2	3	1	Grayish Olive Green	1.53	3.11	2.44	5.55
4	S7	19.00	20.50	1.50	10	7	-3	10	20	10	4	2	-2	Grayish Olive Green	0.21	1.55	0.54	2.09
4	S8			0.00			0			0			0	Moderate Yellow Green		0.61	0.21	0.82
4	C1	38.00	68.00	30.00	6	15	9	10	50	40	1	2	1	Grayish Olive Green	2.33	2.65	2.79	5.44
4	C2	30.00	49.00	19.00	5	5	0	10	20	10	1	1	0	Grayish Olive Green	0.5	0.76	0.75	1.51
5	S1	27.50		-27.50	5		-5	10		-10	2		-2	Moderate Yellow Green		1.83	0.23	2.06
5	S2	25.00	10.00	-15.00	2	3	1	5	20	15	1	1	0	Olive Green	0.03	1.05	0.11	1.16
5	S3	31.00	25.67	-5.33	9	16	7	15	30	15	3	3	0	Olive Green	0.72	3.19	0.87	4.06
5	S4	7.00		-7.00	3		-3	5		-5	1		-1	Olive Green		0.37	0.21	0.58
5	S5	26.67	53.50	26.83	8	17	9	15	40	25	2	2	0	Olive Green	1.37	4.6	1.66	6.26
5	S6	35.00	75.00	40.00	4	7	3	15	25	10	1	1	0	Olive Green	1.72	1.22	2.03	3.25
5	S7			0.00			0			0			0	Moderate Yellow Green		0.33	0	0.33
5	S8			0.00			0			0			0	Moderate Yellow Green		0.48	0	0.48
5	C1	42.00	34.33	-7.67	7	10	3	10	40	30	1	3	2	Olive Green	1.68	3.06	2.21	5.27
5	C2			0.00			0			0			0	Moderate Yellow Green		1.15	0	1.15

Table 12: Data for *Juncus roemerianus*

Tub	Matrix	Height 3 (cm)	Height 21 (cm)	Height Growth (cm)	Leaves 5	Leaves 21	Leaves Growth	Cover 3 (%)	Cover 21 (%)	Cover Growth (%)	Stem 5	Stem 21	Stem Growth	Final Color	Live Above Biomass (g)	Below Biomass (g)	Live and Dead Biomass (g)	Total Biomass (g)
1	S1	11.00		-11.00			0	5		-5	2		-2	Moderate Yellow Green		1.41	0.83	2.24
1	S2			0.00			0			0			0	Moderate Yellow Green		0.63	1.44	2.07
1	S3	7.50		-7.50			0	2		-2			0	Moderate Yellow Green		0.98	1.81	2.79
1	S4			0.00			0			0			0	Moderate Yellow Green		1.04	0.99	2.03
1	S5			0.00			0			0			0	Moderate Yellow Green		2	1.16	3.16
1	S6	12.67		-12.67			0	5		-5	2		-2	Moderate Yellow Green		1.44	2.3	3.74
1	S7	21.50	38.50	17.00			0	4	10	6	3	2	-1	Moderate Olive Green	0.2	1.48	0.93	2.41
1	S8			0.00			0			0			0	Moderate Yellow Green		1.58	2.26	3.84
1	C1	12.00		-12.00			0	5		-5	3		-3	Moderate Yellow Green		1.57	0.53	2.1
1	C2			0.00			0			0			0	Moderate Yellow Green		0.74	1.1	1.84
2	S1	17.00		-17.00			0	5		-5	3		-3	Moderate Yellow Green		1.16	0.56	1.72
2	S2	36.00		-36.00			0	20		-20	6		-6	Olive Green		1.59	1.12	2.71
2	S3			0.00			0			0			0	Moderate Yellow Green		2.49	1.18	3.67
2	S4			0.00			0			0			0	Moderate Yellow Green		1.53	0.21	1.74
2	S5			0.00			0			0			0	Moderate Yellow Green		2.19	0.68	2.87
2	S6	45.33		-45.33			0	25		-25	10		-10	Moderate Yellow Green		1.96	1.18	3.14
2	S7			0.00			0			0			0	Moderate Yellow Green		0.83	1.23	2.06
2	S8			0.00			0			0			0	Moderate Yellow Green		1.04	0.23	1.27
2	C1	34.33	27.33	-7.00	1	1	0	15	15	0	6	3	-3	Olive Green	0.24	2.1	1.42	3.52
2	C2	15.00		-15.00			0	5		-5	3		-3	Moderate Yellow Green		2.5	0.28	2.78
3	S1			0.00			0			0			0	Moderate Yellow Green		1.83	1.26	3.09
3	S2	18.33		-18.33			0	5		-5	4		-4	Moderate Yellow Green		1.59	1.81	3.4
3	S3			0.00			0			0			0	Moderate Yellow Green		0.9	0.2	1.1
3	S4			0.00			0			0			0	Moderate Yellow Green		1.72	0.72	2.44
3	S5			0.00			0			0			0	Moderate Yellow Green		0.78	0.04	0.82
3	S6	32.33		-32.33	1		-1	15		-15	11		-11	Strong Yellow Green		2.29	0.91	3.2
3	S7			0.00			0			0	2		-2	Moderate Yellow Green		1	0.6	1.6
3	S8	18.67		-18.67			0	10		-10	4		-4	Moderate Yellow Green		1.7	0.29	1.99
3	C1	16.00		-16.00			0	15		-15	4		-4	Moderate Yellow Green		1.24	1	2.24
3	C2			0.00			0			0			0	Moderate Yellow Green		0.81	0.6	1.41
4	S1	38.33	54.00	15.67	4		-4	20	15	-5	9	4	-5	Olive Green	0.39	2.85	1.02	3.87
4	S2	32.33		-32.33			0	10		-10	6		-6	Moderate Yellow Green		2.49	1.17	3.66
4	S3	39.67	37.67	-2.00	5	3	-2	20	20	0	8	4	-4	Moderate Olive Green	0.45	1.8	1.12	2.92
4	S4	31.33		-31.33			0	10		-10	4		-4	Moderate Yellow Green		1.05	0.41	1.46
4	S5	70.33	65.67	-4.67	7		-7	15	20	5	6	6	0	Moderate Olive Green	1.12	1.56	1.99	3.55
4	S6	48.00	37.33	-10.67	23	15	-8	30	50	20	25	19	-6	Moderate Olive Green	2.71	3.94	5.11	9.05
4	S7	43.67	26.00	-17.67	4	2	-2	20	15	-5	9	4	-5	Moderate Olive Green	0.17	2.76	2.62	5.38
4	S8	54.00	38.67	-15.33	19	17	-2	30	30	0	15	16	1	Moderate Olive Green	2.73	4.33	4.34	8.67
4	C1	19.00		-19.00			0	1		-1	1		-1	Moderate Yellow Green		0.9	0.54	1.44
4	C2	29.00		-29.00	3		-3	25		-25	8		-8	Moderate Yellow Green		2.52	1.67	4.19
5	S1	25.67	33.00	7.33	6	11	5	15	30	15	14	10	-4	Dark Olive Green	0.87	2.79	1.8	4.59
5	S2	11.00		-11.00			0			0	1		-1	Moderate Yellow Green	1	1.56	1.49	3.05
5	S3	13.00		-13.00	1		-1	3		-3	2		-2	Moderate Yellow Green		0.93	0.15	1.08
5	S4	23.00	12.33	-10.67		2	2		10	10	5	3	-2	Dark Olive Green	0.04	3.84	0.73	4.57
5	S5	43.67	55.67	12.00	10	10	0	25	30	5	13	10	-3	Olive Green	2.28	3.08	2.28	5.36
5	S6	40.00	48.00	8.00	13	13	0	25	30	5	14	15	1	Olive Green	2.08	2.28	2.96	5.24
5	S7			0.00			0			0			0	Moderate Yellow Green		0.73	0.37	1.1
5	S8	46.33	49.33	3.00	11	2	-9	15	25	10	8	5	-3	Olive Green	0.52	1.36	1	2.36
5	C1	45.33	35.00	-10.33	5	5	0	25	30	5	7	9	2	Olive Green	1.56	3.5	2.6	6.1
5	C2	41.67	28.67	-13.00	7	2	-5	15	15	0	10	6	-4	Olive Green	0.59	2.68	2.21	4.89

Table 13: Data for Borrichia frutescens

Tub	Matrix	Height 3 (cm)	Height 21 (cm)	Height Growth (cm)	Leaves 5	Leaves 21	Leaves Growth	Cover 3 (%)	Cover 21 (%)	Cover Growth (%)	Stem 5	Stem 21	Stem Growth	Final Color	Live Above Biomass (g)	Below Biomass (g)	Live and Dead Biomass (g)	Total Biomass (g)
1	S1	32.00	37.00	5.00	56	27	-29	40	30	-10	7	5	-2	Grayish Yellow Green	3.45	1.55	3.95	5.5
1	S2	43.67	31.67	-12.00	36	30	-6	20	60	40	4	5	1	Grayish Yellow Green	4.85	2.1	4.85	6.95
1	S3	46.00	44.00	-2.00	36	28	-8	20	70	50	4	2	-2	Grayish Yellow Green	3.31	2.36	4.33	6.69
1	S4	36.33	27.33	-9.00	103	40	-63	45	70	25	11	7	-4	Moderate Yellow Green	3.09	4.09	3.09	7.18
1	S5	20.33	25.50	5.17	19	15	-4	15	35	20	2	2	0	Grayish Yellow Green	1.33	1.8	1.47	3.27
1	S6	24.50	43.67	19.17	134	103	-31	50	95	45	17	18	1	Moderate Yellow Green	10.55	6.9	11.15	18.05
1	S7	25.00	26.50	1.50	39	25	-14	15	65	50	5	4	-1	Grayish Yellow Green	2.18	2.26	2.88	5.14
1	S8	30.00	14.00	-16.00	38	13	-25	25	40	15	4	2	-2	Grayish Yellow Green	1.34	2.62	2.45	5.07
1	C1	24.00	34.67	10.67	79	26	-53	50	50	0	8	5	-3	Moderate Yellow Green	3.78	3.64	3.78	7.42
1	C2	33.33	38.67	5.33	87	21	-66	50	50	0	9	5	-4	Grayish Yellow Green	6.41	4.36	6.72	11.08
2	S1	27.33	22.00	-5.33	81	100	19	45	95	50	11	19	8	Grayish Olive Green	6.1	4.9	6.22	11.12
2	S2		12.67	12.67	95	47	-48	75	95	20	11	9	-2	Grayish Olive Green	2.34	3.28	2.5	5.78
2	S3	27.00	22.33	-4.67	56	18	-38	25	60	35	5	4	-1	Strong Yellow Green	3.11	3.7	4.32	8.02
2	S4	17.67	31.67	14.00	41	40	-1	15	95	80	6	4	-2	Strong Yellow Green	1.96	2.58	2.7	5.28
2	S5	22.33	29.67	7.33	52	50	-2	20	70	50	7	9	2	Grayish Olive Green	2.77	2.65	2.88	5.53
2	S6	33.33	33.33	0.00	57	61	4	30	70	40	6	11	5	Grayish Yellow Green	2.75	2.58	3.88	6.46
2	S7	34.00	35.33	1.33	68	37	-31	35	65	30	6	6	0	Grayish Olive Green	5.29	4.01	5.53	9.54
2	S8	19.33	27.00	7.67	39	16	-23	35	30	-5	4	4	0	Strong Yellow Green	2.7	2.99	3.07	6.06
2	C1	39.67	53.67	14.00	108	70	-38	45	95	50	11	10	-1	Grayish Olive Green	10.46	3.14	10.46	13.6
2	C2	20.00		-20.00			0			0			0	Moderate Yellow Green		0.41	0.28	0.69
3	S1	26.00	29.50	3.50	35	23	-12	25	80	55	5	2	-3	Grayish Yellow Green	2.47	3.37	3.58	6.95
3	S2	26.00	45.00	19.00	39	17	-22	35	95	60	5	2	-3	Grayish Yellow Green	2.92	2.3	3.13	5.43
3	S3	29.00	42.00	13.00	33	14	-19	20	50	30	3	3	0	Grayish Yellow Green	2.6	2.81	2.64	5.45
3	S4	23.00	14.00	-9.00	10	23	13	10	45	35	2	3	1	Grayish Yellow Green	1.21	1.73	1.75	3.48
3	S5	1.00		-1.00	10		-10	15		-15	2		-2	Moderate Yellow Green		0.91	0.92	1.83
3	S6	28.33	30.00	1.67	48	63	15	30	70	40	7	8	1	Olive Green	3.46	2.67	3.46	6.13
3	S7	6.00	17.00	11.00	39	23	-16	25	70	45	6	4	-2	Olive Green	0.93	2.59	2.51	5.1
3	S8	13.00	17.67	4.67	34	17	-17	15	50	35	3	3	0	Grayish Yellow Green	1.59	1.88	1.81	3.69
3	C1	27.33	43.33	16.00	75	35	-40	45	95	50	8	6	-2	Grayish Yellow Green	6.37	2.6	6.37	8.97
3	C2	5.33	47.33	42.00	34	22	-12	15	60	45	7	4	-3	Olive Green	0.83	1.19	2.05	3.24
4	S1	29.00		-29.00	31		-31	15		-15	4		-4	Olive Green		1.56	0.97	2.53
4	S2	28.67	40.00	11.33	142	71	-71	45	80	35	18	14	-4	Olive Green	6.36	5.2	6.8	12
4	S3	34.67	35.67	1.00	99	20	-79	35	40	5	14	7	-7	Olive Green	5.23	3.11	5.36	8.47
4	S4	33.67	16.00	-17.67	35	31	-4	15	40	25	12	6	-6	Strong Yellow Green	2	2.26	2.26	4.52
4	S5	31.67	30.33	-1.33	72	52	-20	25	30	5	13	6	-7	Grayish Yellow Green	4.33	2.74	4.56	7.3
4	S6	10.50	16.00	5.50	30	20	-10	20	50	30	5	3	-2	Olive Green	1.28	0.6	1.38	1.98
4	S7	34.67	27.50	-7.17	24	9	-15	20	30	10	2	2	0	Strong Yellow Green	1.77	1.37	2.43	3.8
4	S8	32.33	28.67	-3.67	73	19	-54	30	30	0	12	6	-6	Strong Yellow Green	2.38	2.5	2.44	4.94
4	C1	29.33	36.67	7.33	81	41	-40	40	50	10	7	8	1	Strong Yellow Green	4.98	2.91	4.98	7.89
4	C2	30.67	29.33	-1.33	46	30	-16	20	30	10	4	5	1	Grayish Olive Green	2.44	1.26	2.54	3.8
5	S1	27.00	24.67	-2.33	37	20	-17	20	70	50	5	3	-2	Grayish Yellow Green	3	2.33	3	5.33
5	S2	27.33	49.33	22.00	51	33	-18	45	95	50	7	4	-3	Grayish Yellow Green	5.97	4.92	6.2	11.12
5	S3	32.00	53.00	21.00	14	15	1	25	70	45	4	1	-3	Grayish Yellow Green	1.76	1.77	2.04	3.81
5	S4	26.00	35.33	9.33	67	54	-13	35	50	15	20	9	-11	Moderate Yellow Green	5.74	5.76	6.43	12.19
5	S5	23.50	20.33	-3.17	32	24	-8	35	70	35	6	4	-2	Moderate Yellow Green	1.76	2.39	2.57	4.96
5	S6	32.67	34.00	1.33	28	11	-17	20	40	20	3	1	-2	Grayish Yellow Green	1.58	2.33	2.27	4.6
5	S7	37.00	25.33	-11.67	35	11	-24	15	60	45	4	3	-1	Grayish Yellow Green	1.88	2.77	2.2	4.97
5	S8	36.00	29.67	-6.33	59	33	-26	35	90	55	8	4	-4	Grayish Yellow Green	4.42	3.62	4.75	8.37
5	C1	23.67	40.00	16.33	37	26	-11	5	90	85	4	2	-2	Moderate Yellow Green	3.09	4.46	3.09	7.55
5	C2	37.67	28.33	-9.33	96	39	-57	35	90	55	13	5	-8	Grayish Yellow Green	3.76	4.19	4.12	8.31

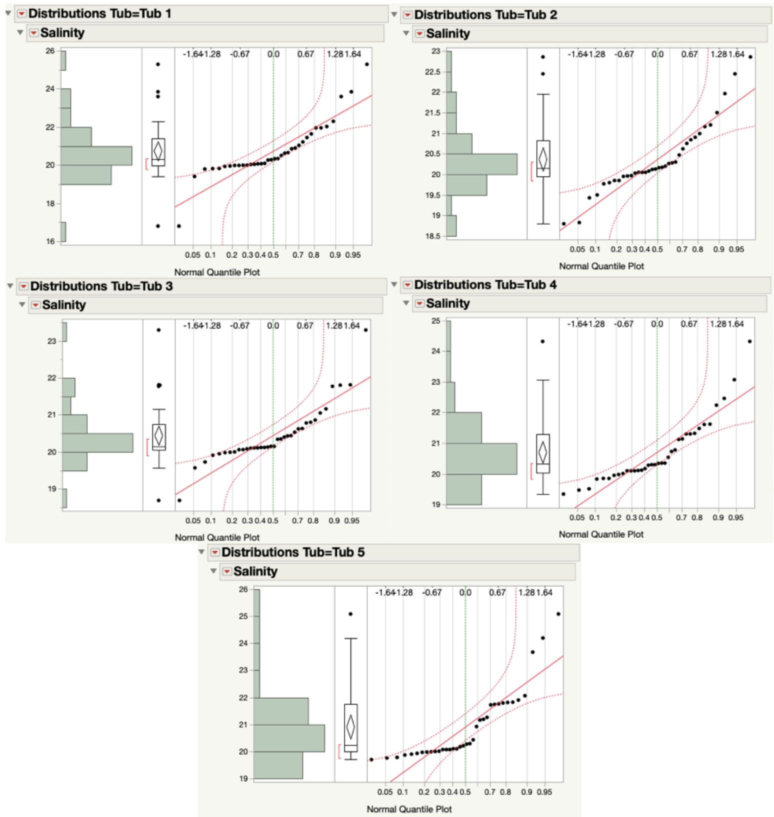


Figure 22: Distributions and NPPs for Salinity Between Tubs

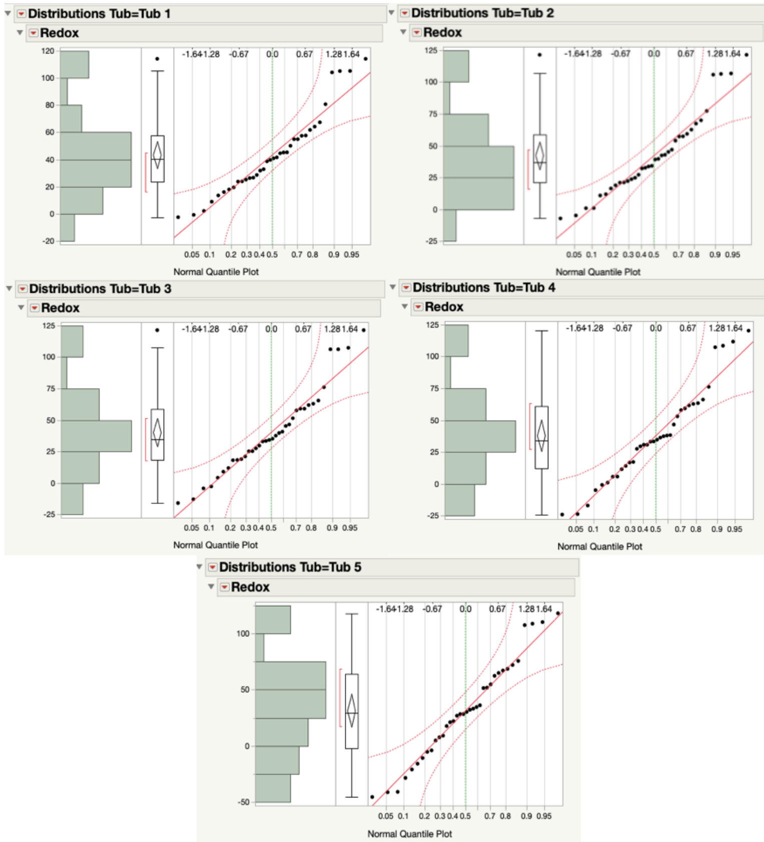


Figure 23: Distributions and NPPs for Redox Between Tubs

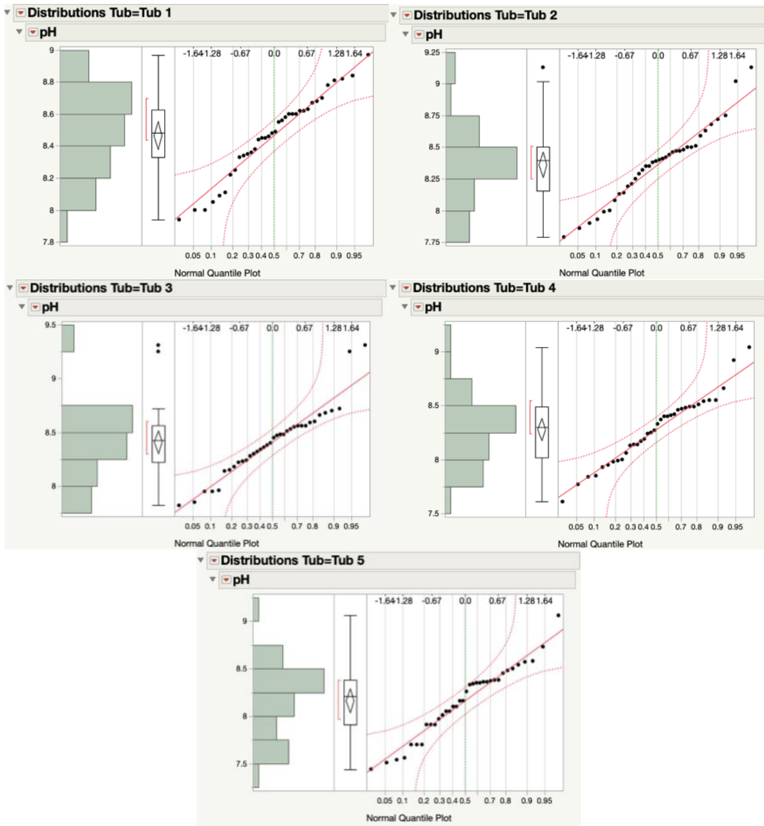


Figure 24: Distributions and NPPs for pH Between Tubs

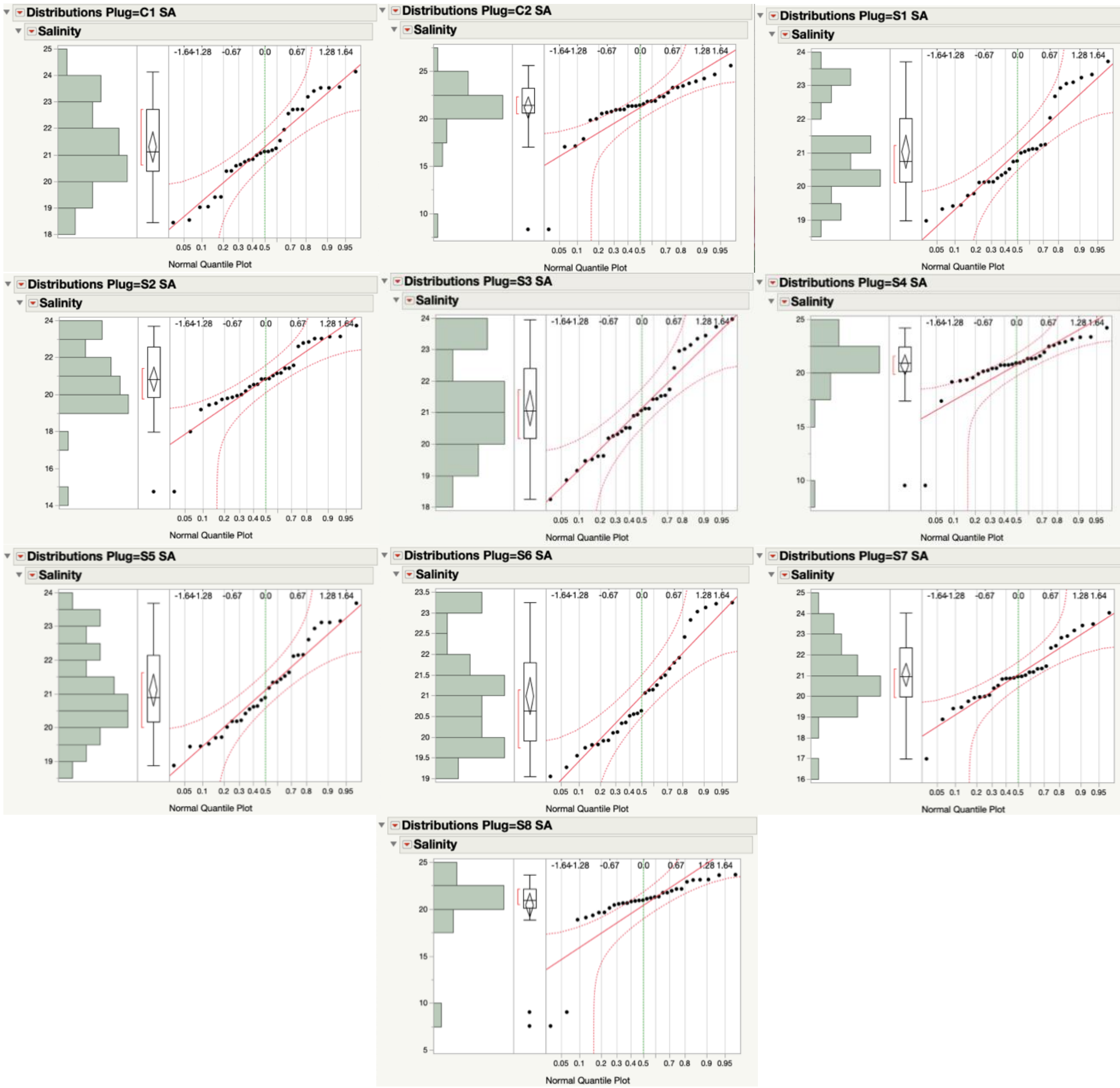


Figure 25: Distributions and NPPs for Salinity in *Spartina alterniflora* Between Soil Matrixes

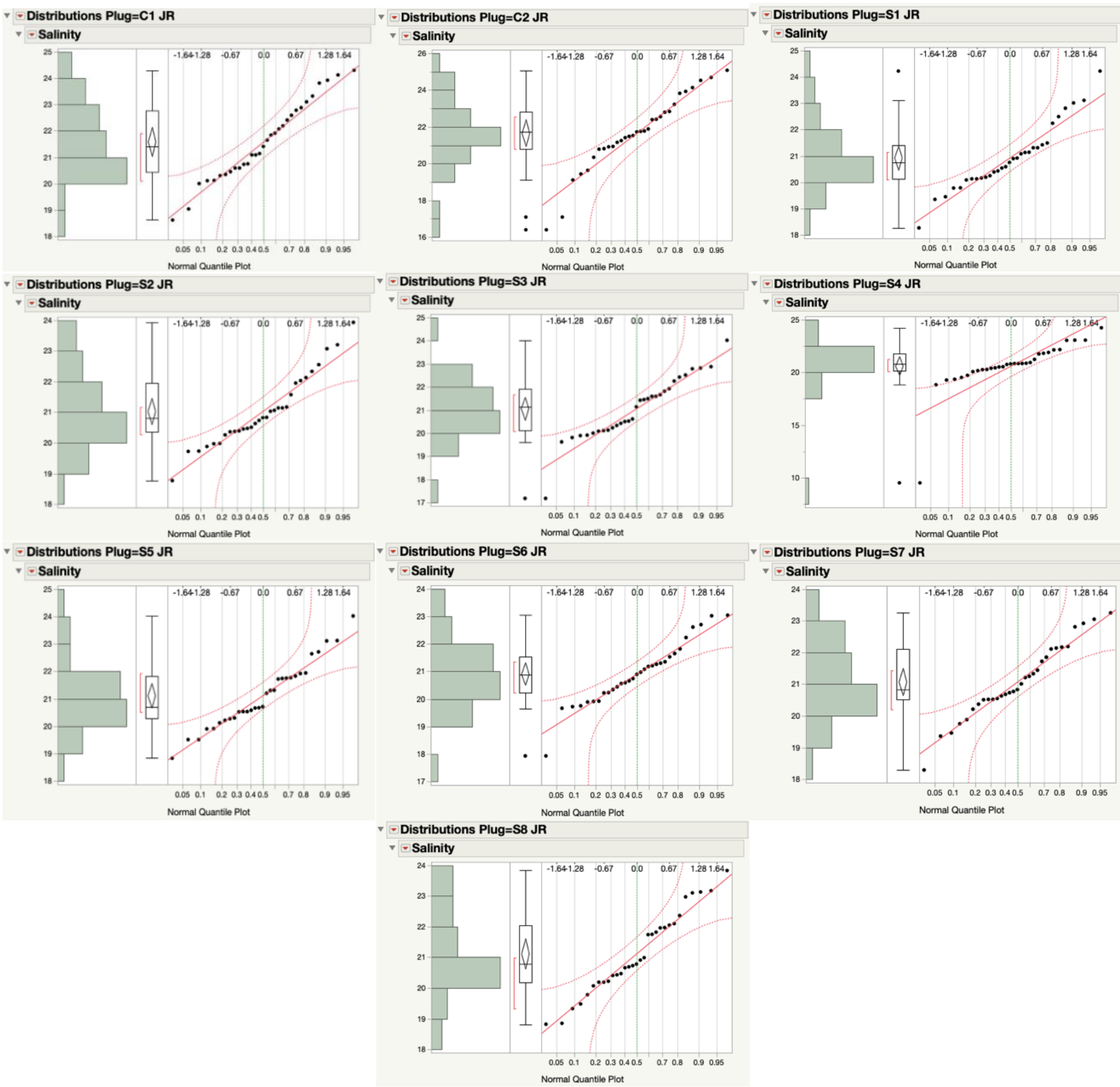


Figure 26: Distributions and NPPs for Salinity in *Juncus roemerianus* Between Soil Matrixes

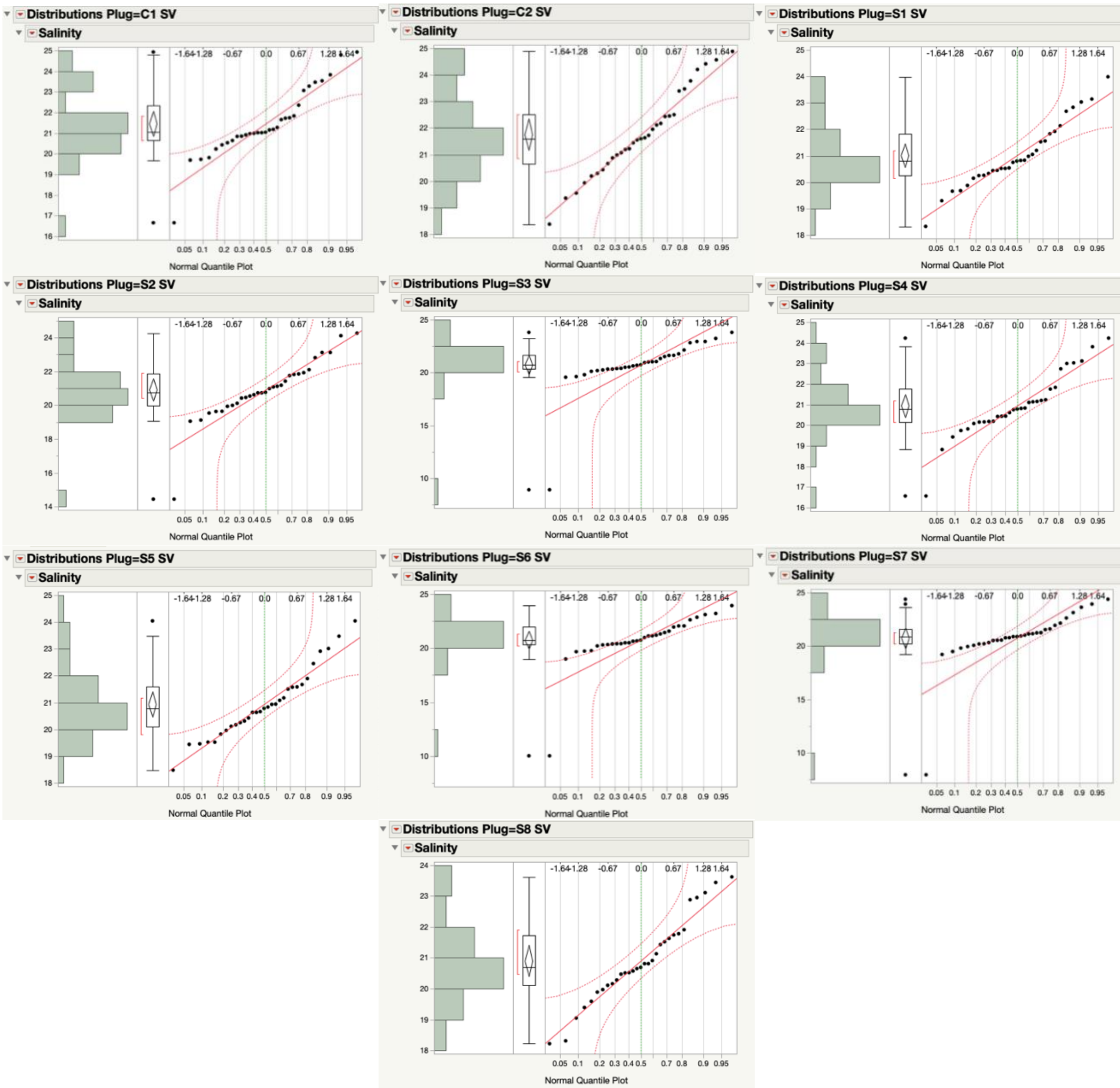


Figure 27: Distributions and NPPs for Salinity in *Schoenoplectus tabernaemontani* Between Soil Matrixes

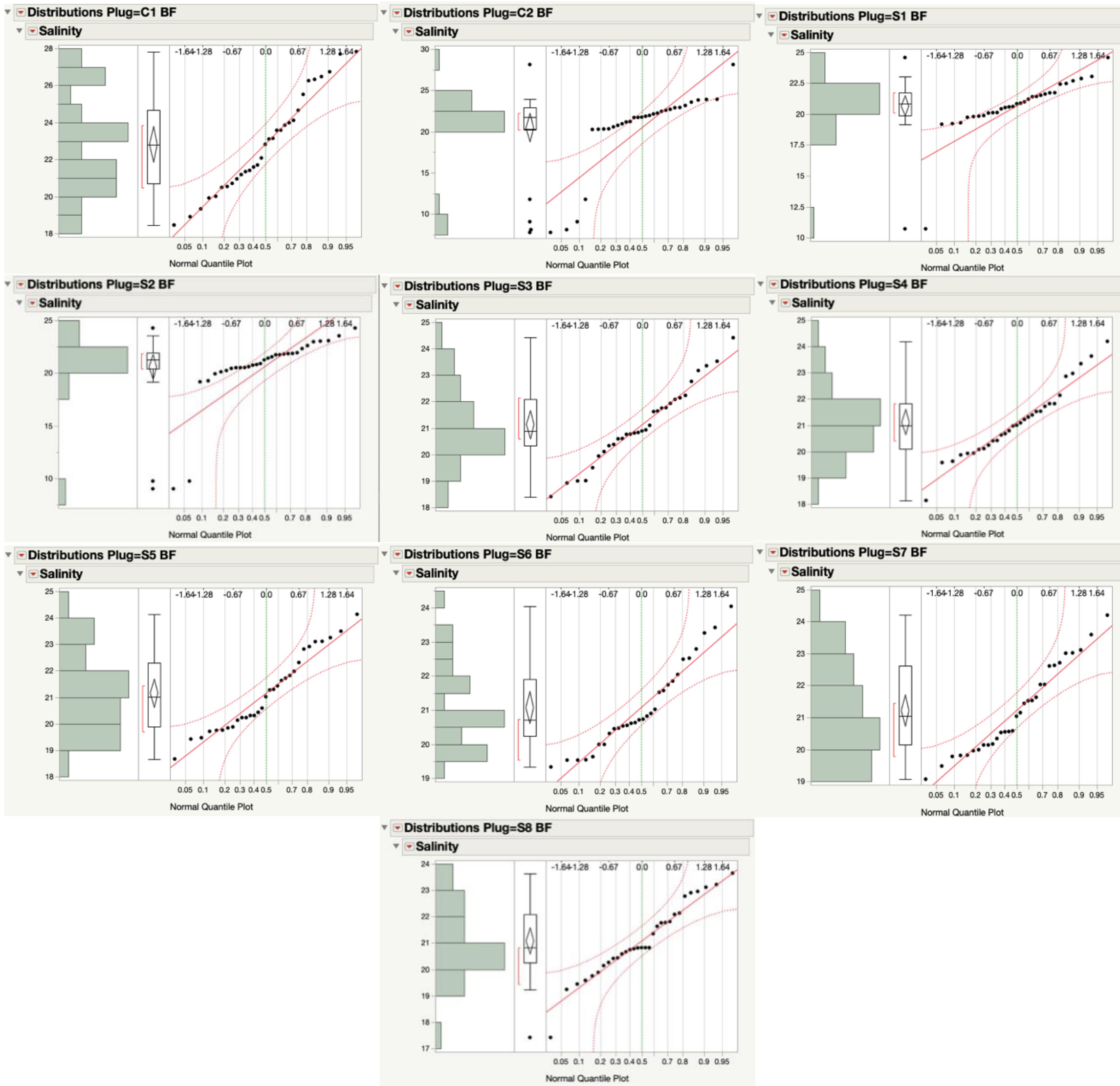


Figure 28: Distributions and NPPs for Salinity in *Borrichia frutescens* Between Soil Matrixes

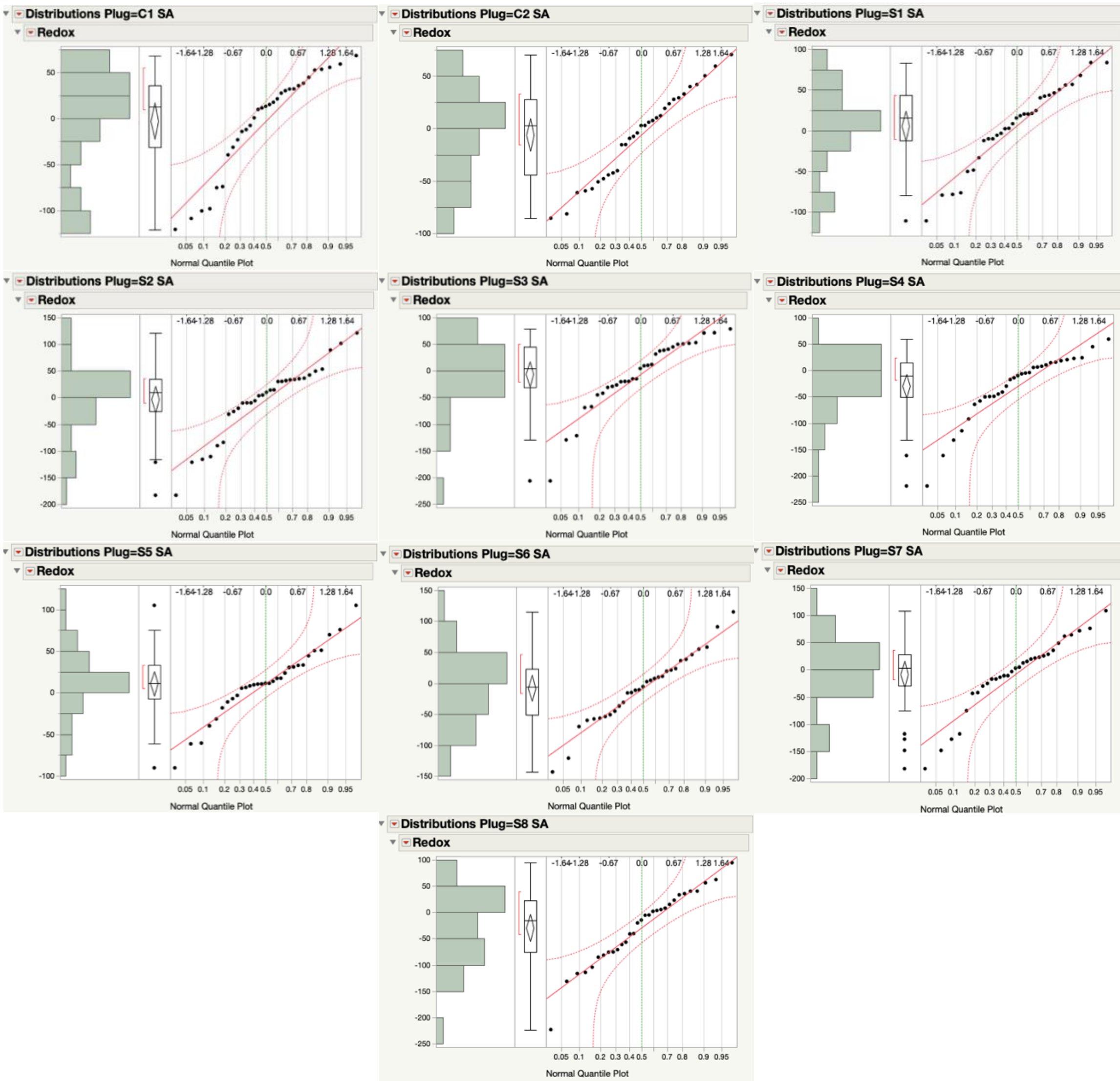


Figure 29: Distributions and NPPs for Redox in *Spartina alterniflora* Between Soil Matrixes

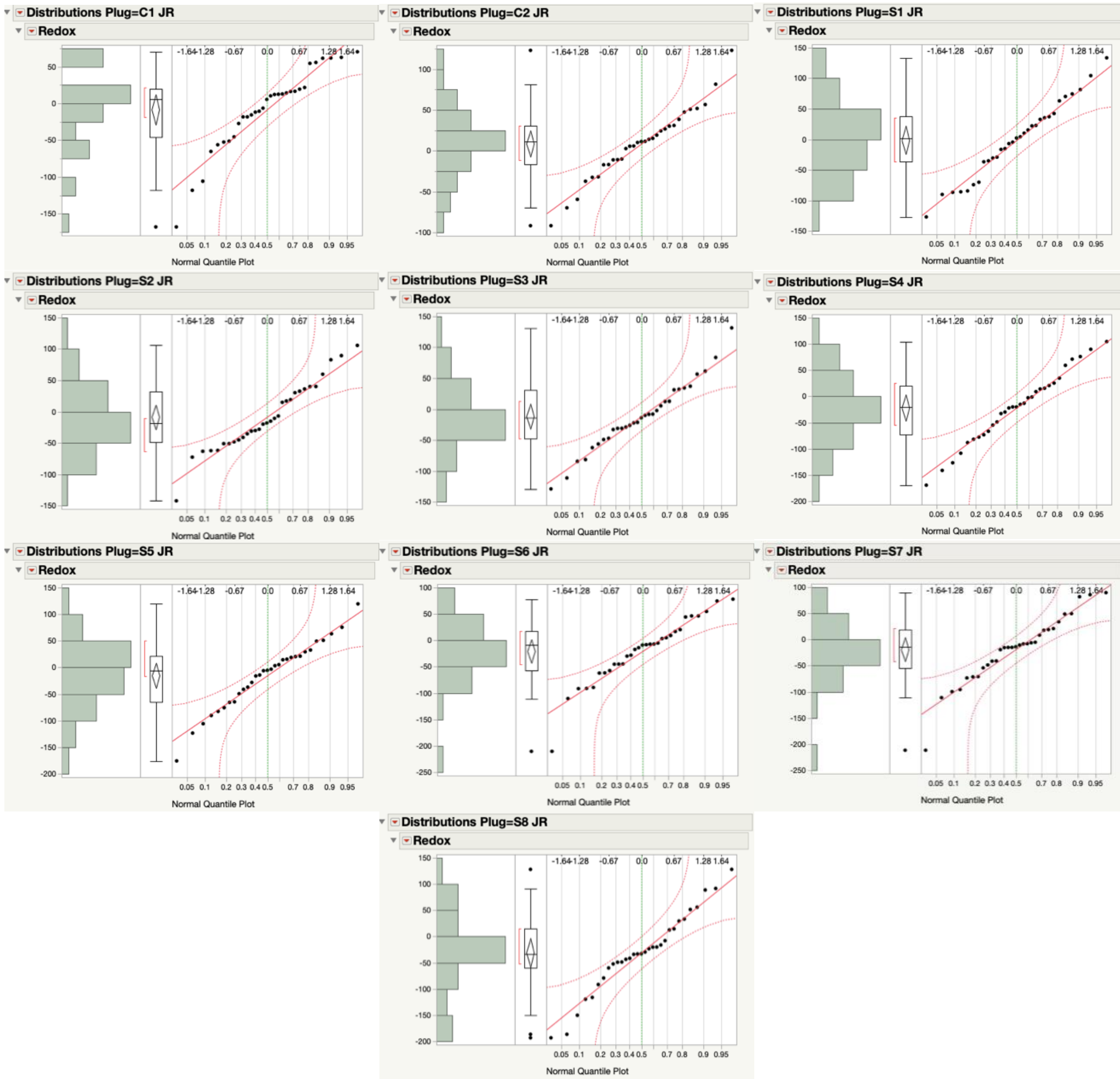


Figure 30: Distributions and NPPs for Redox in *Juncus roemerianus* Between Soil Matrixes

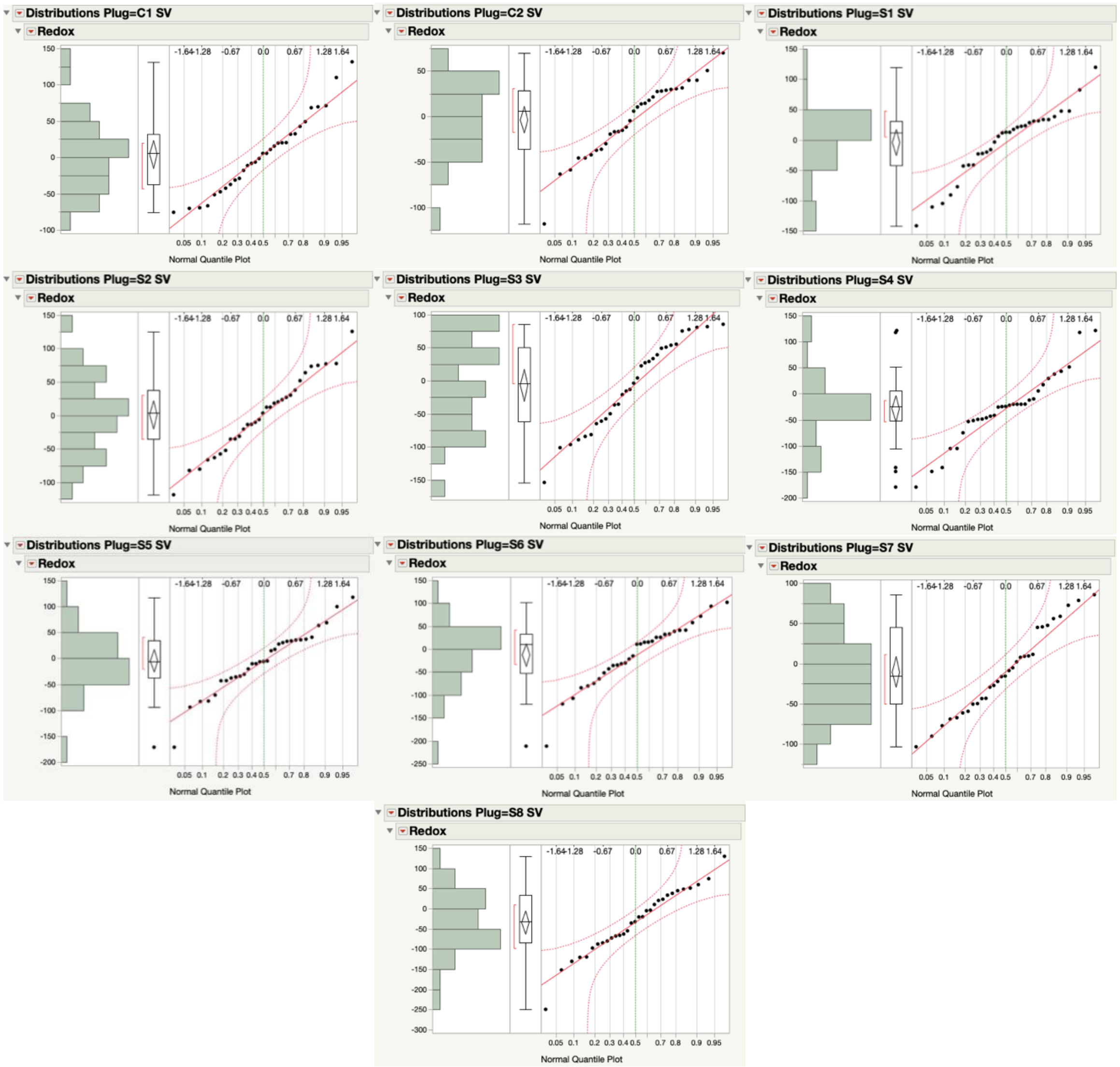


Figure 31: Distributions and NPPs for Redox in *Schoenoplectus tabernaemontani* Between Soil Matrixes

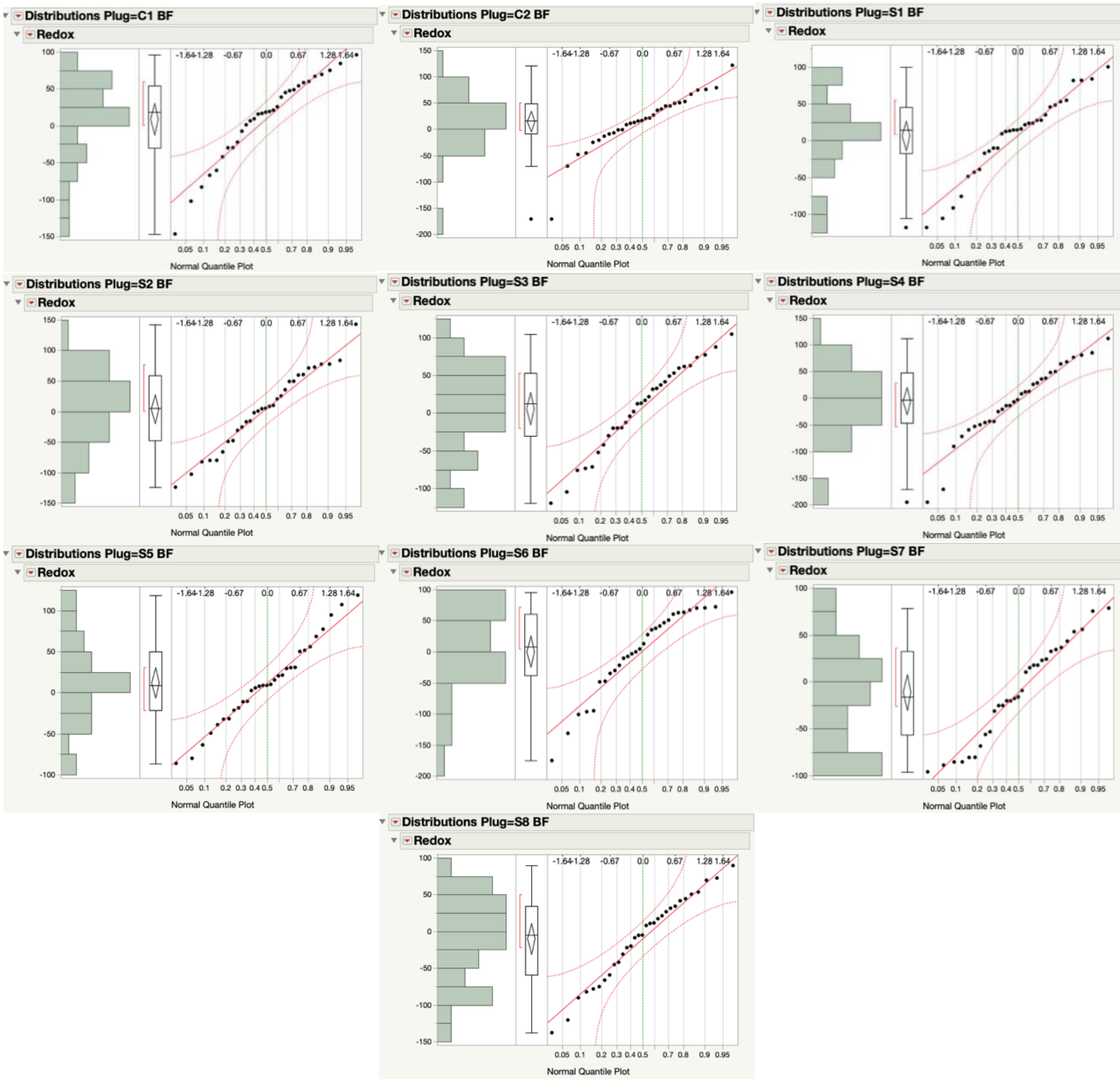


Figure 32: Distributions and NPPs for Redox in *Borrichia frutescens* Between Soil Matrixes

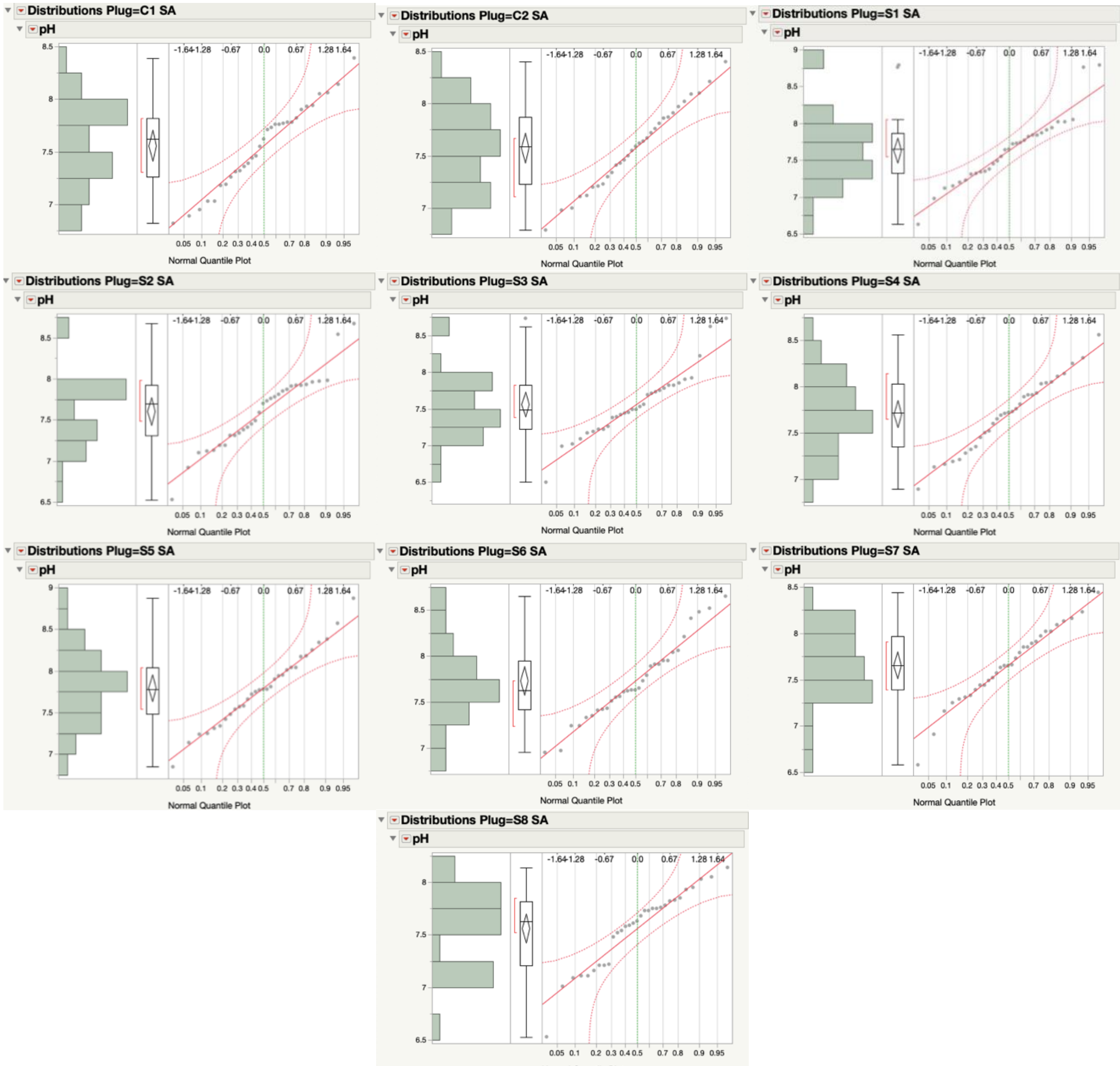


Figure 33: Distributions and NPPs for pH in *Spartina alterniflora* Between Soil Matrixes

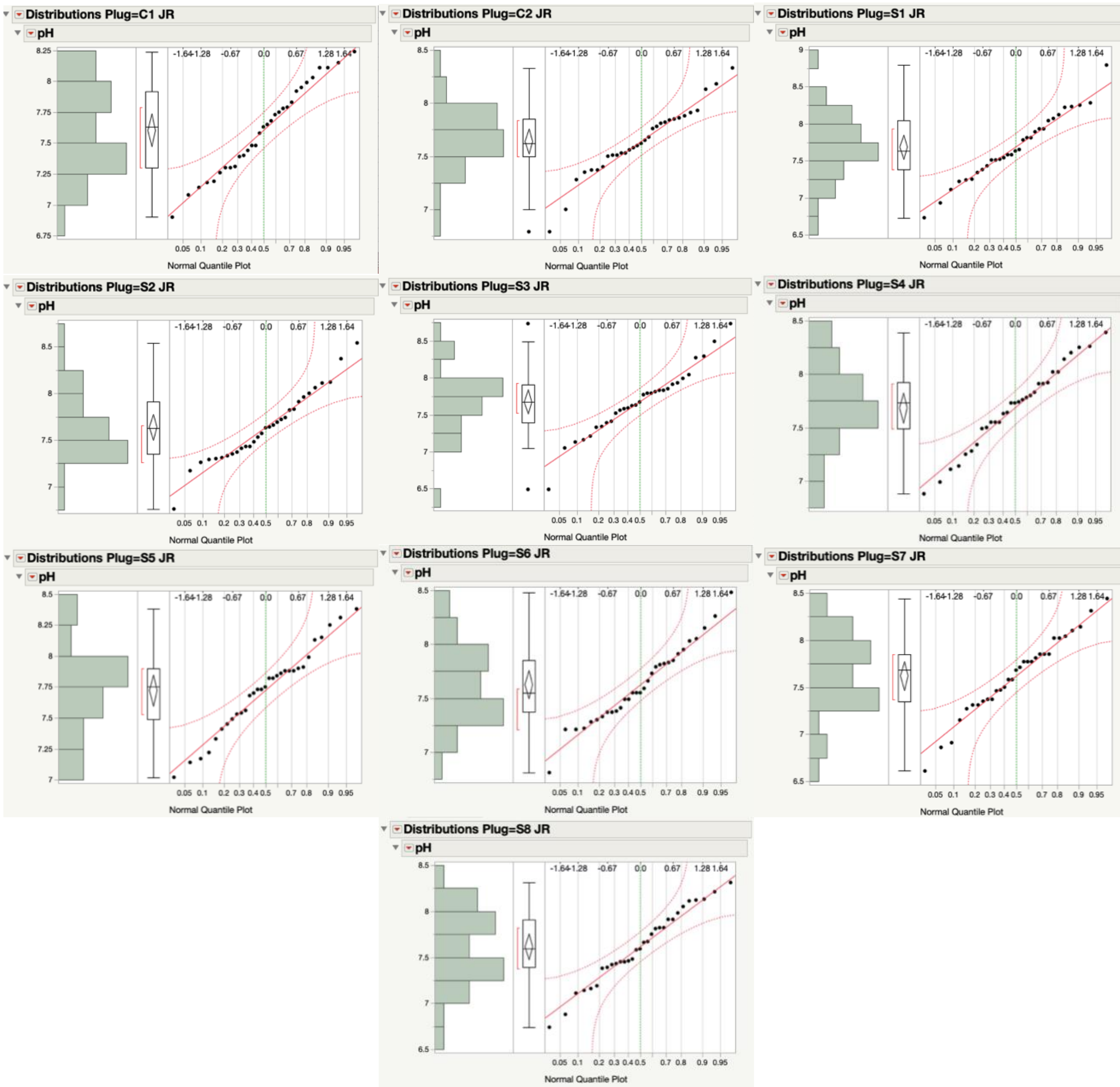


Figure 34: Distributions and NPPs for pH in *Juncus roemerianus* Between Soil Matrixes

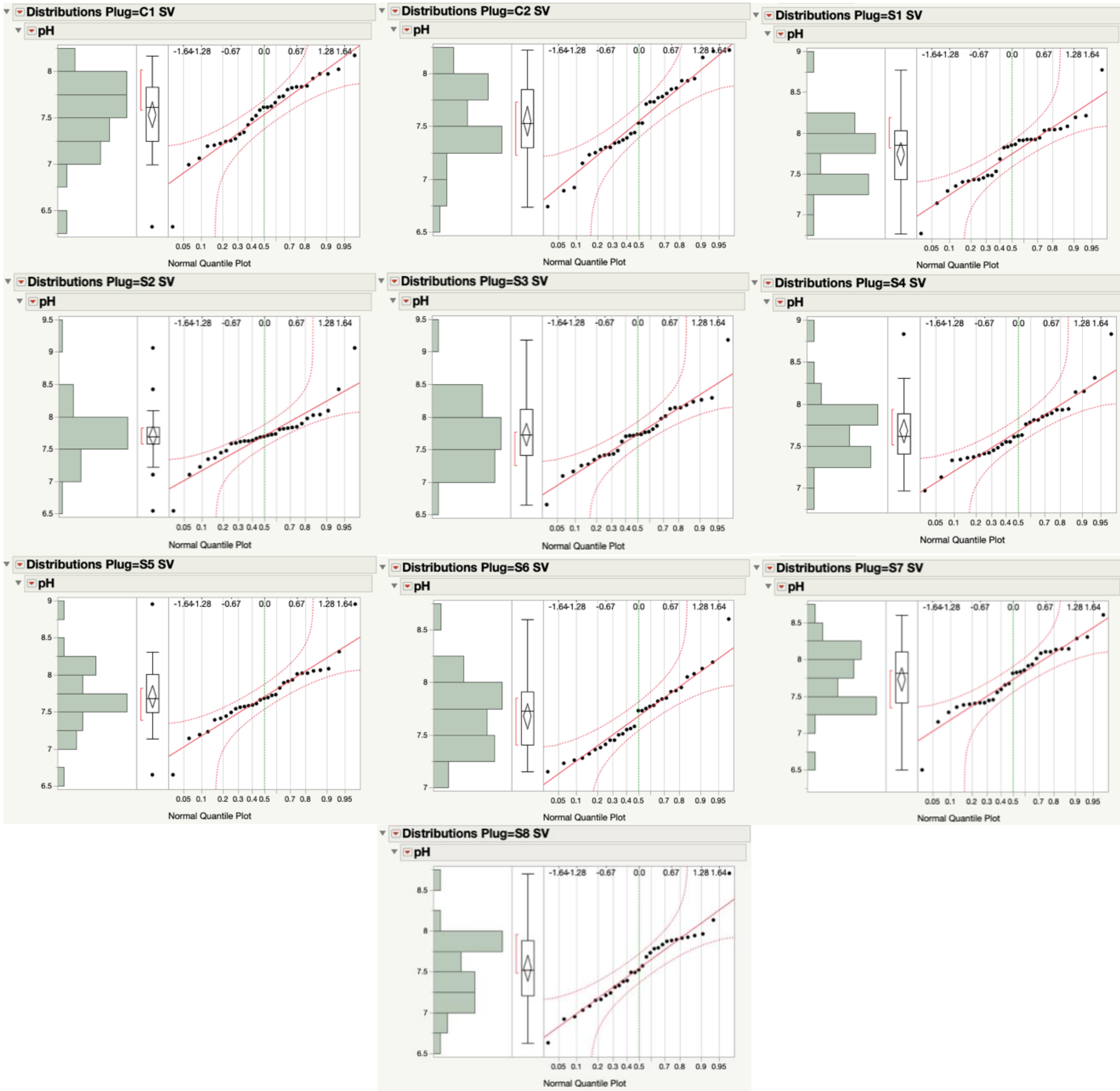


Figure 35: Distributions and NPPs for pH in *Schoenoplectus tabernaemontani* Between Soil Matrixes

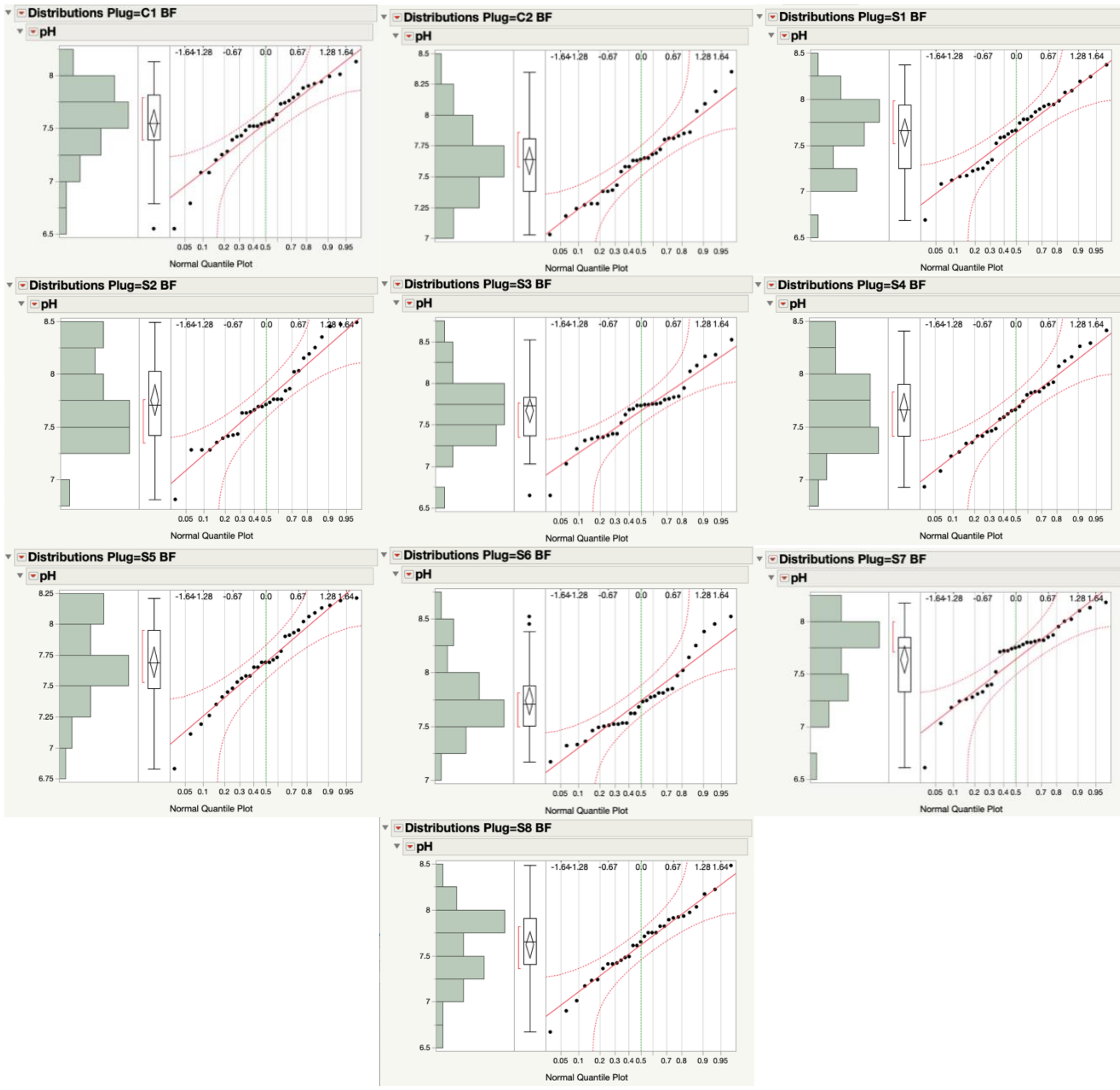


Figure 36: Distributions and NPPs for pH in *Borrichia frutescens* Between Soil Matrixes

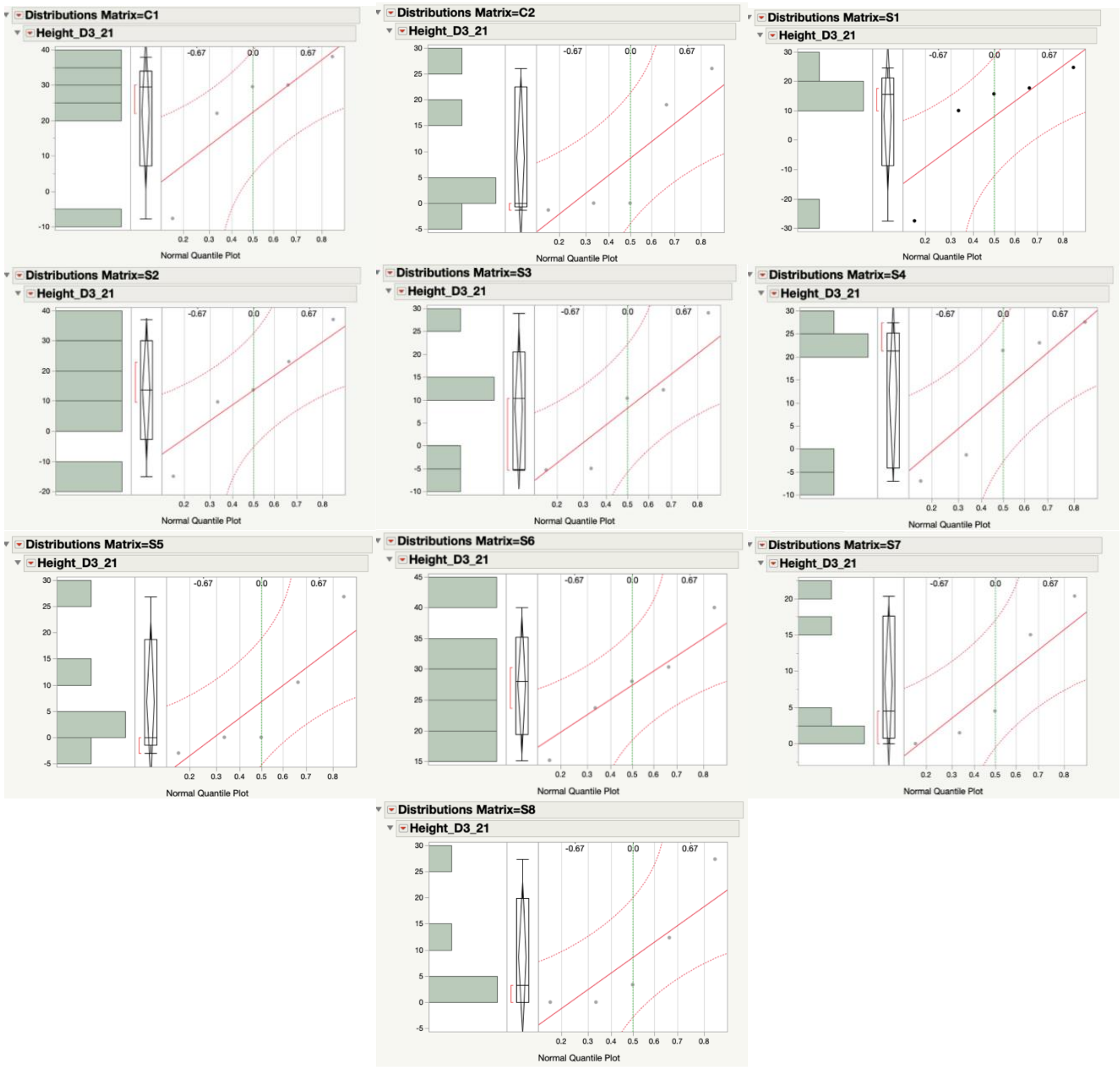


Figure 37: Distributions and NPPs for Growth in Plant Height of *Spartina alterniflora* Between Soil Matrixes

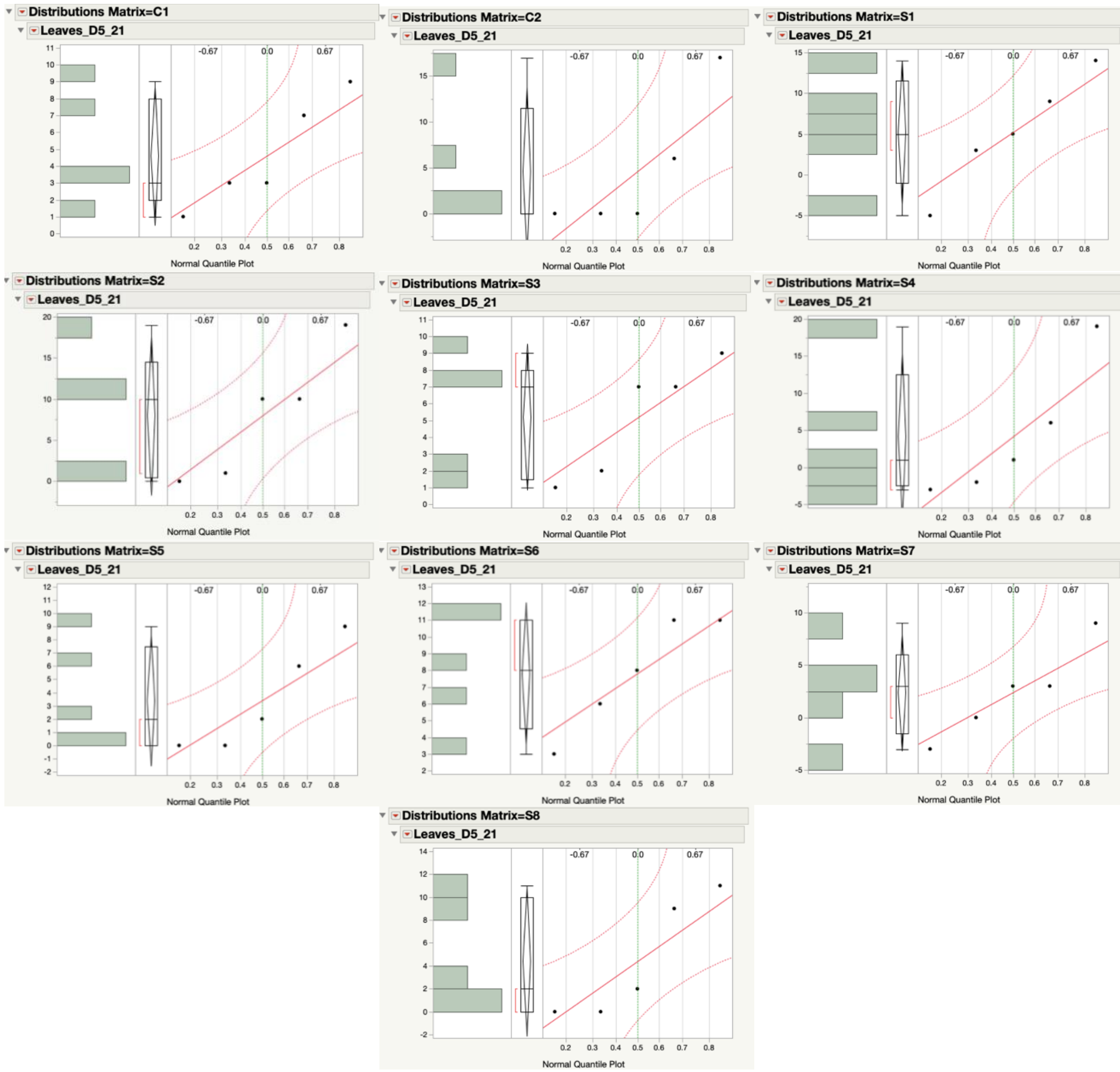


Figure 38: Distributions and NPPs for Growth in Number of Leaves of *Spartina alterniflora* Between Soil Matrixes

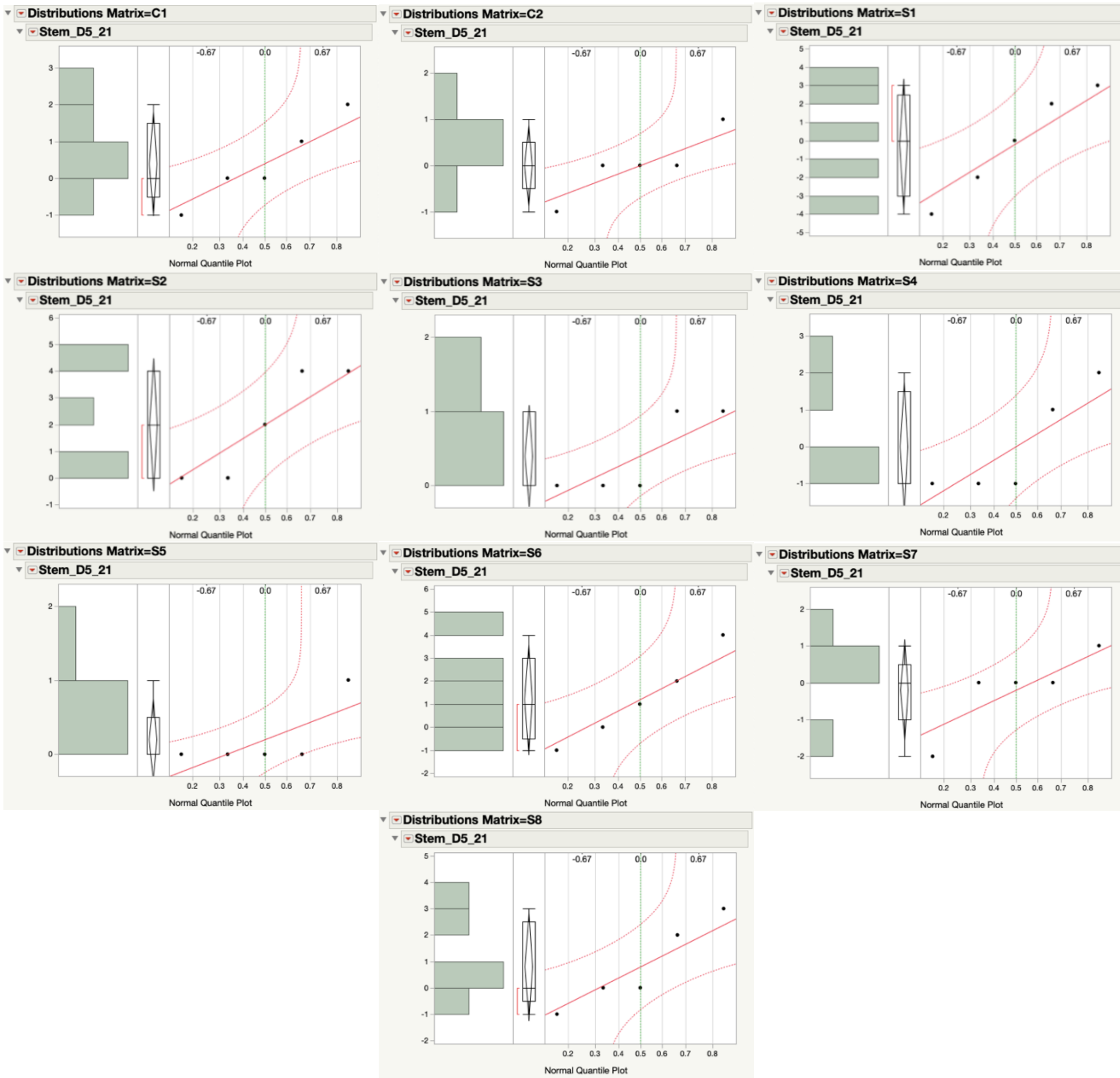


Figure 39: Distributions and NPPs for Growth in Number of Stems of *Spartina alterniflora* Between Soil Matrixes

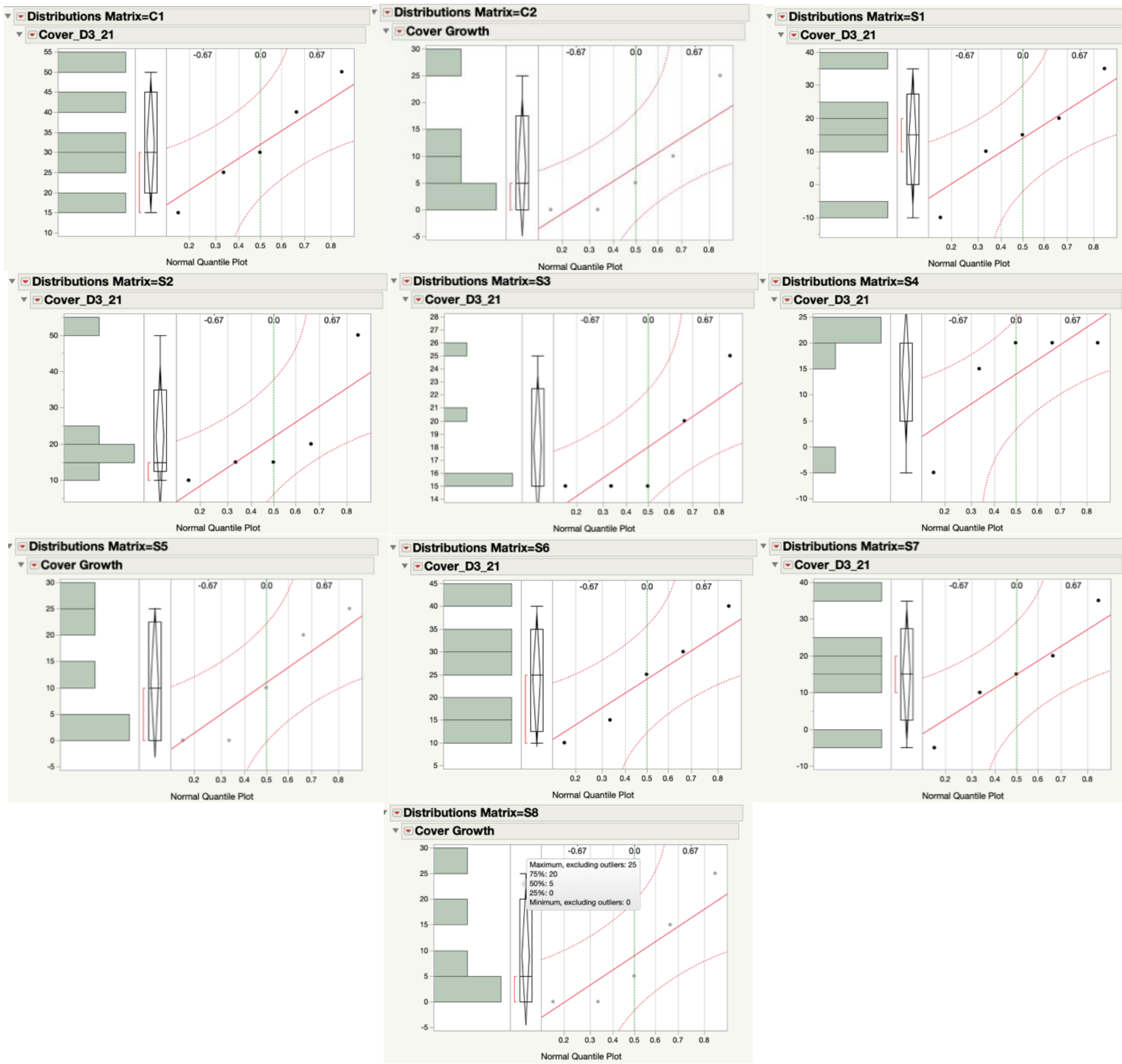


Figure 40: Distributions and NPPs for Growth in Percent Cover of *Spartina alterniflora* Between Soil Matrixes

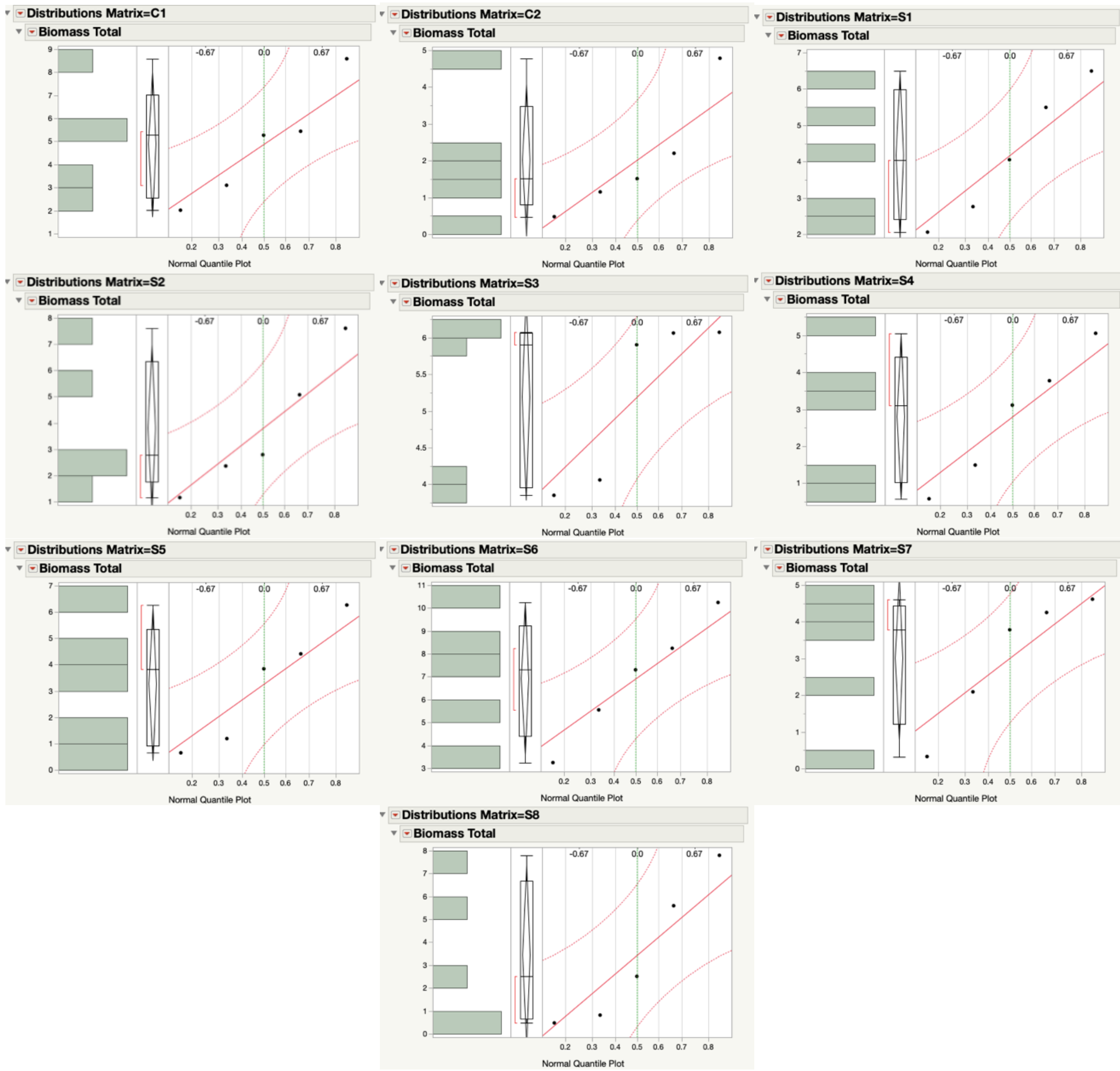


Figure 41: Distributions and NPPs for Total Biomass of *Spartina alterniflora* Between Soil Matrixes

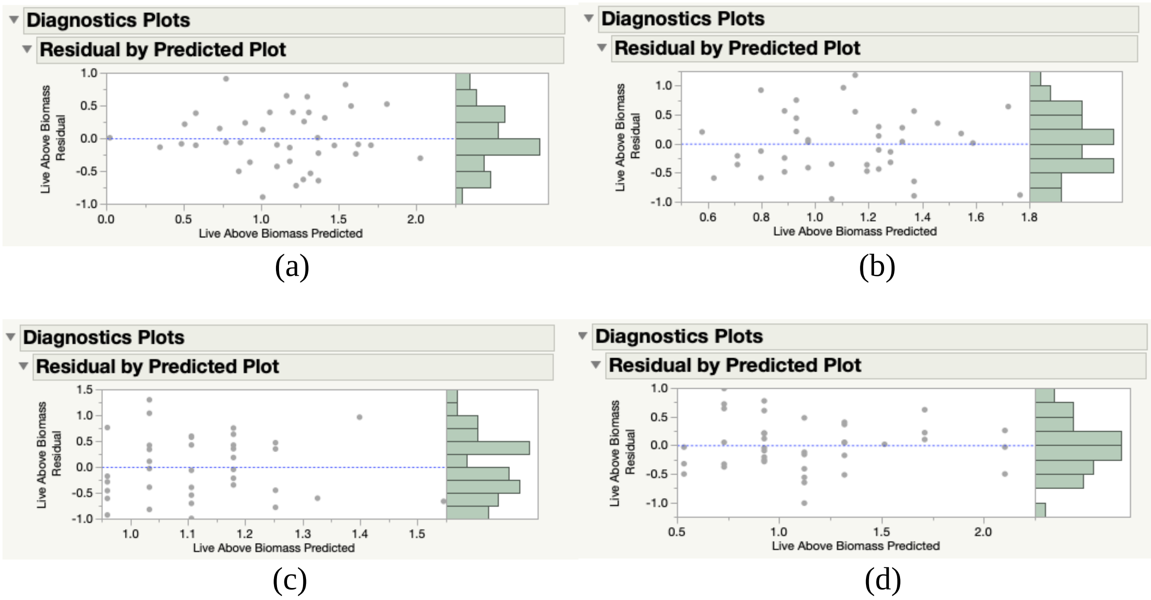


Figure 42: Residual Plot for Live Aboveground Biomass for (a) Plant Height (b) Leaves (c) Stems, and (d) Cover

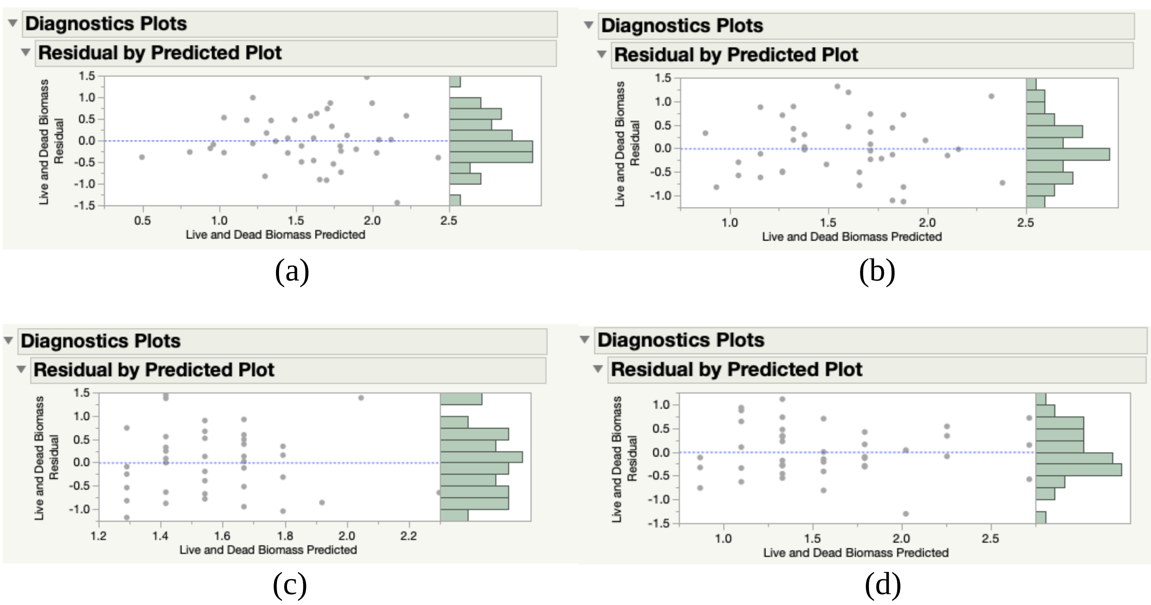


Figure 43: Residual Plot for Live and Dead Aboveground Biomass for (a) Plant Height (b) Leaves (c) Stems, and (d) Cover

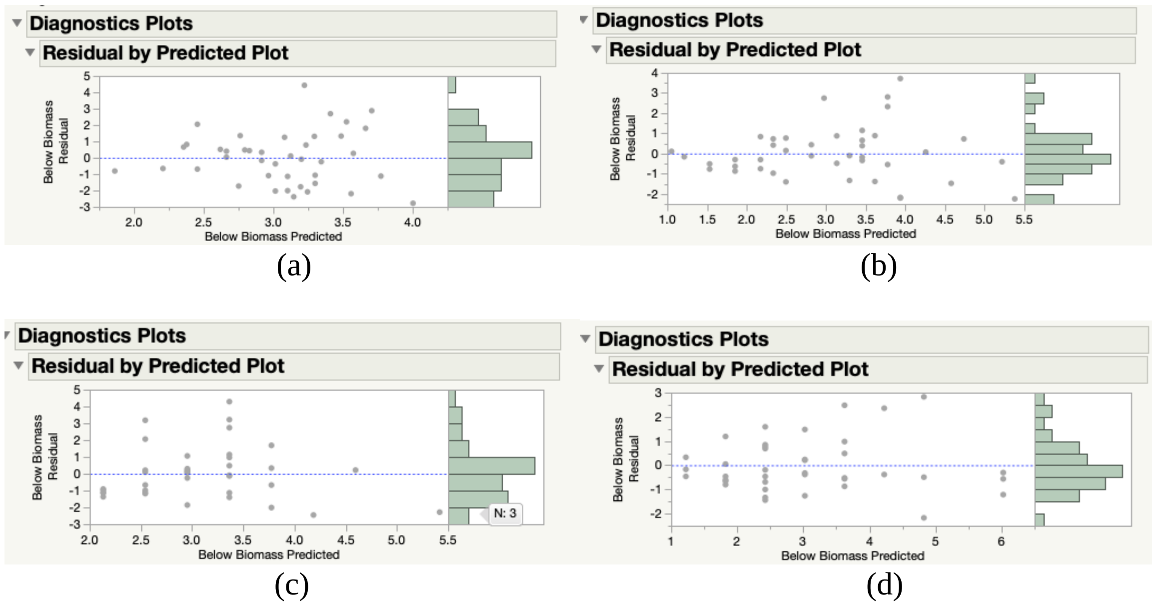


Figure 44: Residual Plot for Belowground Biomass for (a) Plant Height (b) Leaves (c) Stems, and (d) Cover

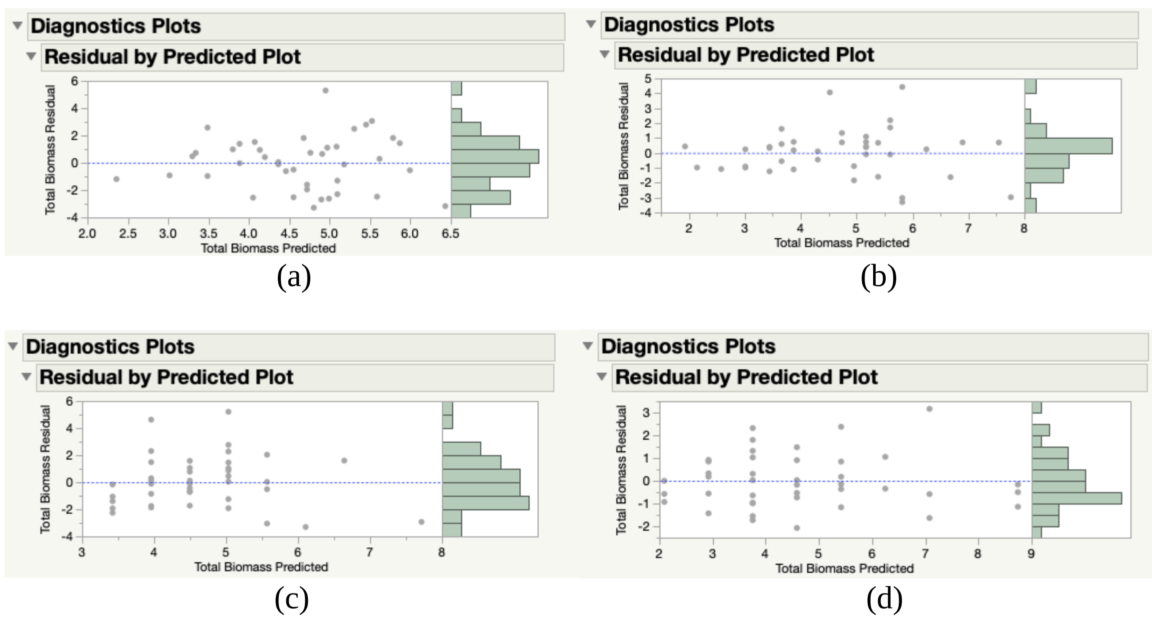


Figure 45: Residual Plot for Total Biomass for (a) Plant Height (b) Leaves (c) Stems, and (d) Cover

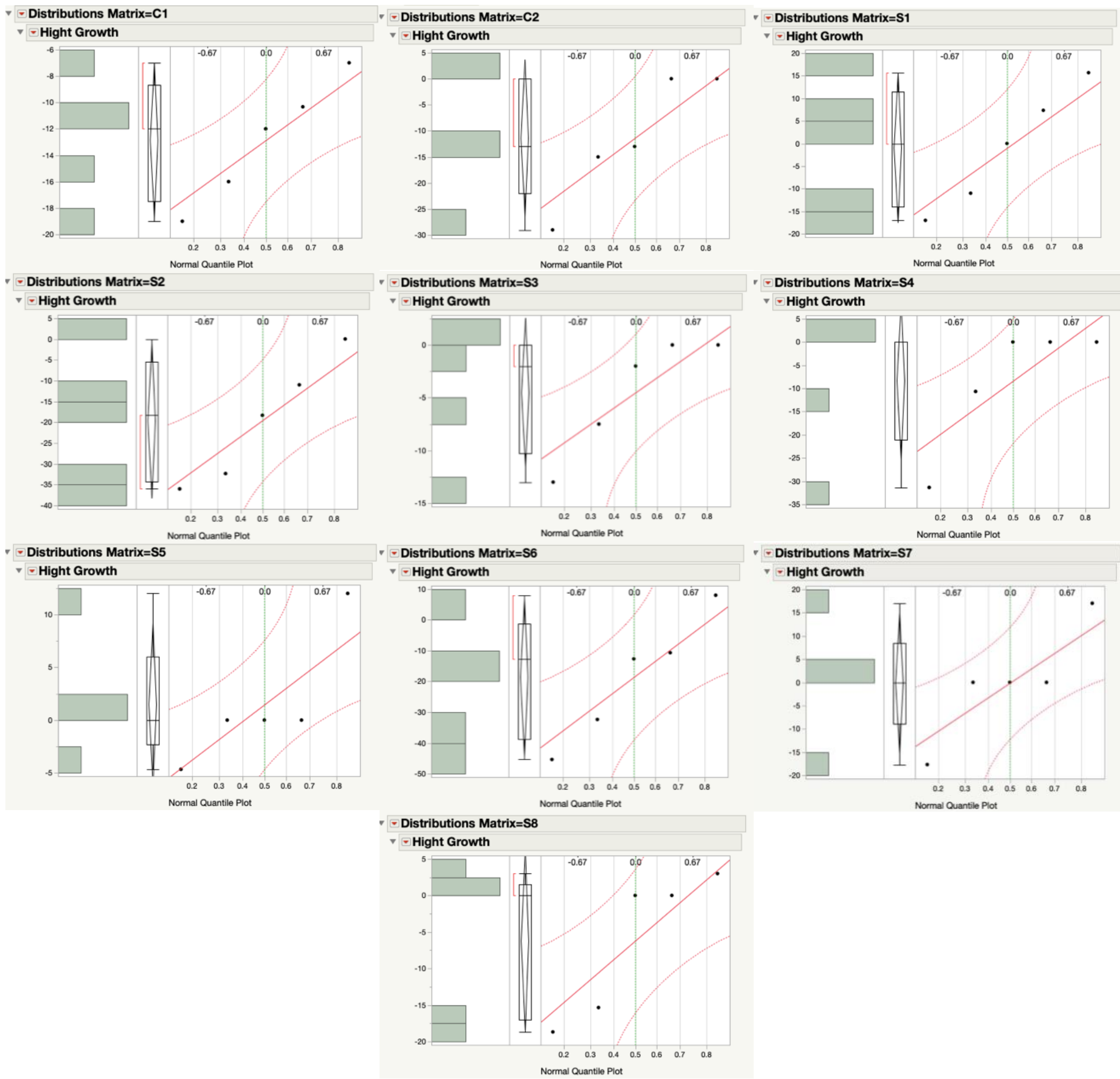


Figure 46: Distributions and NPPs for Growth in Plant Height of *Juncus roemerianus* Between Soil Matrixes

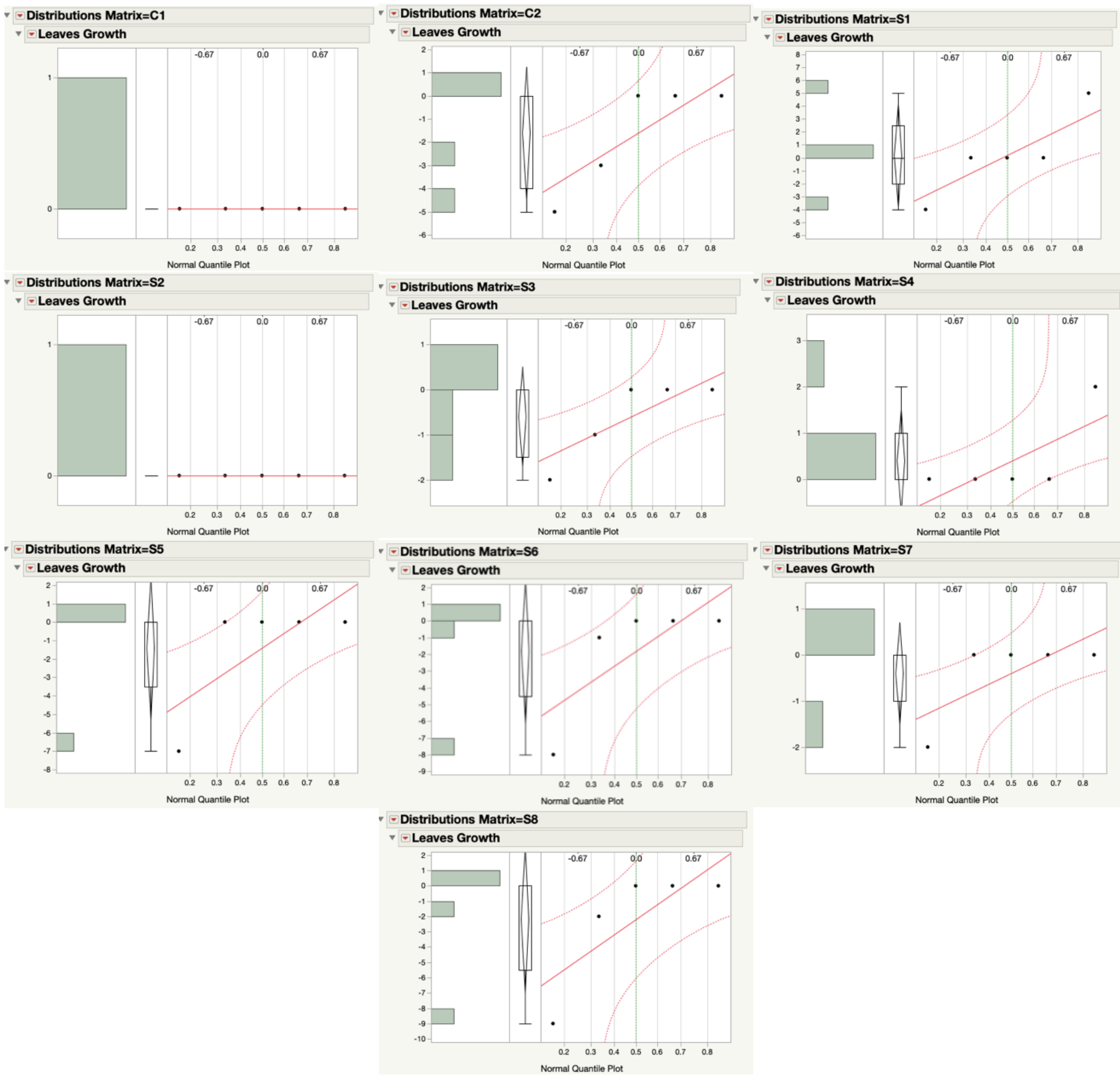


Figure 47: Distributions and NPPs for Growth in Number of Leaves of *Juncus roemerianus* Between Soil Matrixes

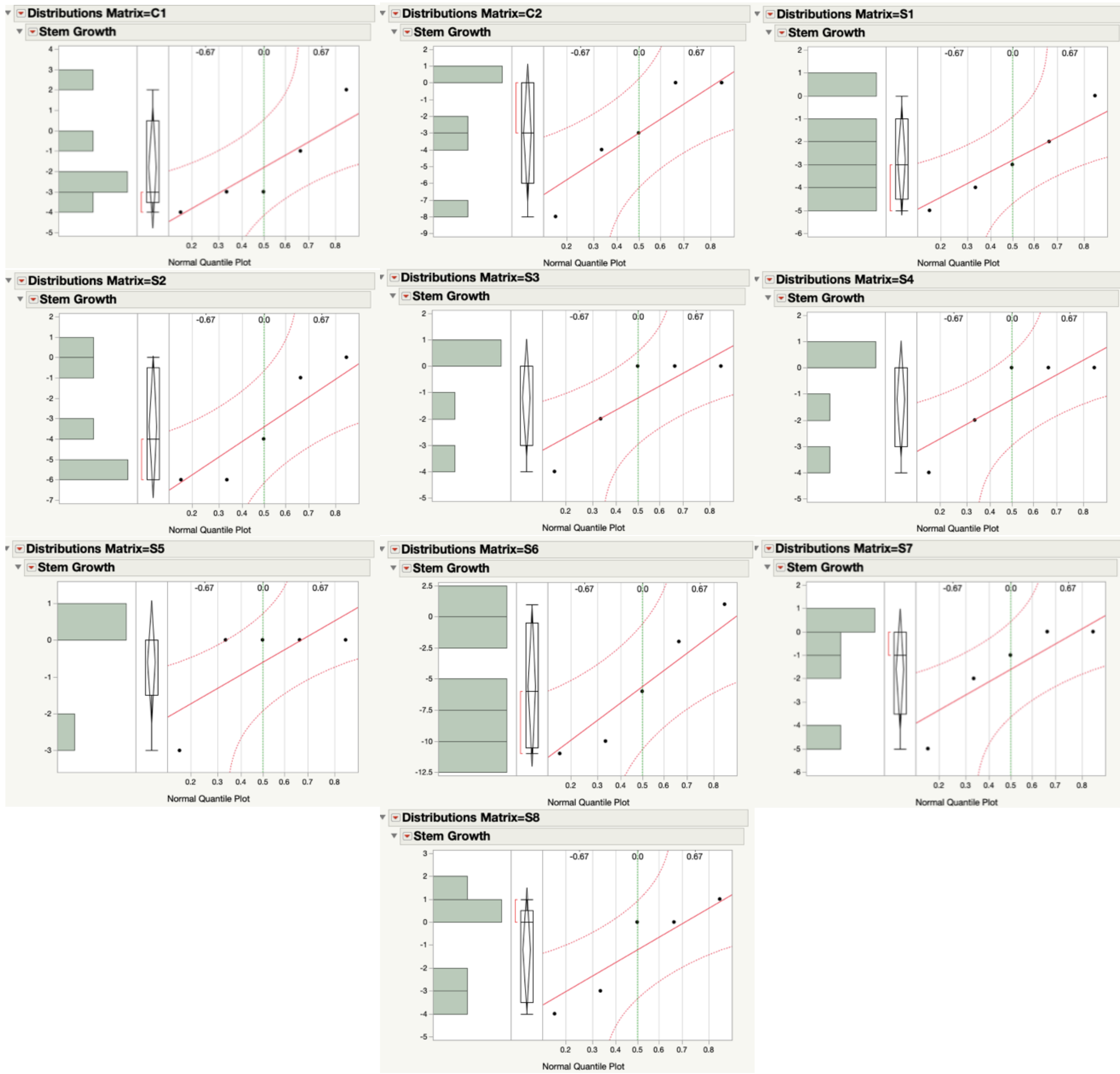


Figure 48: Distributions and NPPs for Growth in Number of Stems of *Juncus roemerianus* Between Soil Matrixes

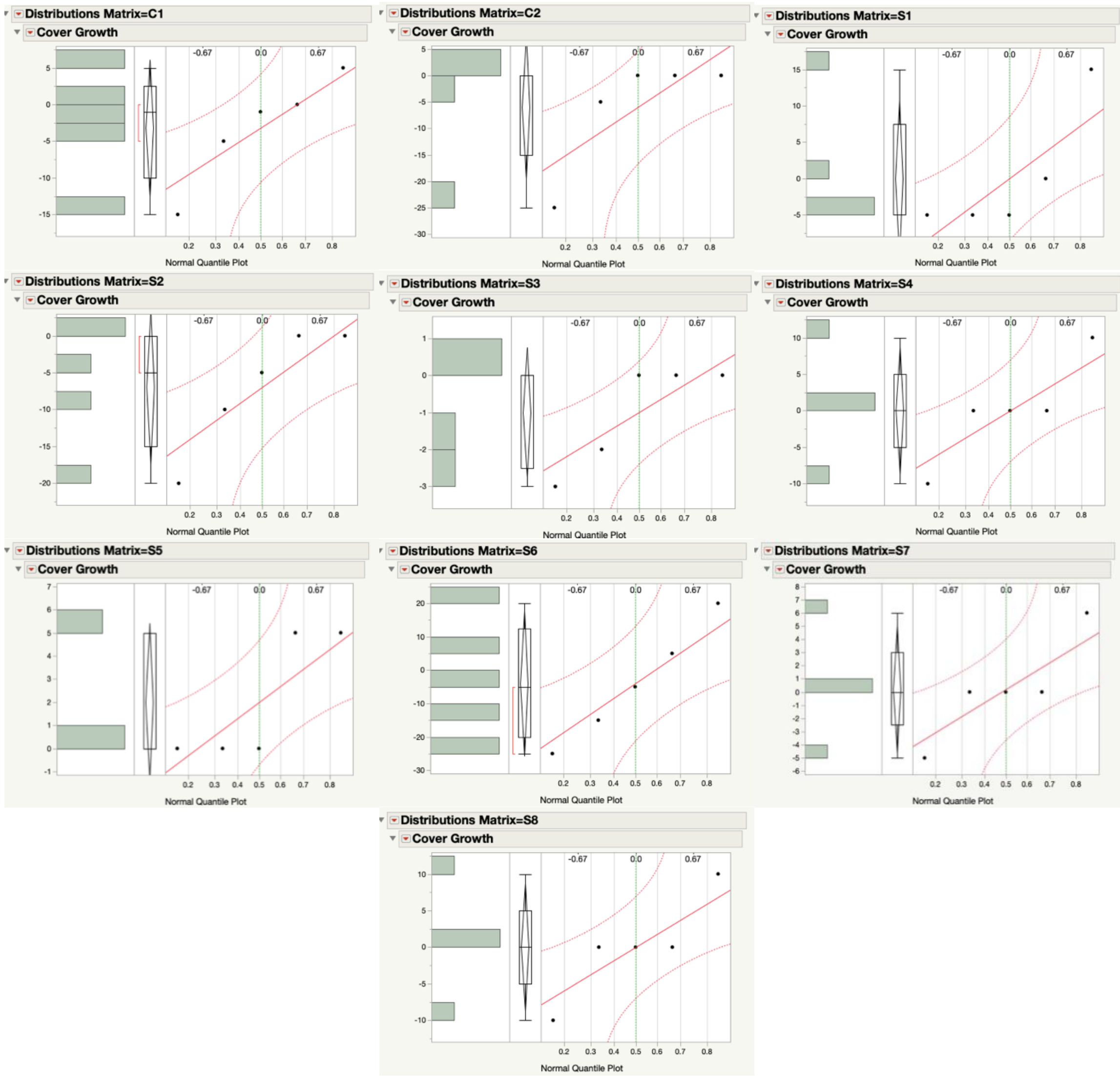


Figure 49: Distributions and NPPs for Growth in Percent Cover of *Juncus roemerianus* Between Soil Matrixes

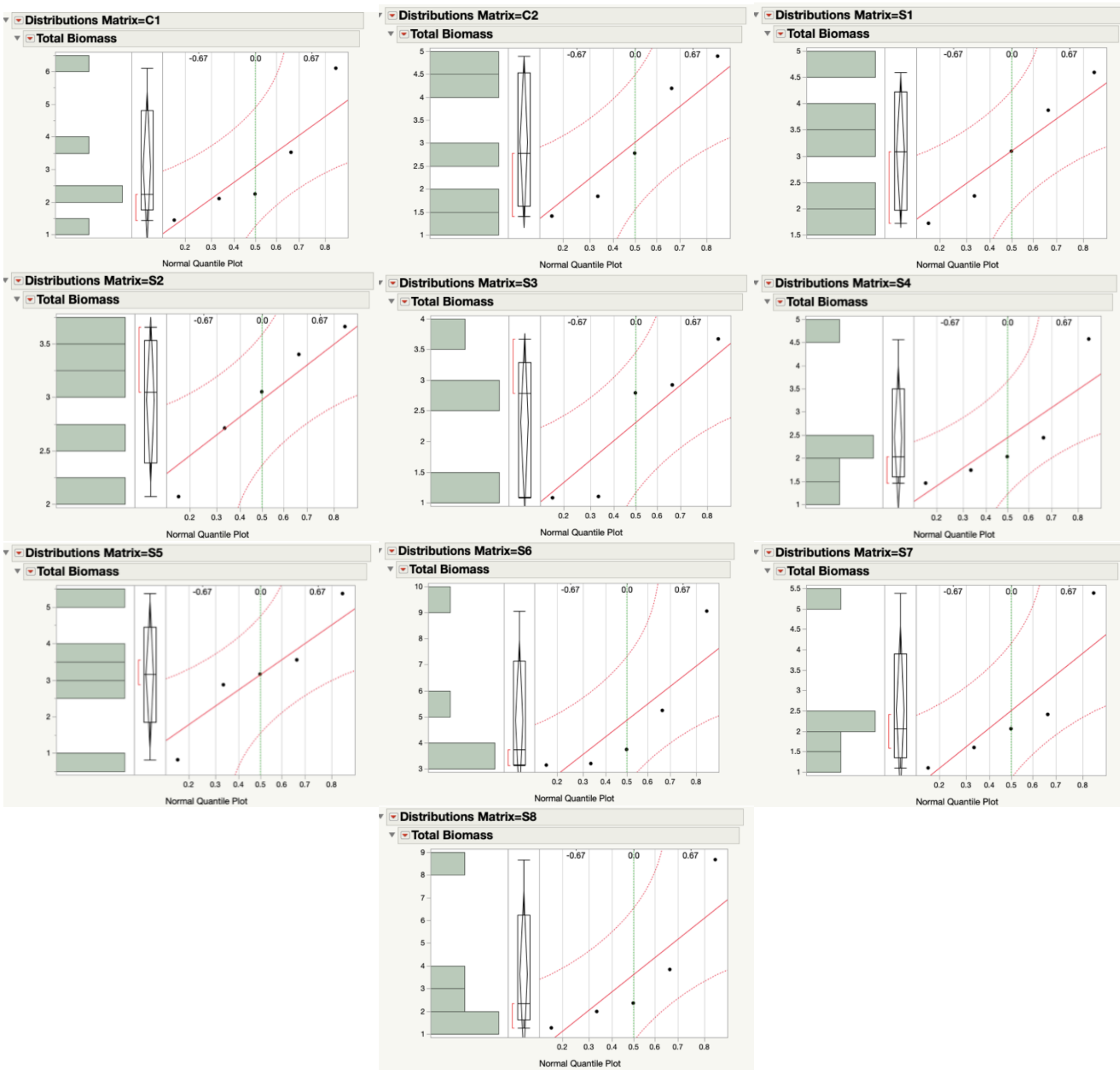


Figure 50: Distributions and NPPs for Total Biomass of *Juncus roemerianus* Between Soil Matrixes

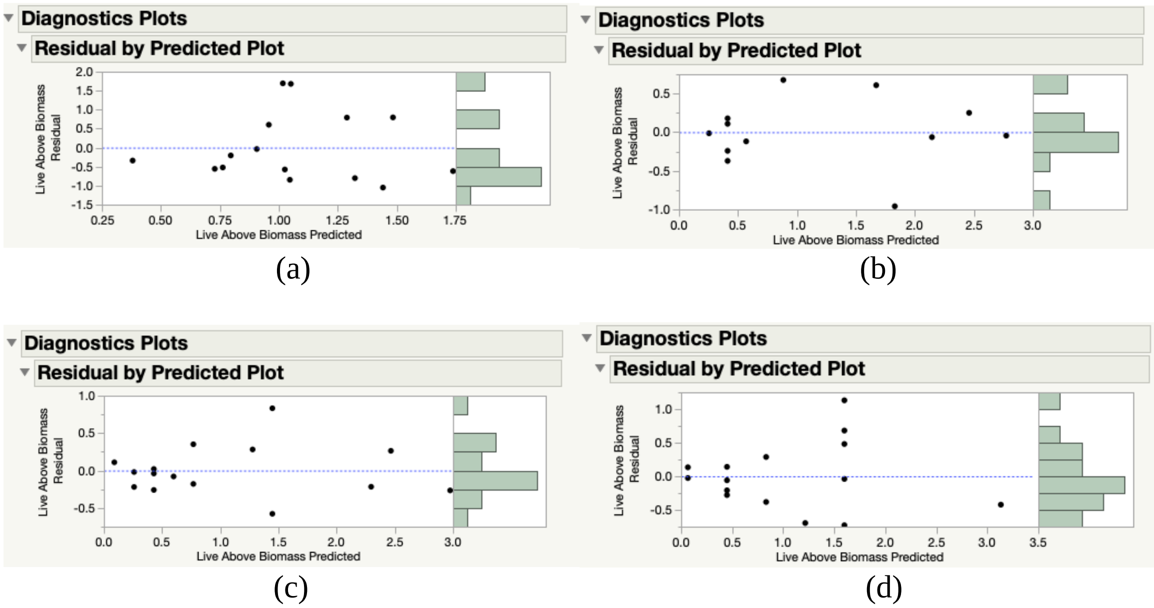


Figure 51: Residual Plot for Live Aboveground Biomass for (a) Plant Height (b) Leaves (c) Stems, and (d) Cover

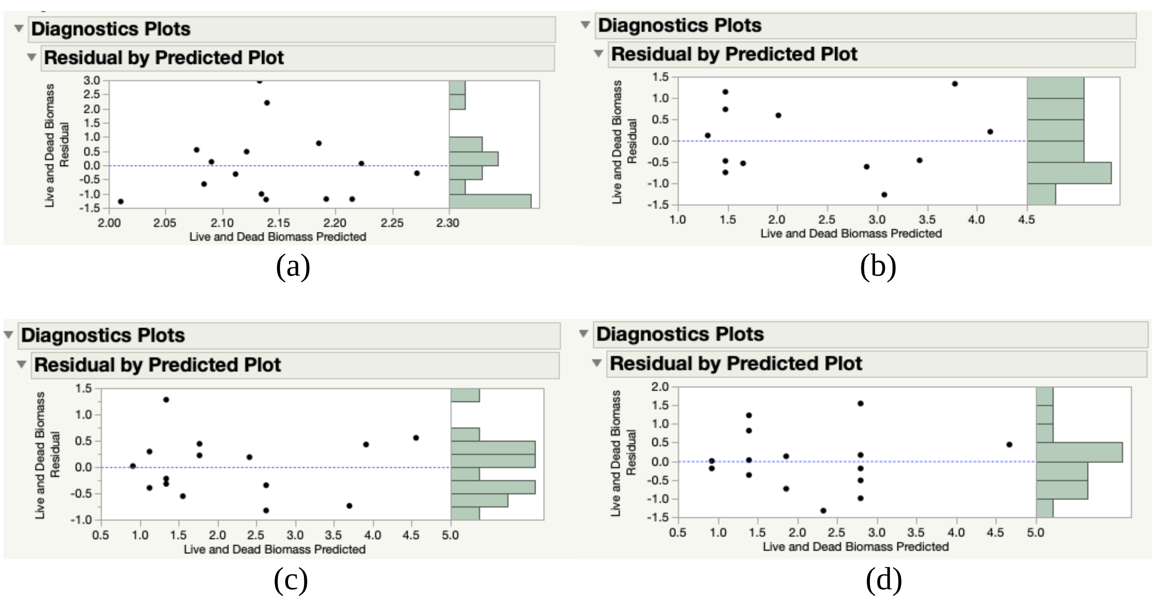


Figure 52: Residual Plot for Live and Dead Aboveground Biomass for (a) Plant Height (b) Leaves (c) Stems, and (d) Cover

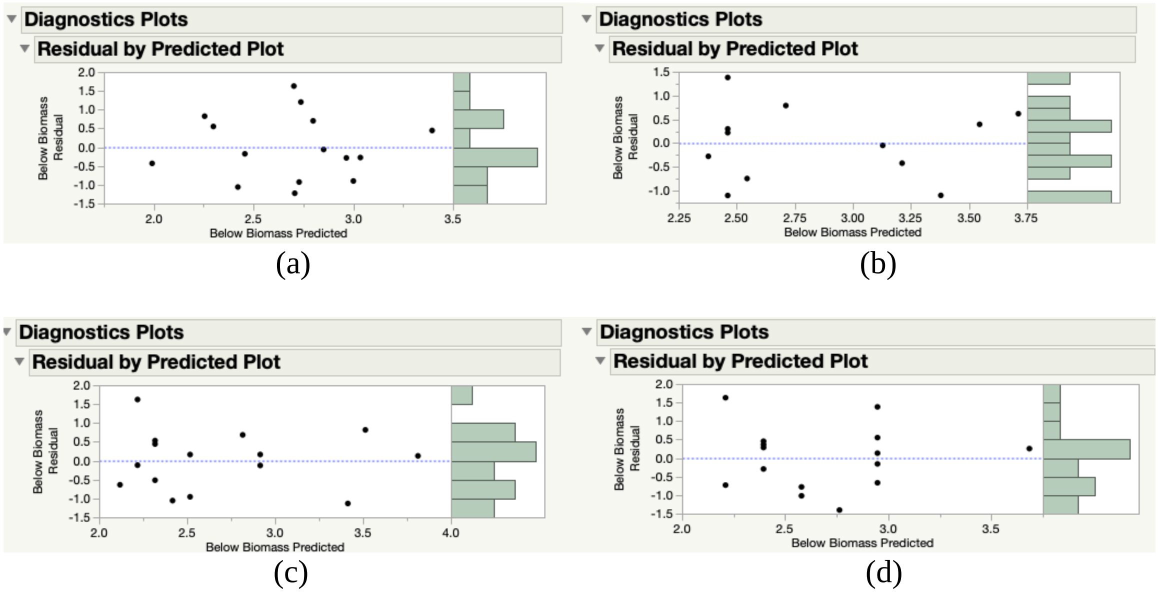


Figure 53: Residual Plot for Belowground Biomass for (a) Plant Height (b) Leaves (c) Stems, and (d) Cover

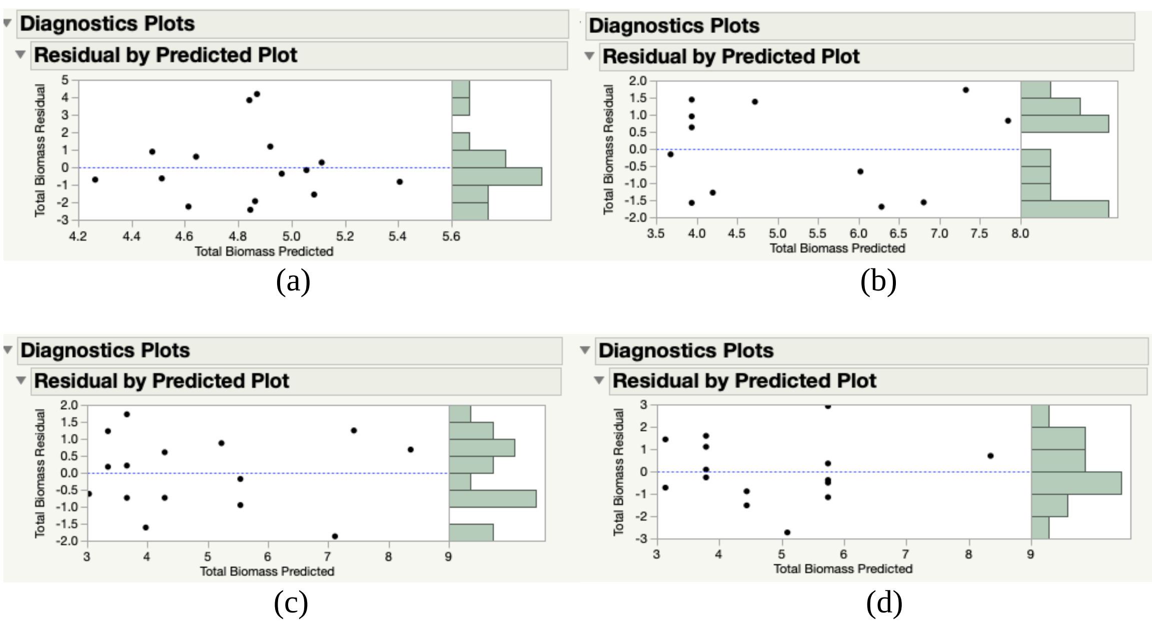


Figure 54: Residual Plot for Total Biomass for (a) Plant Height (b) Leaves (c) Stems, and (d) Cover

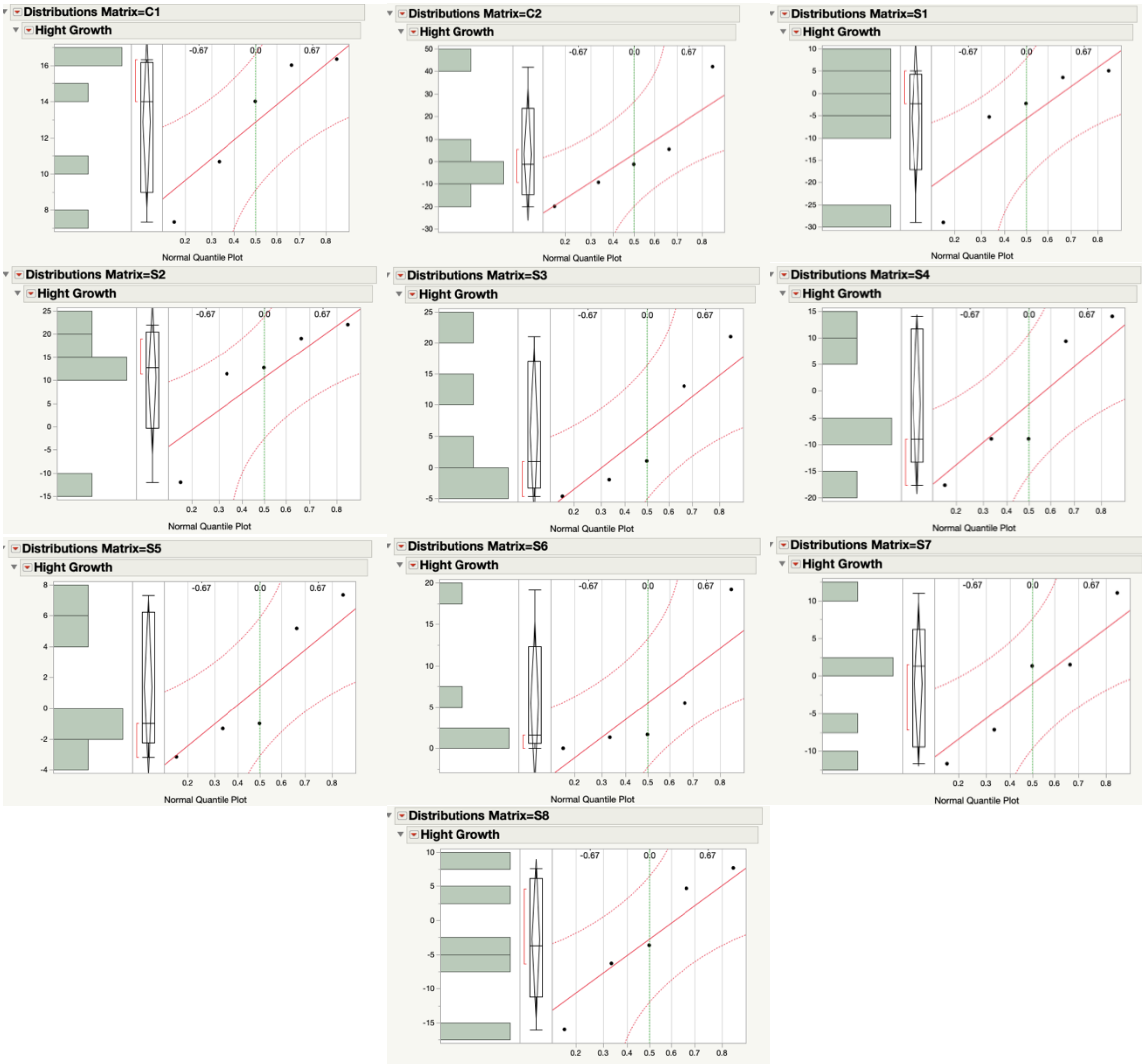


Figure 55: Distributions and NPPs for Growth in Plant Height of *Borrichia frutescens* Between Soil Matrixes

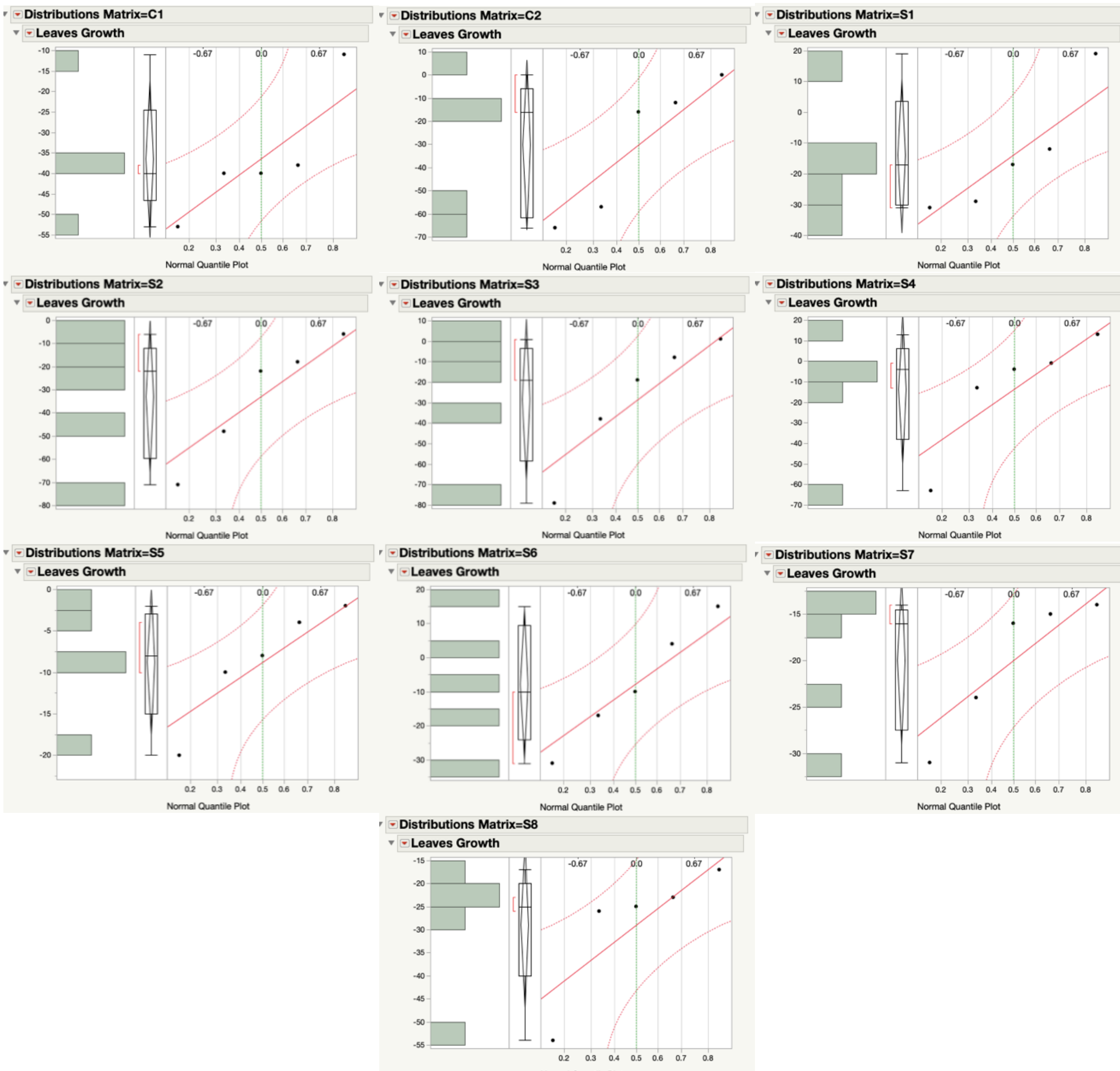


Figure 56: Distributions and NPPs for Growth in Number of Leaves of *Borrichia frutescens* Between Soil Matrixes

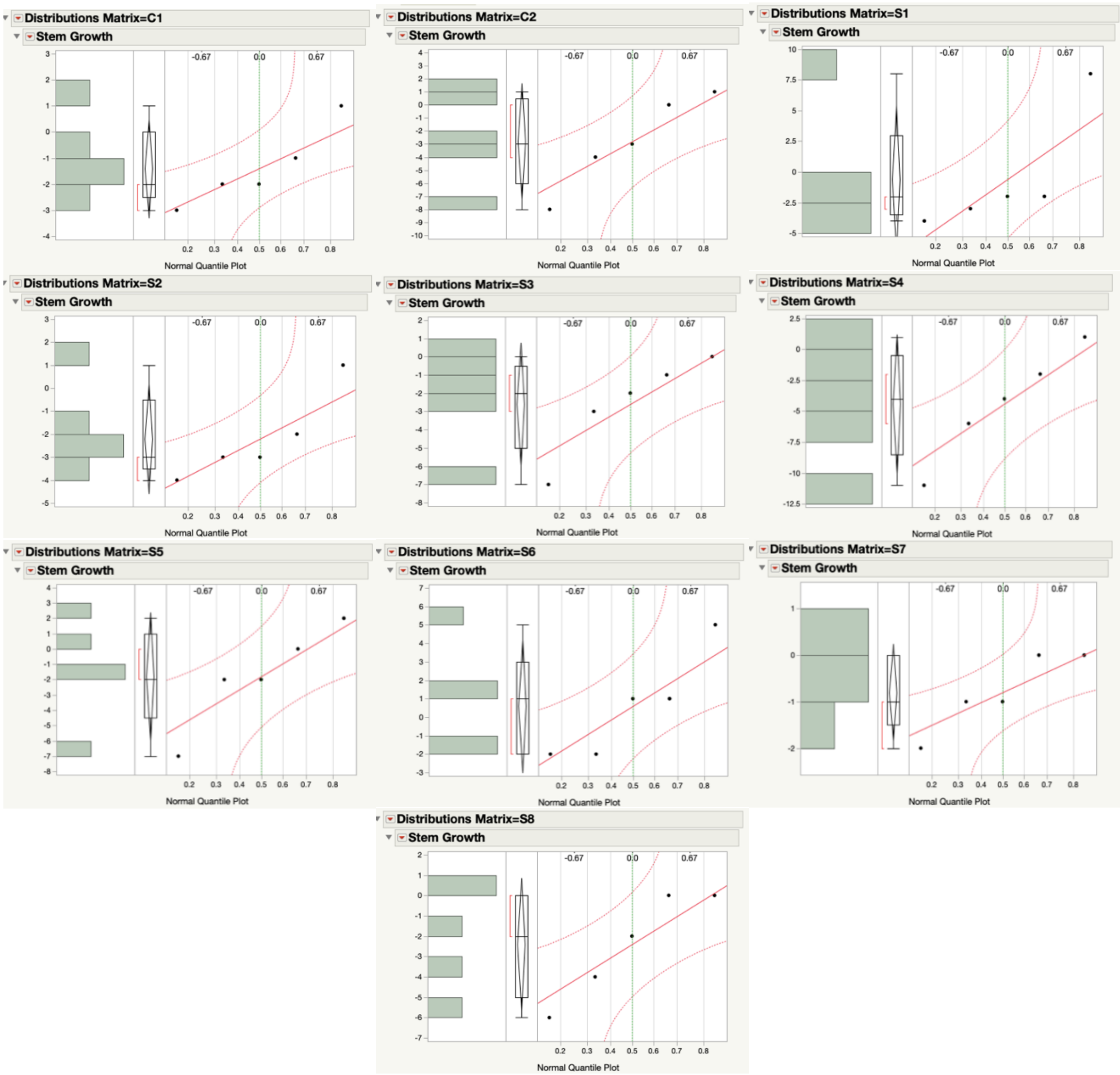


Figure 57: Distributions and NPPs for Growth in Number of Stems of *Borrichia frutescens* Between Soil Matrixes

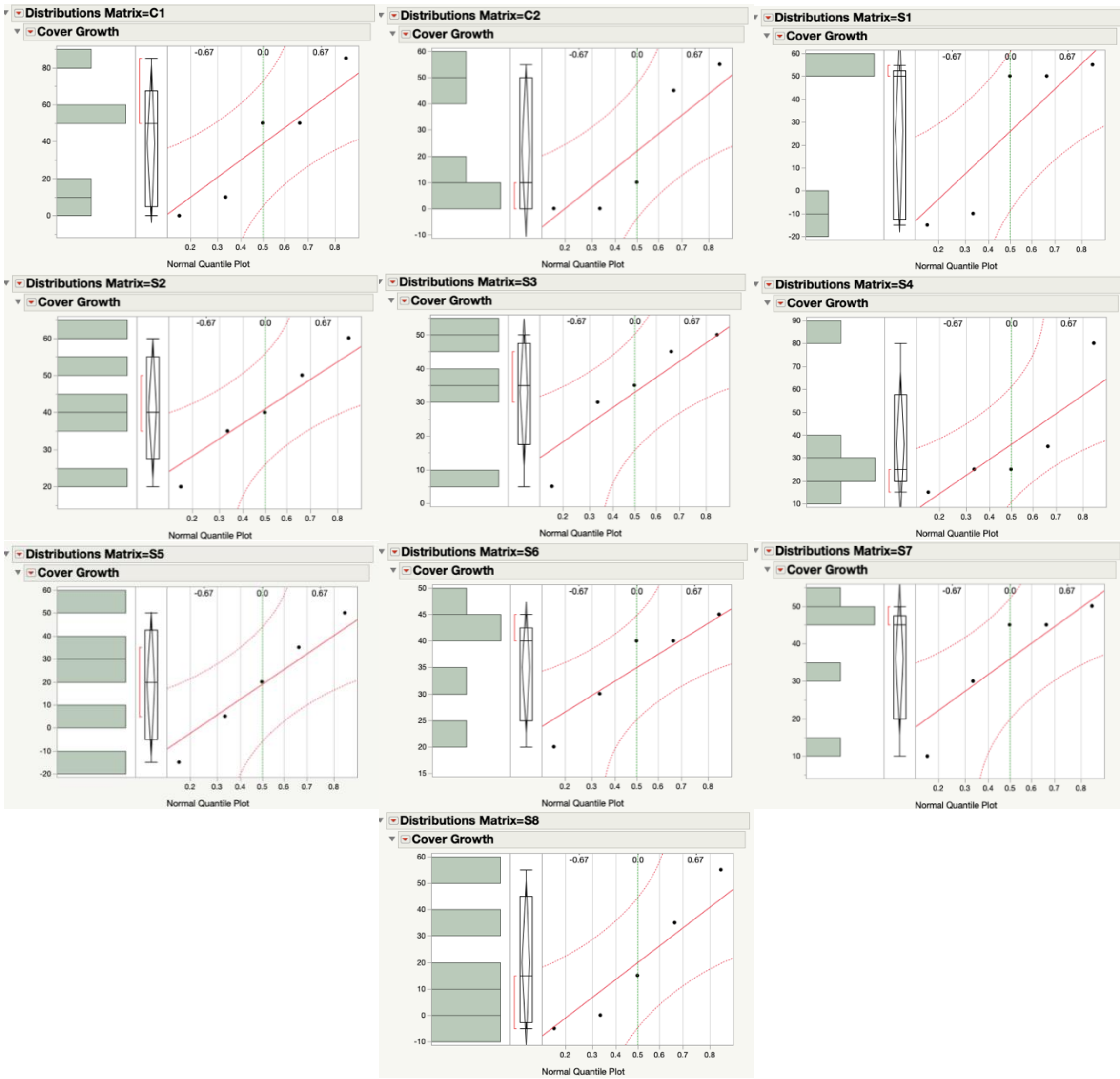


Figure 58: Distributions and NPPs for Growth in Percent Cover of *Borrichia frutescens* Between Soil Matrixes

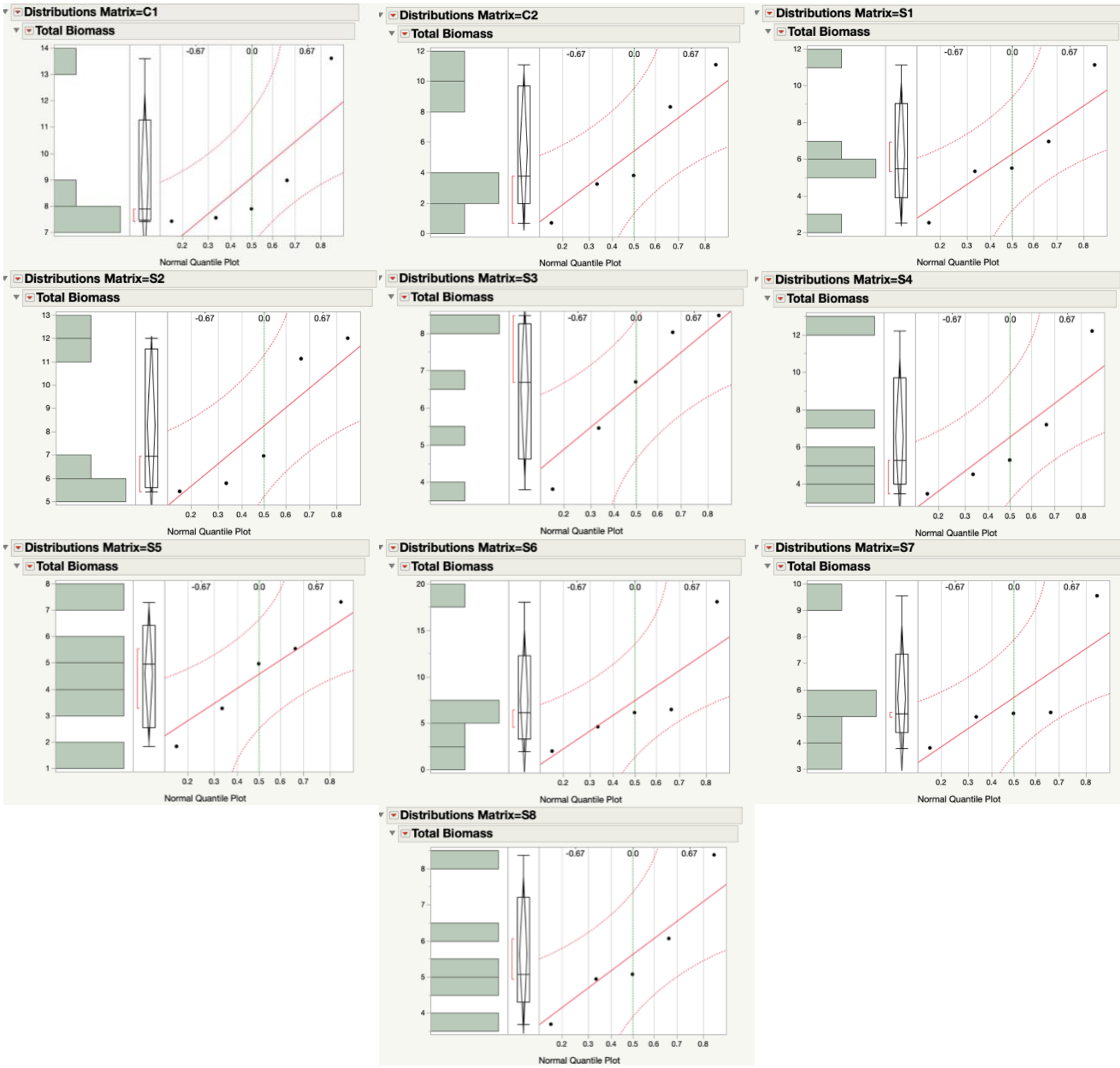


Figure 59: Distributions and NPPs for Total Biomass of *Borrichia frutescens* Between Soil Matrixes

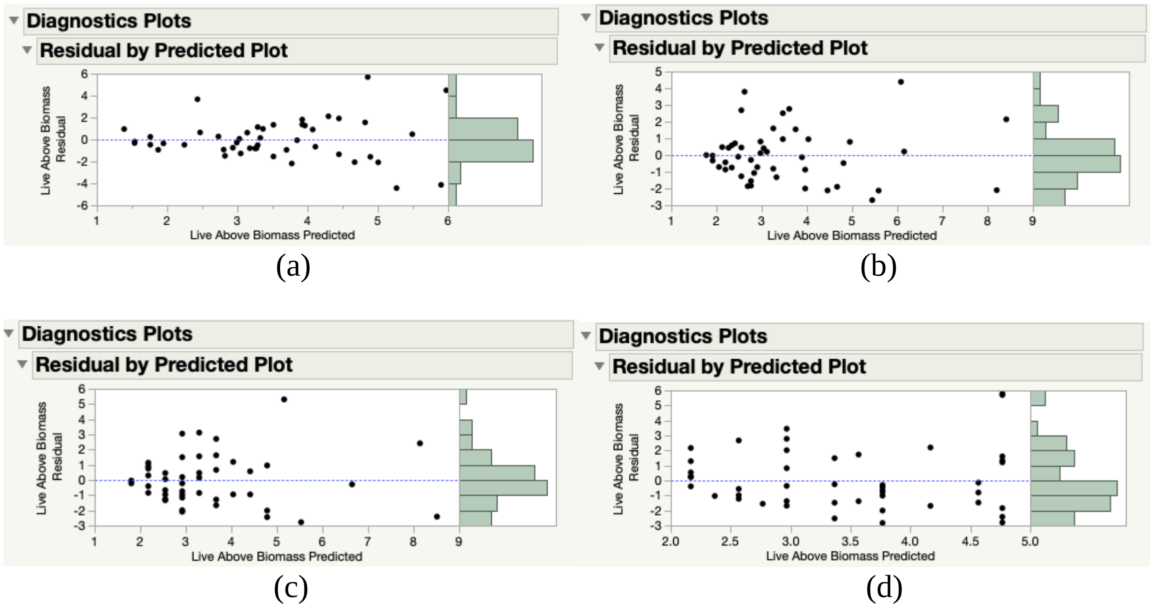


Figure 60: Residual Plot for Live Aboveground Biomass for (a) Plant Height (b) Leaves (c) Stems, and (d) Cover

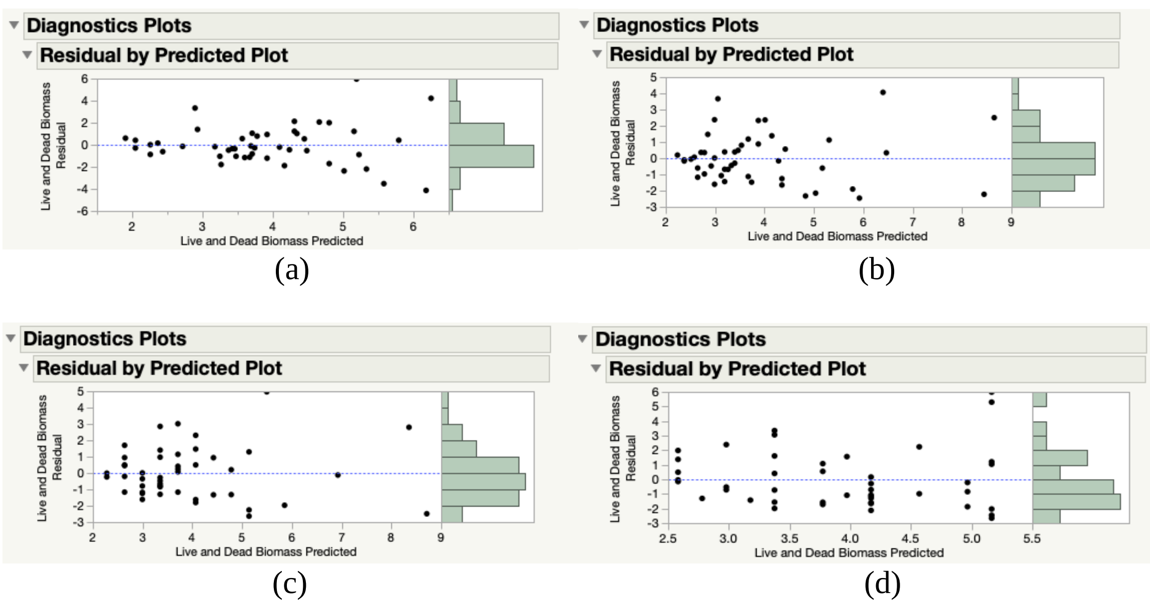
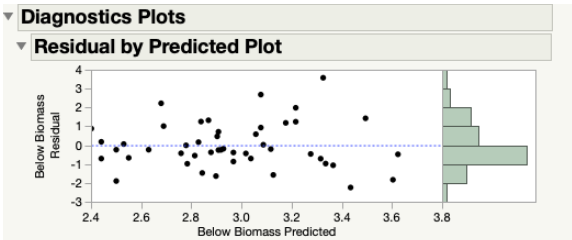
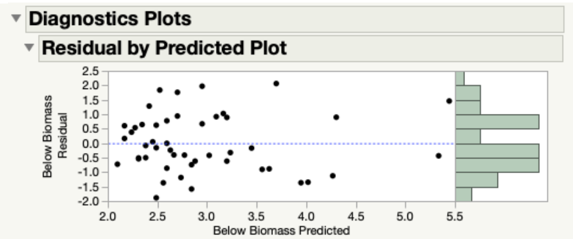


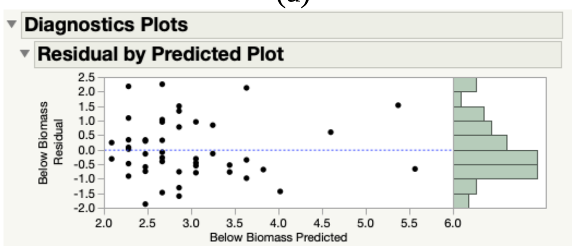
Figure 61: Residual Plot for Live and Dead Aboveground Biomass for (a) Plant Height (b) Leaves (c) Stems, and (d) Cover



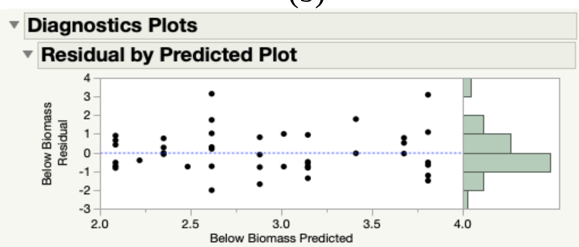
(a)



(b)

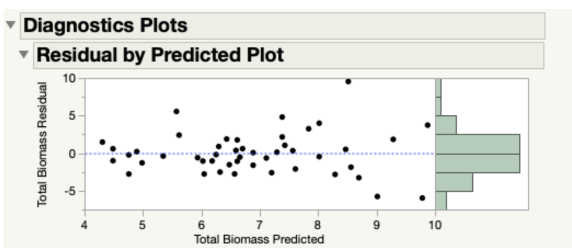


(c)

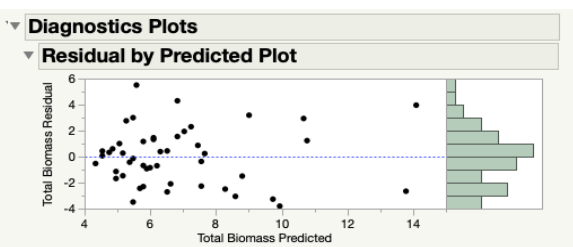


(d)

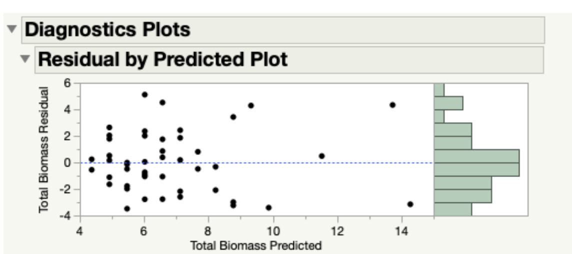
Figure 62: Residual Plot for Belowground Biomass for (a) Plant Height (b) Leaves (c) Stems, and (d) Cover



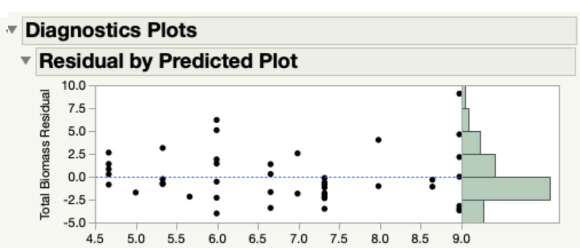
(a)



(b)



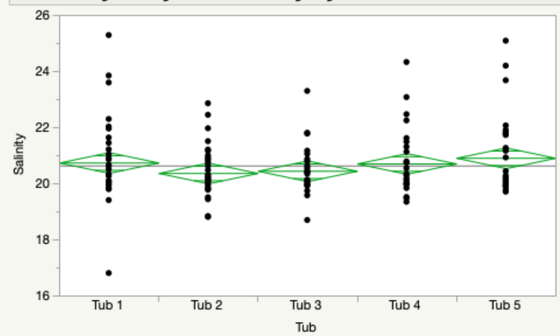
(c)



(d)

Figure 63: Residual Plot for Total Biomass for (a) Plant Height (b) Leaves (c) Stems, and (d) Cover

Oneway Analysis of Salinity By Tub



Oneway Anova

Summary of Fit

Analysis of Variance

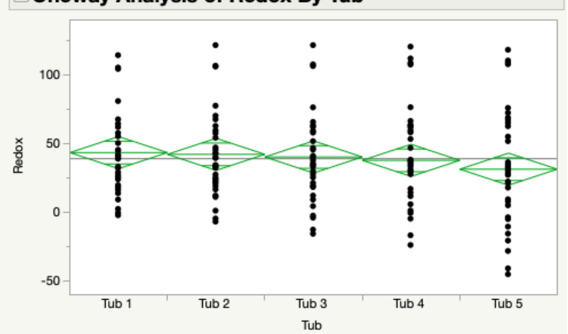
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Tub	4	7.13704	1.78426	1.4191	0.2295
Error	175	220.02661	1.25729		
C. Total	179	227.16364			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Tub 1	36	20.741111	1.4501858	0.2416976	20.250439	21.231783
Tub 2	36	20.368611	0.8557141	0.142619	20.079079	20.658143
Tub 3	36	20.446389	0.7873651	0.1312275	20.179983	20.712795
Tub 4	36	20.706667	1.0614411	0.1769068	20.347527	21.065807
Tub 5	36	20.909444	1.3055988	0.2175998	20.467693	21.351196

Figure 64: One-Way ANOVA for Salinity By Tub

Oneway Analysis of Redox By Tub



Oneway Anova

Summary of Fit

Analysis of Variance

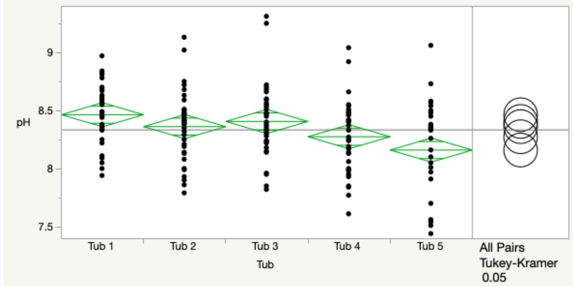
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Tub	4	3278.98	819.75	0.6482	0.6289
Error	175	221323.50	1264.71		
C. Total	179	224602.48			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Tub 1	36	43.477778	30.099133	5.0165221	33.293697	53.661859
Tub 2	36	42.202778	32.179643	5.3632738	31.314753	53.090802
Tub 3	36	40.294444	33.578164	5.5963607	28.933228	51.655661
Tub 4	36	37.838889	36.723696	6.1206161	25.413378	50.2644
Tub 5	36	31.4	43.656824	7.2761373	16.628656	46.171344

Figure 65: One-Way ANOVA for Redox By Tub

Oneway Analysis of pH By Tub



Oneway Anova

Summary of Fit

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Tub	4	2.041072	0.510268	5.1243	0.0006*
Error	175	17.426281	0.099579		
C. Total	179	19.467353			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Tub 1	36	8.4672222	0.2598418	0.043307	8.3793044	8.55514
Tub 2	36	8.3647222	0.3000522	0.0500087	8.2631991	8.4662453
Tub 3	36	8.4091667	0.3229275	0.0538212	8.2999037	8.5184296
Tub 4	36	8.2777778	0.3105121	0.051752	8.1727156	8.38284
Tub 5	36	8.1630556	0.3736906	0.0622818	8.0366168	8.2894943

Connecting Letters Report

Level			Mean
Tub 1	A		8.4672222
Tub 3	A		8.4091667
Tub 2	A	B	8.3647222
Tub 4	A	B	8.2777778
Tub 5		B	8.1630556

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
Tub 1	Tub 5	0.3041667	0.0743784	0.099148	0.5091857	0.0006*
Tub 3	Tub 5	0.2461111	0.0743784	0.041092	0.4511302	0.0099*
Tub 2	Tub 5	0.2016667	0.0743784	-0.003352	0.4066857	0.0563
Tub 1	Tub 4	0.1894444	0.0743784	-0.015575	0.3944635	0.0851
Tub 3	Tub 4	0.1313889	0.0743784	-0.073630	0.3364080	0.3965
Tub 4	Tub 5	0.1147222	0.0743784	-0.090297	0.3197413	0.5364
Tub 1	Tub 2	0.1025000	0.0743784	-0.102519	0.3075191	0.6425
Tub 2	Tub 4	0.0869444	0.0743784	-0.118075	0.2919635	0.7690
Tub 1	Tub 3	0.0580556	0.0743784	-0.146964	0.2630746	0.9360
Tub 3	Tub 2	0.0444444	0.0743784	-0.160575	0.2494635	0.9753

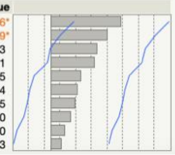
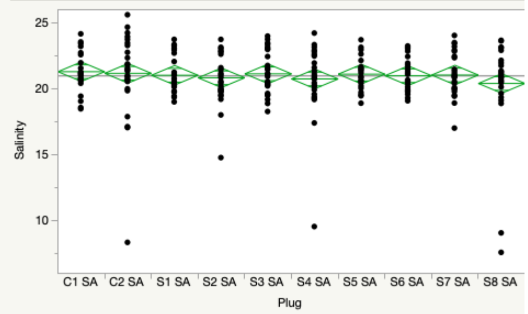


Figure 66: One-Way ANOVA and Tukey-Kramer HSD Test for pH By Tub

Oneway Analysis of Salinity By Plug



Oneway Anova

Summary of Fit

Analysis of Variance

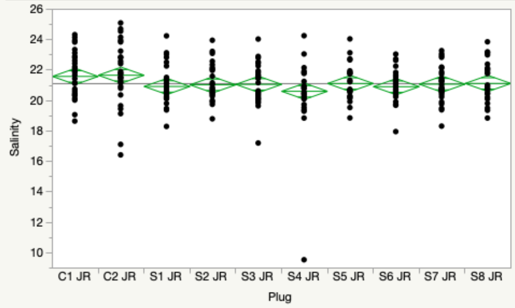
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Plug	9	18.3654	2.04060	0.4664	0.8966
Error	300	1312.5169	4.37506		
C. Total	309	1330.8823			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1 SA	31	21.300645	1.58957	0.2854952	20.717586	21.883704
C2 SA	31	21.177419	3.1086792	0.5583353	20.037147	22.317692
S1 SA	31	21.02871	1.3390587	0.240502	20.537539	21.51988
S2 SA	31	20.839032	1.8062306	0.3244086	20.176502	21.501563
S3 SA	31	21.139677	1.5225231	0.2734532	20.581211	21.698143
S4 SA	31	20.749032	2.5584883	0.4595181	19.810571	21.687493
S5 SA	31	21.113226	1.2966659	0.2328881	20.637605	21.588847
S6 SA	31	20.996774	1.2253935	0.2200872	20.547296	21.446252
S7 SA	31	21.046452	1.5125664	0.2716649	20.491638	21.601265
S8 SA	31	20.408065	3.4885053	0.6265541	19.12847	21.687659

Figure 67: One-Way ANOVA for Salinity in *Spartina alterniflora* By Soil Matrixes

Oneway Analysis of Salinity By Plug



Oneway Anova

Summary of Fit

Analysis of Variance

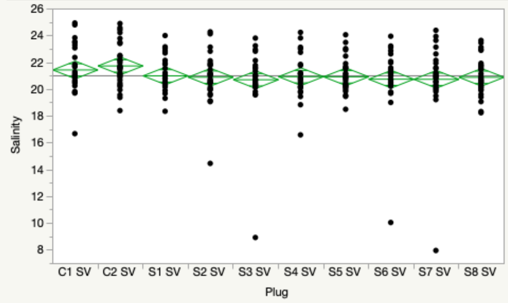
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Plug	9	26.85433	2.98381	1.3264	0.2224
Error	300	674.87100	2.24957		
C. Total	309	701.72533			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1 JR	31	21.589355	1.4806641	0.2659351	21.046243	22.132467
C2 JR	31	21.667419	2.007202	0.3605041	20.931172	22.403667
S1 JR	31	20.93129	1.2563406	0.2256454	20.470461	21.39212
S2 JR	31	21.037742	1.1529027	0.2070674	20.614854	21.46063
S3 JR	31	21.066452	1.3383536	0.2403754	20.57554	21.557364
S4 JR	31	20.611935	2.4039945	0.4317702	19.730143	21.493728
S5 JR	31	21.123871	1.1999602	0.2155192	20.683722	21.56402
S6 JR	31	20.916129	1.1146619	0.2001992	20.507268	21.32499
S7 JR	31	21.080968	1.1623492	0.2087641	20.654615	21.507321
S8 JR	31	21.127419	1.3278127	0.2384822	20.640374	21.614465

Figure 68: One-Way ANOVA for Salinity in *Juncus roemerianus* By Soil Matrixes

Oneway Analysis of Salinity By Plug



Oneway Anova

Summary of Fit

Analysis of Variance

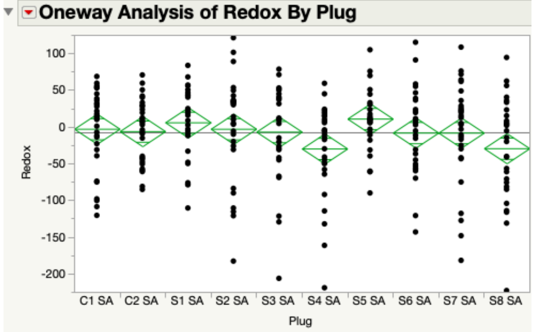
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Plug	9	30.5391	3.39324	0.9856	0.4519
Error	300	1032.8895	3.44297		
C. Total	309	1063.4287			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1 SV	31	21.454516	1.6541702	0.2970977	20.847762	22.061271
C2 SV	31	21.752903	1.6091244	0.2890073	21.162672	22.343135
S1 SV	31	21.011935	1.2348075	0.221778	20.559004	21.464867
S2 SV	31	20.914194	1.7979855	0.3229277	20.254687	21.5737
S3 SV	31	20.722903	2.4510409	0.4402199	19.823854	21.621952
S4 SV	31	20.950645	1.5246878	0.273842	20.391385	21.509905
S5 SV	31	20.941935	1.2722406	0.2285012	20.475274	21.408597
S6 SV	31	20.763226	2.300573	0.4131951	19.919369	21.607083
S7 SV	31	20.756129	2.6896192	0.4830699	19.769569	21.742689
S8 SV	31	20.904839	1.3671256	0.245543	20.403373	21.406304

Figure 69: One-Way ANOVA for Salinity in *Schoenoplectus tabernaemontani* By Soil Matrixes

Oneway Analysis of Redox By Plug



Oneway Anova

Summary of Fit

Analysis of Variance

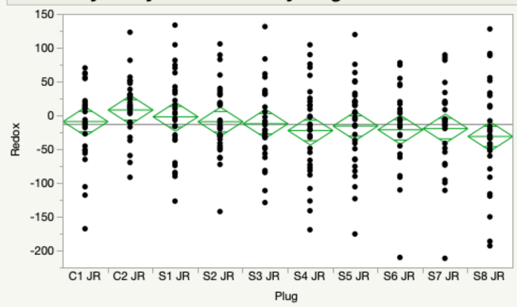
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Plug	9	47726.5	5302.94	1.5765	0.1215
Error	300	1009140.6	3363.80		
C. Total	309	1056867.0			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1 SA	31	-2.832258	53.992576	9.6973529	-22.63689	16.972379
C2 SA	31	-6.080645	41.864825	7.5191446	-21.43679	9.2754968
S1 SA	31	5.9419355	49.361691	8.8656214	-12.16408	24.04795
S2 SA	31	-2.864516	68.122862	12.235227	-27.85218	22.123151
S3 SA	31	-6.776774	64.487051	11.582216	-30.43082	16.877267
S4 SA	31	-29.7129	61.779175	11.095867	-52.37369	-7.052119
S5 SA	31	11	40.652651	7.3014316	-3.911513	25.911513
S6 SA	31	-8.048387	55.792747	10.020673	-28.51333	12.416558
S7 SA	31	-8.1	66.510936	11.945717	-32.49641	16.296408
S8 SA	31	-29.34194	68.763628	12.350312	-54.56464	-4.119233

Figure 70: One-Way ANOVA for Redox in *Spartina alterniflora* By Soil Matrixes

Oneway Analysis of Redox By Plug



Oneway Anova

Summary of Fit

Analysis of Variance

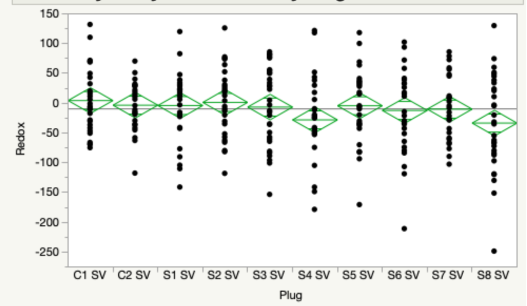
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Plug	9	34861.4	3873.49	1.0538	0.3972
Error	300	1102759.2	3675.86		
C. Total	309	1137620.6			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1 JR	31	-8.532258	55.523979	9.972401	-28.89862	11.834102
C2 JR	31	8.6290323	43.657861	7.8411832	-7.3848	24.642865
S1 JR	31	-1.419355	62.761275	11.272258	-24.44038	21.601667
S2 JR	31	-8.719355	54.207462	9.7359476	-28.60281	11.164103
S3 JR	31	-11.73226	55.490884	9.9664571	-32.08648	8.6219627
S4 JR	31	-21.77419	67.588648	12.13928	-46.56591	3.0175226
S5 JR	31	-15.05806	62.936385	11.303708	-38.14332	8.0271878
S6 JR	31	-20.63258	60.289777	10.828364	-42.74705	1.481888
S7 JR	31	-18.89032	63.267071	11.363101	-42.09687	4.3162263
S8 JR	31	-30.57097	75.141596	13.495829	-58.13313	-3.008808

Figure 71: One-Way ANOVA for Redox in *Juncus roemerianus* By Soil Matrixes

Oneway Analysis of Redox By Plug



Oneway Anova

Summary of Fit

Analysis of Variance

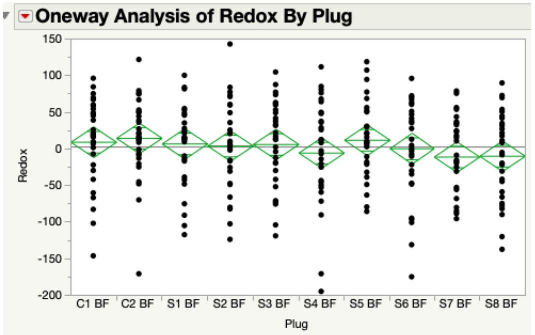
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Plug	9	41482.5	4609.17	1.2558	0.2607
Error	300	1101050.9	3670.17		
C. Total	309	1142533.4			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1 SV	31	4.4419355	52.114328	9.3600096	-14.67375	23.557625
C2 SV	31	-3.4	40.429362	7.2613278	-18.22961	11.42961
S1 SV	31	-3.958065	57.248248	10.282089	-24.95689	17.040762
S2 SV	31	1.3129032	56.63836	10.17255	-19.46221	22.088021
S3 SV	31	-6.535484	65.528897	11.769337	-30.57168	17.50071
S4 SV	31	-28.03484	66.792525	11.996292	-52.53453	-3.535143
S5 SV	31	-4.304194	59.974318	10.771705	-26.30295	17.694564
S6 SV	31	-12.20323	67.289254	12.085507	-36.88512	12.478672
S7 SV	31	-10.03548	52.129023	9.3626489	-29.15656	9.0855961
S8 SV	31	-33.41935	79.173987	14.220068	-62.46061	-4.378102

Figure 72: One-Way ANOVA for Redox in *Schoenoplectus tabernaemontani* By Soil Matrixes

Oneway Analysis of Redox By Plug



Oneway Anova

Summary of Fit

Analysis of Variance

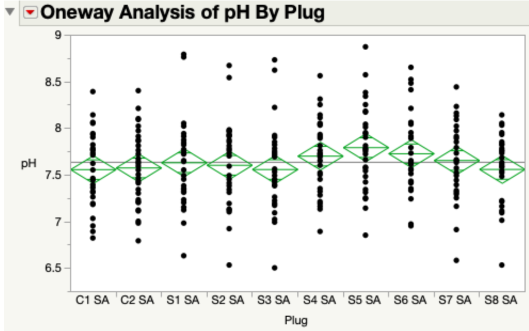
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Plug	9	22261.2	2473.47	0.7132	0.6968
Error	299	1036978.6	3468.16		
C. Total	308	1059239.8			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1 BF	31	9.0903226	57.787959	10.379024	-12.10647	30.287117
C2 BF	31	14.419355	53.81852	9.6660915	-5.321438	34.160147
S1 BF	31	6.7935484	54.678387	9.8205281	-13.26265	26.849742
S2 BF	31	3.9354839	63.361805	11.380116	-19.30581	27.176782
S3 BF	31	6.0290323	57.558412	10.337796	-15.08356	27.141628
S4 BF	31	-5.641935	69.748141	12.527136	-31.22576	19.941889
S5 BF	31	11.833548	50.950718	9.1510191	-6.855326	30.522423
S6 BF	30	0.2566667	68.024816	12.419575	-25.14422	25.657551
S7 BF	31	-11.12258	51.809264	9.3052185	-30.12637	7.8812107
S8 BF	31	-9.983871	58.26275	10.464299	-31.35482	11.387078

Figure 73: One-Way ANOVA for Redox in *Borrichia frutescens* By Soil Matrixes

Oneway Analysis of pH By Plug



Oneway Anova

Summary of Fit

Analysis of Variance

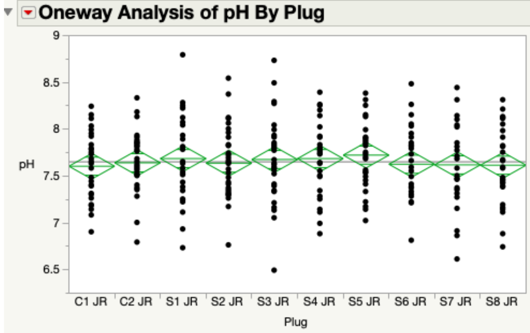
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Plug	9	1.881045	0.209005	1.1792	0.3078
Error	300	53.170935	0.177236		
C. Total	309	55.051981			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1 SA	31	7.5587097	0.3987877	0.0716244	7.4124332	7.7049862
C2 SA	31	7.5764516	0.3958413	0.0710952	7.4312559	7.7216474
S1 SA	31	7.6325806	0.4564133	0.0819743	7.4651669	7.7999944
S2 SA	31	7.6051613	0.4513895	0.0810719	7.4395903	7.7707323
S3 SA	31	7.5596774	0.4558763	0.0818778	7.3924606	7.7268942
S4 SA	31	7.7032258	0.3949885	0.070942	7.5583429	7.8481088
S5 SA	31	7.7945161	0.4439207	0.0797305	7.6316847	7.9573476
S6 SA	31	7.7290323	0.4298554	0.0772043	7.57136	7.8867045
S7 SA	31	7.6564516	0.4039847	0.0725578	7.5082688	7.8046344
S8 SA	31	7.5606452	0.3683652	0.0661603	7.4255277	7.6957626

Figure 74: One-Way ANOVA for pH in *Spartina alterniflora* By Soil Matrixes

Oneway Analysis of pH By Plug



Oneway Anova

Summary of Fit

Analysis of Variance

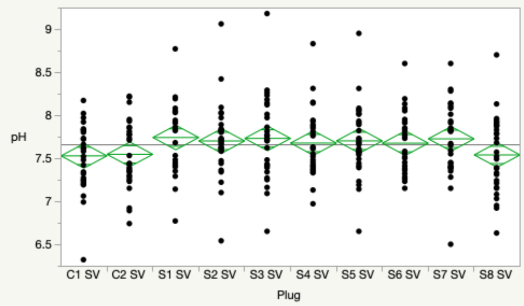
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Plug	9	0.422960	0.046996	0.3129	0.9704
Error	300	45.052277	0.150174		
C. Total	309	45.475237			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1 JR	31	7.6054839	0.3558543	0.0639133	7.4749555	7.7360123
C2 JR	31	7.6422581	0.3209643	0.0576469	7.5245274	7.7599887
S1 JR	31	7.6870968	0.4461778	0.0801359	7.5234374	7.8507561
S2 JR	31	7.6383871	0.3780132	0.0678932	7.4997307	7.7770435
S3 JR	31	7.6774194	0.4475486	0.0803821	7.5132572	7.8415815
S4 JR	31	7.6867742	0.3837915	0.068931	7.5459983	7.8275501
S5 JR	31	7.7241935	0.34348	0.0616908	7.5982041	7.850183
S6 JR	31	7.6267742	0.3615189	0.0649307	7.494168	7.7593804
S7 JR	31	7.6203226	0.4211372	0.0756385	7.4658482	7.774797
S8 JR	31	7.6164516	0.395597	0.0710513	7.4713455	7.7615578

Figure 75: One-Way ANOVA for pH in *Juncus roemerianus* By Soil Matrixes

Oneway Analysis of pH By Plug



Oneway Anova

Summary of Fit

Analysis of Variance

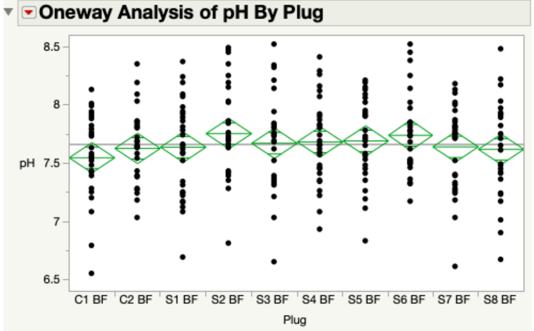
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Plug	9	2.013658	0.223740	1.3744	0.1989
Error	300	48.837529	0.162792		
C. Total	309	50.851187			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1 SV	31	7.5329032	0.3812453	0.0684737	7.3930613	7.6727451
C2 SV	31	7.5506452	0.3806568	0.068368	7.4110191	7.6902712
S1 SV	31	7.746129	0.3887645	0.0698242	7.6035291	7.888729
S2 SV	31	7.706129	0.4191156	0.0752754	7.5523962	7.8598619
S3 SV	31	7.7358065	0.4751826	0.0853453	7.5615081	7.9101048
S4 SV	31	7.6816129	0.371251	0.0666786	7.5454369	7.8177889
S5 SV	31	7.7070968	0.410976	0.0738135	7.5563496	7.857844
S6 SV	31	7.6803226	0.3323902	0.059699	7.5584009	7.8022443
S7 SV	31	7.7306452	0.4257929	0.0764747	7.5744631	7.8868272
S8 SV	31	7.543871	0.4319311	0.0775771	7.3854373	7.7023046

Figure 76: One-Way ANOVA for pH in *Schoenoplectus tabernaemontani* By Soil Matrixes

Oneway Analysis of pH By Plug



Oneway Anova

Summary of Fit

Analysis of Variance

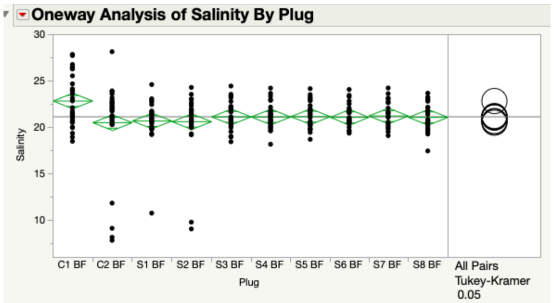
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Plug	9	1.025083	0.113898	0.8441	0.5760
Error	299	40.347374	0.134941		
C. Total	308	41.372456			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1 BF	31	7.5477419	0.3597102	0.0646059	7.4157992	7.6796847
C2 BF	31	7.6280645	0.304329	0.0546591	7.5164357	7.7396933
S1 BF	31	7.6387097	0.3996811	0.0717848	7.4921055	7.7853139
S2 BF	31	7.7551613	0.4046222	0.0726723	7.6067447	7.9035779
S3 BF	31	7.6722581	0.395472	0.0710289	7.5271978	7.8173183
S4 BF	31	7.6835484	0.3600514	0.0646671	7.5514805	7.8156163
S5 BF	31	7.6922581	0.3384052	0.0607794	7.56813	7.8163861
S6 BF	30	7.7406667	0.341931	0.0624278	7.6129875	7.8683458
S7 BF	31	7.6412903	0.3581037	0.0643173	7.5099368	7.7726438
S8 BF	31	7.6203226	0.3970263	0.071308	7.4746922	7.765953

Figure 77: One-Way ANOVA for pH in *Borrichia frutescens* By Soil Matrixes

Oneway Analysis of Salinity By Plug



Oneway Anova

Summary of Fit

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Plug	9	117.4441	13.0493	2.3277	0.0152*
Error	299	1676.2427	5.6062		
C. Total	308	1793.6868			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1 BF	31	22.845161	2.6384501	0.4738796	21.87737	23.812953
C2 BF	31	20.512258	4.7223601	0.8481609	18.780082	22.244434
S1 BF	31	20.692903	2.2413139	0.4025519	19.870783	21.515024
S2 BF	31	20.617419	3.2334615	0.5807468	19.431376	21.803463
S3 BF	31	21.137097	1.4380802	0.2582868	20.609605	21.664589
S4 BF	31	21.128065	1.3193772	0.2369671	20.644113	21.612016
S5 BF	31	21.161935	1.434107	0.2575732	20.635901	21.68797
S6 BF	30	21.083667	1.25682	0.2294629	20.614362	21.552971
S7 BF	31	21.23129	1.3559025	0.2435273	20.733941	21.728639
S8 BF	31	21.086774	1.3794863	0.2477631	20.580775	21.592774

Connecting Letters Report

Level			Mean
C1 BF	A		22.845161
S7 BF	A	B	21.231290
S5 BF	A	B	21.161935
S3 BF	A	B	21.137097
S4 BF	A	B	21.128065
S8 BF	A	B	21.086774
S6 BF	A	B	21.083667
S1 BF		B	20.692903
S2 BF		B	20.617419
C2 BF		B	20.512258

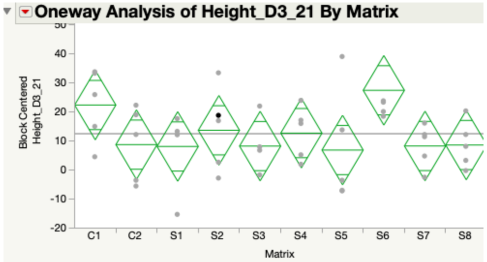
Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
C1 BF	C2 BF	2.332903	0.6014050	0.41574	4.250068	0.0050*
C1 BF	S2 BF	2.227742	0.6014050	0.31058	4.144906	0.0094*
C1 BF	S1 BF	2.152258	0.6014050	0.23509	4.069422	0.0145*

Figure 78: One-Way ANOVA and Tukey-Kramer HSD Test for Salinity in *Borrichia frutescens* By Soil Matrixes

Oneway Analysis of Height_D3_21 By Matrix



Oneway Anova

Summary of Fit

Rsquare	0.422217
Adj Rsquare	0.213573
Root Mean Square Error	13.20106
Mean of Response	12.49667
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Matrix	9	2191.872	243.541	1.3975	0.2257
Tub	4	2392.619	598.155	3.4324	0.0178*
Error	36	6273.648	174.268		
C. Total	49	10858.138			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
C1	5	22.3667	5.9037	10.39	34.340
C2	5	8.7333	5.9037	-3.24	20.707
S1	5	8.1000	5.9037	-3.87	20.073
S2	5	13.6667	5.9037	1.69	25.640
S3	5	8.2333	5.9037	-3.74	20.207
S4	5	12.7000	5.9037	0.73	24.673
S5	5	6.8667	5.9037	-5.11	18.840
S6	5	27.4333	5.9037	15.46	39.407
S7	5	8.2667	5.9037	-3.71	20.240
S8	5	8.6000	5.9037	-3.37	20.573

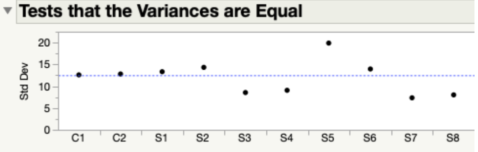
Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1	5	22.366667	12.596458	5.6333072	6.7260985	38.007235
C2	5	8.7333333	12.805204	5.7266613	-7.166427	24.633094
S1	5	8.1	13.3244	5.9588529	-8.444428	24.644428
S2	5	13.666667	14.318749	6.4035394	-4.112409	31.445742
S3	5	8.2333333	8.5450392	3.8214577	-2.376734	18.843401
S4	5	12.7	9.0580642	4.0508895	1.4529277	23.947072
S5	5	6.8666667	19.889589	8.8948946	-17.82952	31.562853
S6	5	27.433333	13.946701	6.2371544	10.116217	44.75045
S7	5	8.2666667	7.3389694	3.2820869	-0.845867	17.379201
S8	5	8.6	8.0105434	3.5824239	-1.346403	18.546403

Block Tub

Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
C1	5	12.59646	10.19600	9.51000
C2	5	12.80520	10.74267	10.07667
S1	5	13.32440	9.41467	6.86000
S2	5	14.31875	11.10267	10.47333
S3	5	8.54504	5.44533	4.97667
S4	5	9.05806	7.40933	6.78000
S5	5	19.88959	15.52400	13.41000
S6	5	13.94670	9.85200	7.48667
S7	5	7.33897	5.81600	5.21000
S8	5	8.01054	6.01733	5.89333

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	0.7116	9	40	0.6949
Brown-Forsythe	0.3946	9	40	0.9305
Levene	1.1596	9	40	0.3463
Bartlett	0.7274	9	.	0.6842

Warning: Small sample sizes. Use Caution.

Welch's Test

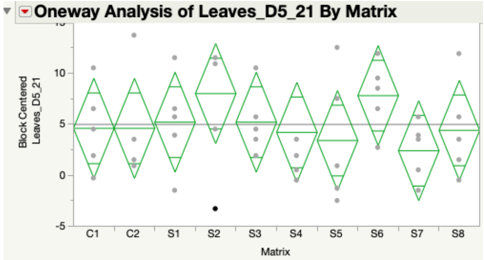
Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
1.1381	9	16.231	0.3922

Block Tub

Figure 79: One-Way ANOVA for Growth in Plant Height of *Spartina alterniflora* By Soil Matrixes

Oneway Analysis of Leaves_D5_21 By Matrix



Oneway Anova

Summary of Fit

Rsquare	0.305529
Adj Rsquare	0.054748
Root Mean Square Error	5.402469
Mean of Response	4.98
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Matrix	9	137.7800	15.3089	0.5245	0.8470
Tub	4	324.4800	81.1200	2.7794	0.0413*
Error	36	1050.7200	29.1867		
C. Total	49	1512.9800			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
C1	5	4.60000	2.4161	-0.300	9.500
C2	5	4.60000	2.4161	-0.300	9.500
S1	5	5.20000	2.4161	0.300	10.100
S2	5	8.00000	2.4161	3.100	12.900
S3	5	5.20000	2.4161	0.300	10.100
S4	5	4.20000	2.4161	-0.700	9.100
S5	5	3.40000	2.4161	-1.500	8.300
S6	5	7.80000	2.4161	2.900	12.700
S7	5	2.40000	2.4161	-2.500	7.300
S8	5	4.40000	2.4161	-0.500	9.300

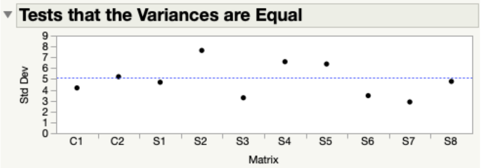
Std Error uses a pooled estimate of error variance

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1	5	4.6	4.1751647	1.8671904	-0.584152	9.7841517
C2	5	4.6	5.2088386	2.3294635	-1.867627	11.067627
S1	5	5.2	4.6959557	2.1000952	-0.630799	11.030799
S2	5	8	7.6296789	3.4120961	-1.473498	17.473498
S3	5	5.2	3.2637402	1.459589	1.1475313	9.2524687
S4	5	4.2	6.5918131	2.9479484	-3.984817	12.384817
S5	5	3.4	6.3790281	2.8527881	-4.52061	11.32061
S6	5	7.8	3.4600578	1.5473849	3.5037708	12.096229
S7	5	2.4	2.8795833	1.2877888	-1.175475	5.9754749
S8	5	4.4	4.7740968	2.135041	-1.527824	10.327824

Block Tub

Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
C1	5	4.175165	3.104000	3.080000
C2	5	5.208839	3.632000	2.960000
S1	5	4.695956	3.216000	3.120000
S2	5	7.629679	5.936000	5.360000
S3	5	3.263740	2.304000	2.160000
S4	5	6.591813	4.592000	3.840000
S5	5	6.379028	5.264000	4.760000
S6	5	3.460058	2.576000	2.440000
S7	5	2.879583	2.336000	2.120000
S8	5	4.774097	3.504000	3.320000

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	0.6663	9	40	0.7338
Brown-Forsythe	0.3998	9	40	0.9278
Levene	0.9778	9	40	0.4727
Bartlett	0.7325	9	.	0.6794

Warning: Small sample sizes. Use Caution.

Welch's Test

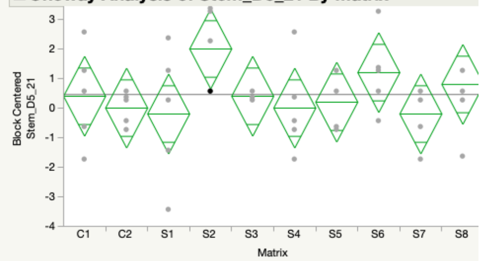
Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
0.7156	9	16.225	0.6883

Block Tub

Figure 80: One-Way ANOVA for Growth in Number of Leaves of *Spartina alterniflora* By Soil Matrixes

Oneway Analysis of Stem_D5_21 By Matrix



Oneway Anova

Summary of Fit

Rsquare	0.325452
Adj Rsquare	0.081865
Root Mean Square Error	1.489594
Mean of Response	0.46
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Matrix	9	22.02000	2.44667	1.1027	0.3856
Tub	4	16.52000	4.13000	1.8613	0.1386
Error	36	79.88000	2.21889		
C. Total	49	118.42000			

Means for Oneway Anova

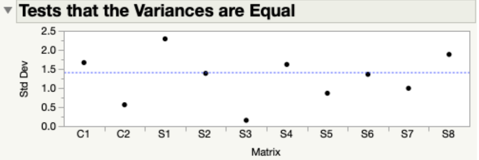
Level	Number	Mean	Std Error	Lower 95%	Upper 95%
C1	5	0.4000	0.66617	-0.951	1.7510
C2	5	0.0000	0.66617	-1.351	1.3510
S1	5	-0.2000	0.66617	-1.551	1.1510
S2	5	2.0000	0.66617	0.649	3.3510
S3	5	0.4000	0.66617	-0.951	1.7510
S4	5	0.0000	0.66617	-1.351	1.3510
S5	5	0.2000	0.66617	-1.151	1.5510
S6	5	1.2000	0.66617	-0.151	2.5510
S7	5	-0.2000	0.66617	-1.551	1.1510
S8	5	0.8000	0.66617	-0.551	2.1510

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1	5	0.4	1.6652327	0.7447147	-1.66766	2.4676595
C2	5	0	0.559464	0.2501999	-0.694666	0.6946663
S1	5	-0.2	2.2875751	1.0230347	-3.0404	2.6403997
S2	5	2	1.3831124	0.6185467	0.2826391	3.7173609
S3	5	0.4	0.1516575	0.0678233	0.2116923	0.5883077
S4	5	0	1.6164777	0.7229108	-2.007122	2.0071221
S5	5	0.2	0.8619745	0.3854867	-0.870283	1.2702827
S6	5	1.2	1.3575714	0.6071244	-0.485647	2.8856475
S7	5	-0.2	0.9914636	0.443396	-1.431065	1.0310646
S8	5	0.8	1.8796276	0.840595	-1.533866	3.1338659

Block Tub

Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
C1	5	1.665233	1.272000	1.240000
C2	5	0.559464	0.472000	0.420000
S1	5	2.287575	1.792000	1.700000
S2	5	1.383112	1.152000	1.100000
S3	5	0.151658	0.128000	0.120000
S4	5	1.616478	1.168000	1.080000
S5	5	0.861974	0.712000	0.640000
S6	5	1.357571	0.912000	0.900000
S7	5	0.991464	0.792000	0.700000
S8	5	1.879628	1.288000	1.240000

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	1.2217	9	40	0.3094
Brown-Forsythe	1.2517	9	40	0.2927
Levene	1.9349	9	40	0.0744
Bartlett	2.4455	9	.	0.0088*

Warning: Small sample sizes. Use Caution.

Welch's Test

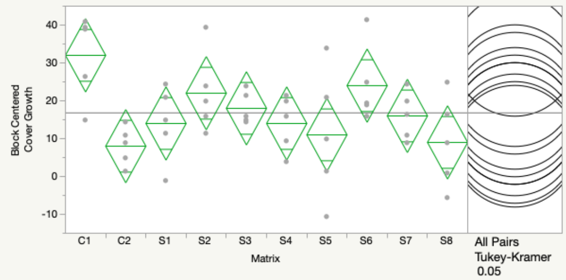
Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
1.1382	9	15.132	0.3955

Block Tub

Figure 81: One-Way ANOVA for Growth in Number of Stems of *Spartina alterniflora* By Soil Matrixes

Oneway Analysis of Cover Growth By Matrix



Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
C1	5	32.0000	4.7709	22.32	41.676
C2	5	8.0000	4.7709	-1.68	17.676
S1	5	14.0000	4.7709	4.32	23.676
S2	5	22.0000	4.7709	12.32	31.676
S3	5	18.0000	4.7709	8.32	27.676
S4	5	14.0000	4.7709	4.32	23.676
S5	5	11.0000	4.7709	1.32	20.676
S6	5	24.0000	4.7709	14.32	33.676
S7	5	16.0000	4.7709	6.32	25.676
S8	5	9.0000	4.7709	-0.68	18.676

Std Error uses a pooled estimate of error variance

Connecting Letters Report

Level			Mean
C1	A		32.000000
S6	A	B	24.000000
S2	A	B	22.000000
S3	A	B	18.000000
S7	A	B	16.000000
S1	A	B	14.000000
S4	A	B	14.000000
S5	A	B	11.000000
S8		B	9.000000
C2		B	8.000000

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
C1	C2	24.00000	6.747016	1.2705	46.72951	0.0315*
C1	S8	23.00000	6.747016	0.2705	45.72951	0.0454*

Oneway Anova

Summary of Fit

Rsquare	0.520145
Adj Rsquare	0.346864
Root Mean Square Error	10.66797
Mean of Response	16.8
Observations (or Sum Wgts)	50

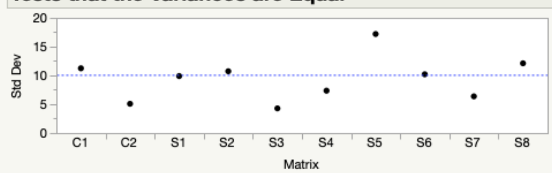
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Matrix	9	2498.0000	277.556	2.4389	0.0279*
Tub	4	1943.0000	485.750	4.2682	0.0063*
Error	36	4097.0000	113.806		
C. Total	49	8538.0000			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1	5	32	11.239439	5.0264301	18.044393	45.955607
C2	5	8	5.0818304	2.2726636	1.6900742	14.309926
S1	5	14	9.8906522	4.4232341	1.7191333	26.280867
S2	5	22	10.727302	4.7973951	8.6802958	35.319704
S3	5	18	4.280771	1.914419	12.684721	23.315279
S4	5	14	7.3535706	3.2886167	4.8693362	23.130664
S5	5	11	17.192295	7.688628	-10.34705	32.347053
S6	5	24	10.201716	4.5623459	11.332897	36.667103
S7	5	16	6.3698509	2.8486839	8.0907855	23.909214
S8	5	9	12.106816	5.4143328	-6.032598	24.032598

Tests that the Variances are Equal



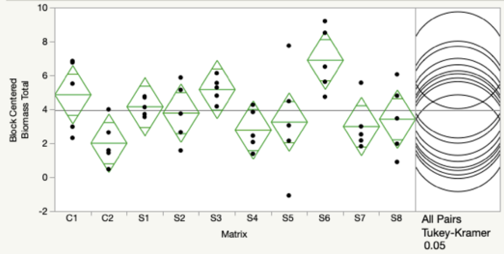
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
C1	5	11.23944	9.16000	7.80000
C2	5	5.08183	3.96000	3.80000
S1	5	9.89065	7.16000	7.00000
S2	5	10.72730	7.64000	7.20000
S3	5	4.28077	3.64000	3.20000
S4	5	7.35357	5.96000	5.60000
S5	5	17.19229	13.04000	12.80000
S6	5	10.20172	7.24000	6.30000
S7	5	6.36985	4.96000	4.90000
S8	5	12.10682	9.24000	9.20000

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	1.2443	9	40	0.2968
Brown-Forsythe	0.8353	9	40	0.5883
Levene	1.3982	9	40	0.2215
Bartlett	1.2006	9	.	0.2893

Warning: Small sample sizes. Use Caution.

Figure 82: One-Way ANOVA and Tukey-Kramer HSD Test for Growth in Percent Cover of *Spartina alterniflora* By Soil Matrixes

Oneway Analysis of Biomass Total By Matrix



Oneway Anova

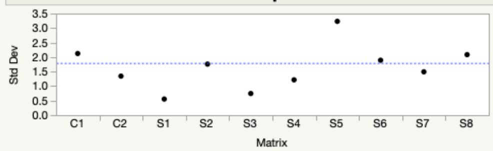
Summary of Fit

Rsquare	0.548469
Adj Rsquare	0.385416
Root Mean Square Error	1.895262
Mean of Response	3.94954
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Matrix	9	89.53859	9.9487	2.7697	0.0142*
Tub	4	67.53565	16.8839	4.7004	0.0037*
Error	36	129.31260	3.5920		
C. Total	49	286.38684			

Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
C1	5	2.122615	1.789968	1.663800
C2	5	1.343348	1.034032	0.945800
S1	5	0.553347	0.448832	0.439400
S2	5	1.758241	1.367752	1.357660
S3	5	0.744670	0.560768	0.541660
S4	5	1.215445	1.002552	0.931660
S5	5	3.231736	2.276232	2.233060
S6	5	1.891012	1.548832	1.468340
S7	5	1.492267	1.021416	0.915340
S8	5	2.083681	1.605448	1.599940

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	1.4564	9	40	0.1977
Brown-Forsythe	1.2752	9	40	0.2802
Levene	1.8096	9	40	0.0966
Bartlett	1.6298	9	.	0.1005

Warning: Small sample sizes. Use Caution.

Connecting Letters Report

Level			Mean
S6	A		6.9160000
S3	A	B	5.1880000
C1	A	B	4.8820000
S1	A	B	4.1700000
S2	A	B	3.7960000
S8	A	B	3.4380000
S5	A	B	3.2694000
S7	A	B	3.0120000
S4		B	2.8000000
C2		B	2.0240000

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
S6	C2	4.892000	1.198669	0.85390	8.930105	0.0079*
S6	S4	4.116000	1.198669	0.07790	8.154105	0.0427*

Figure 83: One-Way ANOVA and Tukey-Kramer HSD Test for Total Biomass of *Spartina alterniflora* By Soil Matrixes

Standard Least Squares

Model Summary

Response	Live Above Biomass
Distribution	Normal
Estimation Method	Standard Least Squares
Validation Method	None
Mean Model Link	Identity
Scale Model Link	Identity

Measure	
Number of rows	72
Sum of Frequencies	40
-LogLikelihood	13.846673
Number of Parameters	4
BIC	42.448863
AICc	36.836202
RSquare	0.667852
RSquare Adj	0.6498981
RMSE	0.3420591

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Intercept	-0.801285	0.2300777	12.128987	0.0005*	-1.252229	-0.350341
Hight 21	0.0215679	0.0046546	21.470908	<.0001*	0.0124451	0.0306908
Cover 21	0.026818	0.0060211	19.838196	<.0001*	0.0150169	0.0386191

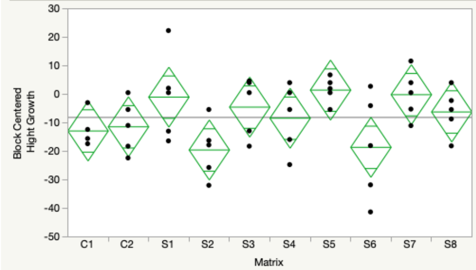
Normal Distribution Parameters	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Scale	0.3556561	0.0422086	71	<.0001*	0.2729288	0.4383835

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Hight 21	1	1	2.7158827	21.470908	<.0001*
Cover 21	1	1	2.5093588	19.838196	<.0001*

Figure 84: Generalized Regression Model for *Spartina alterniflora*

Oneway Analysis of Hight Growth By Matrix



Oneway Anova

Summary of Fit

Rsquare	0.430193
Adj Rsquare	0.22443
Root Mean Square Error	11.59124
Mean of Response	-8.11667
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Matrix	9	2483.1917	275.910	2.0536	0.0612
Tub	4	1168.5333	292.133	2.1743	0.0916
Error	36	4836.8444	134.357		
C. Total	49	8488.5694			

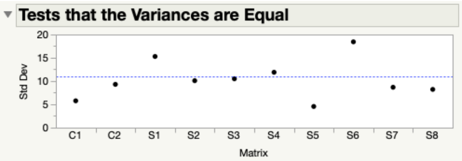
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
C1	5	-12.867	5.1838	-23.38	-2.35
C2	5	-11.400	5.1838	-21.91	-0.89
S1	5	-1.000	5.1838	-11.51	9.51
S2	5	-19.533	5.1838	-30.05	-9.02
S3	5	-4.500	5.1838	-15.01	6.01
S4	5	-8.400	5.1838	-18.91	2.11
S5	5	1.467	5.1838	-9.05	11.98
S6	5	-18.600	5.1838	-29.11	-8.09
S7	5	-0.133	5.1838	-10.65	10.38
S8	5	-6.200	5.1838	-16.71	4.31

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1	5	-12.86667	5.7585203	2.5752885	-20.01681	-5.716519
C2	5	-11.4	9.2963254	4.1574431	-22.94291	0.1429126
S1	5	-1	15.285869	6.8360482	-19.97991	17.979913
S2	5	-19.53333	10.082961	4.5092374	-32.05298	-7.013683
S3	5	-4.5	10.492696	4.6924762	-17.5284	8.5284027
S4	5	-8.4	11.888697	5.3167868	-23.16177	6.3617668
S5	5	1.4666667	4.5456939	2.0328961	-4.177558	7.1108912
S6	5	-18.6	18.428827	8.241622	-41.48241	4.2824111
S7	5	-0.133333	8.6691983	3.8769834	-10.89756	10.630898
S8	5	-6.2	8.2114081	3.6722533	-16.39581	3.9958098

Tests that the Variances are Equal



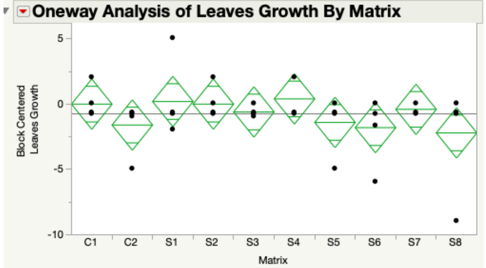
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
C1	5	5.75852	4.06667	3.52333
C2	5	9.29633	7.21333	7.15000
S1	5	15.28587	11.03333	10.75000
S2	5	10.08296	7.53333	7.21000
S3	5	10.49270	8.94000	7.95667
S4	5	11.88870	9.61333	9.03333
S5	5	4.54569	3.20667	3.13000
S6	5	18.42883	14.45333	14.36667
S7	5	8.66920	6.49333	6.38333
S8	5	8.21141	5.86667	5.72667

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	1.7201	9	40	0.1162
Brown-Forsythe	1.2763	9	40	0.2796
Levene	1.7655	9	40	0.1058
Bartlett	1.1709	9	.	0.3087

Warning: Small sample sizes. Use Caution.

Figure 85: One-Way ANOVA for Growth in Plant Height of *Juncus roemerianus* By Soil Matrixes

Oneway Analysis of Leaves Growth By Matrix



Oneway Anova

Summary of Fit

Rsquare	0.372622
Adj Rsquare	0.146068
Root Mean Square Error	2.127074
Mean of Response	-0.74
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Matrix	9	39.22000	4.3578	0.9632	0.4855
Tub	4	57.52000	14.3800	3.1783	0.0246*
Error	36	162.88000	4.5244		
C. Total	49	259.62000			

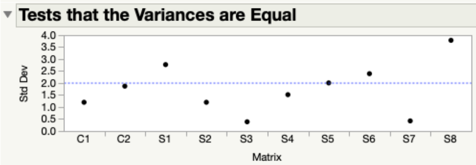
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
C1	5	0.0000	0.95126	-1.929	1.929
C2	5	-1.6000	0.95126	-3.529	0.329
S1	5	0.2000	0.95126	-1.729	2.129
S2	5	0.0000	0.95126	-1.929	1.929
S3	5	-0.6000	0.95126	-2.529	1.329
S4	5	0.4000	0.95126	-1.529	2.329
S5	5	-1.4000	0.95126	-3.329	0.529
S6	5	-1.8000	0.95126	-3.729	0.129
S7	5	-0.4000	0.95126	-2.329	1.529
S8	5	-2.2000	0.95126	-4.129	-0.271

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1	5	0	1.1991664	0.5362835	-1.488962	1.4889617
C2	5	-1.6	1.8702941	0.8364209	-3.922277	0.7222768
S1	5	0.2	2.7691154	1.238386	-3.238311	3.6383109
S2	5	0	1.1991664	0.5362835	-1.488962	1.4889617
S3	5	-0.6	0.3847077	0.1720465	-1.077678	-0.122322
S4	5	0.4	1.5159156	0.6779381	-1.482258	2.2822578
S5	5	-1.4	2.0069878	0.8975522	-3.892004	1.0920045
S6	5	-1.8	2.391234	1.0693924	-4.769109	1.1691092
S7	5	-0.4	0.4219005	0.1886796	-0.923859	0.1238586
S8	5	-2.2	3.7825917	1.6916264	-6.896708	2.4967079

Tests that the Variances are Equal



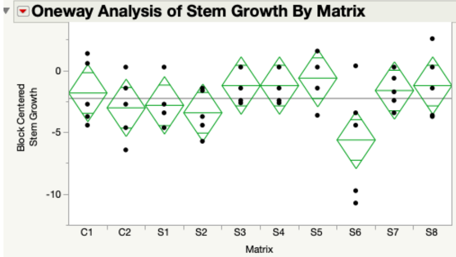
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
C1	5	1.199166	0.848000	0.720000
C2	5	1.870294	1.336000	0.900000
S1	5	2.769115	1.944000	1.420000
S2	5	1.199166	0.848000	0.720000
S3	5	0.384708	0.264000	0.220000
S4	5	1.515916	1.328000	1.120000
S5	5	2.006988	1.416000	1.020000
S6	5	2.391234	1.656000	1.380000
S7	5	0.421900	0.368000	0.320000
S8	5	3.782592	2.696000	1.820000

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	0.7744	9	40	0.6405
Brown-Forsythe	0.3501	9	40	0.9516
Levene	1.8590	9	40	0.0872
Bartlett	2.8630	9	.	0.0022*

Warning: Small sample sizes. Use Caution.

Figure 86: One-Way ANOVA for Growth in Number of Leaves of *Juncus roemerianus* By Soil Matrixes

Oneway Analysis of Stem Growth By Matrix



Oneway Anova

Summary of Fit

Rsquare	0.389647
Adj Rsquare	0.169241
Root Mean Square Error	2.5619
Mean of Response	-2.24
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Matrix	9	100.32000	11.1467	1.6983	0.1255
Tub	4	50.52000	12.6300	1.9243	0.1275
Error	36	236.28000	6.5633		
C. Total	49	387.12000			

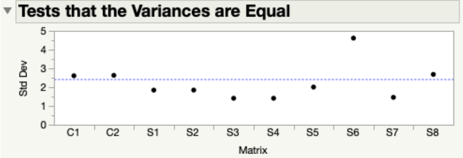
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
C1	5	-1.8000	1.1457	-4.124	0.524
C2	5	-3.0000	1.1457	-5.324	-0.676
S1	5	-2.8000	1.1457	-5.124	-0.476
S2	5	-3.4000	1.1457	-5.724	-1.076
S3	5	-1.2000	1.1457	-3.524	1.124
S4	5	-1.2000	1.1457	-3.524	1.124
S5	5	-0.6000	1.1457	-2.924	1.724
S6	5	-5.6000	1.1457	-7.924	-3.276
S7	5	-1.6000	1.1457	-3.924	0.724
S8	5	-1.2000	1.1457	-3.524	1.124

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1	5	-1.8	2.6063384	1.16559	-5.036197	1.4361966
C2	5	-3	2.6292585	1.1758401	-6.264656	0.2646556
S1	5	-2.8	1.8420098	0.8237718	-5.087157	-0.512843
S2	5	-3.4	1.8447222	0.8249848	-5.690525	-1.109475
S3	5	-1.2	1.4081903	0.6297619	-2.948499	0.5484992
S4	5	-1.2	1.4081903	0.6297619	-2.948499	0.5484992
S5	5	-0.6	2.0057418	0.896995	-3.090457	1.8904573
S6	5	-5.6	4.6122663	2.0626682	-11.32688	0.126885
S7	5	-1.6	1.4570518	0.6516134	-3.409169	0.2091688
S8	5	-1.2	2.6801119	1.1985825	-4.527799	2.1277985

Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
C1	5	2.606338	2.208000	2.020000
C2	5	2.629258	2.032000	1.980000
S1	5	1.842010	1.248000	1.120000
S2	5	1.844722	1.488000	1.420000
S3	5	1.408190	1.168000	1.120000
S4	5	1.408190	1.168000	1.120000
S5	5	2.005742	1.552000	1.380000
S6	5	4.612266	3.712000	3.480000
S7	5	1.457052	1.128000	1.100000
S8	5	2.680112	2.088000	2.040000

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	2.4945	9	40	0.0228*
Brown-Forsythe	1.2479	9	40	0.2948
Levene	2.5367	9	40	0.0209*
Bartlett	1.1898	9	.	0.2962

Warning: Small sample sizes. Use Caution.

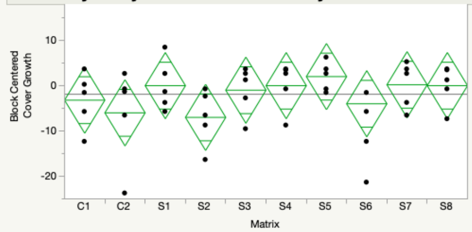
Welch's Test

Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
1.1389	9	16.233	0.3917

Figure 87: One-Way ANOVA for Growth in Number of Stems of *Juncus roemerianus* By Soil Matrixes

Oneway Analysis of Cover Growth By Matrix



Oneway Anova

Summary of Fit

Rsquare	0.31065
Adj Rsquare	0.061717
Root Mean Square Error	8.062258
Mean of Response	-1.9
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Matrix	9	400.9000	44.544	0.6853	0.7171
Tub	4	653.6000	163.400	2.5138	0.0585
Error	36	2340.0000	65.000		
C. Total	49	3394.5000			

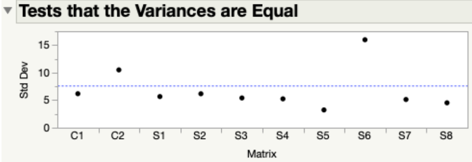
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
C1	5	-3.2000	3.6056	-10.51	4.1124
C2	5	-6.0000	3.6056	-13.31	1.3124
S1	5	0.0000	3.6056	-7.31	7.3124
S2	5	-7.0000	3.6056	-14.31	0.3124
S3	5	-1.0000	3.6056	-8.31	6.3124
S4	5	0.0000	3.6056	-7.31	7.3124
S5	5	2.0000	3.6056	-5.31	9.3124
S6	5	-4.0000	3.6056	-11.31	3.3124
S7	5	0.2000	3.6056	-7.11	7.5124
S8	5	0.0000	3.6056	-7.31	7.3124

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1	5	-3.2	6.1595454	2.7546325	-10.84809	4.4480858
C2	5	-6	10.480458	4.6870033	-19.01321	7.0132074
S1	5	0	5.6426944	2.5234896	-7.00633	7.0063305
S2	5	-7	6.1514226	2.7509998	-14.638	0.638
S3	5	-1	5.3888774	2.4099793	-7.691175	5.6911751
S4	5	0	5.2287666	2.3383755	-6.492371	6.4923712
S5	5	2	3.215587	1.4380542	-1.992679	5.9926787
S6	5	-4	15.948041	7.1321806	-23.80211	15.802108
S7	5	0.2	5.1127292	2.286482	-6.148292	6.5482918
S8	5	0	4.5099889	2.0169284	-5.599891	5.5998909

Tests that the Variances are Equal



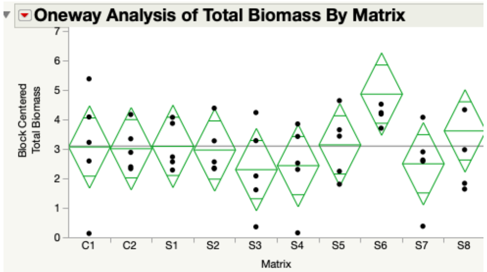
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
C1	5	6.15955	4.72000	4.40000
C2	5	10.48046	7.36000	6.44000
S1	5	5.64269	4.40000	4.12000
S2	5	6.15142	4.48000	4.40000
S3	5	5.38888	4.16000	3.72000
S4	5	5.22877	3.84000	3.32000
S5	5	3.21559	2.56000	2.44000
S6	5	15.94804	11.04000	10.68000
S7	5	5.11273	4.32000	3.84000
S8	5	4.50999	3.28000	3.04000

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	1.3352	9	40	0.2501
Brown-Forsythe	0.9012	9	40	0.5334
Levene	1.4845	9	40	0.1870
Bartlett	1.8049	9	.	0.0619

Warning: Small sample sizes. Use Caution.

Figure 88: One-Way ANOVA for Growth in Percent Cover of *Juncus roemerianus* By Soil Matrixes

Oneway Analysis of Total Biomass By Matrix



Oneway Anova

Summary of Fit

Rsquare	0.419544
Adj Rsquare	0.209935
Root Mean Square Error	1.540437
Mean of Response	3.1104
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Matrix	9	24.20447	2.68939	1.1334	0.3656
Tub	4	37.54005	9.38501	3.9550	0.0092*
Error	36	85.42607	2.37295		
C. Total	49	147.17059			

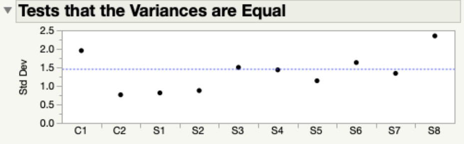
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
C1	5	3.08000	0.68890	1.6828	4.4772
C2	5	3.02200	0.68890	1.6248	4.4192
S1	5	3.10200	0.68890	1.7048	4.4992
S2	5	2.97800	0.68890	1.5808	4.3752
S3	5	2.31200	0.68890	0.9148	3.7092
S4	5	2.44800	0.68890	1.0508	3.8452
S5	5	3.15200	0.68890	1.7548	4.5492
S6	5	4.87400	0.68890	3.4768	6.2712
S7	5	2.51000	0.68890	1.1128	3.9072
S8	5	3.62600	0.68890	2.2288	5.0232

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1	5	3.08	1.9515484	0.872759	0.6568326	5.5031674
C2	5	3.022	0.760068	0.3399127	2.078251	3.965749
S1	5	3.102	0.8104957	0.3624647	2.0956367	4.1083633
S2	5	2.978	0.8731376	0.390479	1.8938565	4.0621435
S3	5	2.312	1.4991875	0.6704571	0.4505128	4.1734872
S4	5	2.448	1.4320926	0.6404513	0.6698221	4.2261779
S5	5	3.152	1.1381776	0.5090085	1.7387658	4.5652342
S6	5	4.874	1.6293404	0.7286632	2.8509066	6.8970934
S7	5	2.51	1.3377972	0.5982811	0.8489054	4.1710946
S8	5	3.626	2.3479027	1.050014	0.7106937	6.5413063

Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
C1	5	1.951548	1.376080	1.347800
C2	5	0.760068	0.585920	0.557800
S1	5	0.810496	0.693520	0.618800
S2	5	0.873138	0.679120	0.595200
S3	5	1.499188	1.154720	1.108600
S4	5	1.432093	0.976880	0.962800
S5	5	1.138178	0.904480	0.848400
S6	5	1.629340	1.146960	0.874800
S7	5	1.337797	0.853440	0.802400
S8	5	2.347903	1.775120	1.644200

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	0.7988	9	40	0.6195
Brown-Forsythe	0.5648	9	40	0.8173
Levene	0.9397	9	40	0.5024
Bartlett	0.9927	9	.	0.4434

Warning: Small sample sizes. Use Caution.

Figure 89: One-Way ANOVA for Total Biomass of *Juncus roemerianus* By Soil Matrixes

Standard Least Squares

Model Summary

Response	Live Above Biomass
Distribution	Normal
Estimation Method	Standard Least Squares
Validation Method	None
Mean Model Link	Identity
Scale Model Link	Identity

Measure	
Number of rows	50
Sum of Frequencies	15
-LogLikelihood	1.863767
Number of Parameters	4
BIC	14.559735
AICc	15.727534
RSquare	0.9127651
RSquare Adj	0.898226
RMSE	0.2739835

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Intercept	-0.730176	0.2604736	7.8582804	0.0051*	-1.240695	-0.219657
Hight 21	0.0135644	0.0061374	4.8846615	0.0271*	0.0015354	0.0255935
Stem 21	0.163259	0.0157305	107.7134	<.0001*	0.1324278	0.1940902

Normal Distribution Parameters	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Scale	0.3063229	0.0668451	21	<.0001*	0.1753088	0.4373369

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Stem 21	1	1	10.107146	107.7134	<.0001*
Hight 21	1	1	0.4583458	4.8846615	0.0473*

Figure 90: Generalized Regression Model for *Juncus roemerianus* with Parameters Height and Number of Stems

Model Summary

Response	Live Above Biomass
Distribution	Normal
Estimation Method	Standard Least Squares
Validation Method	None
Mean Model Link	Identity
Scale Model Link	Identity

Measure	
Number of rows	50
Sum of Frequencies	15
-LogLikelihood	4.4250092
Number of Parameters	3
BIC	16.974169
AICc	17.031837
RSquare	0.8772557
RSquare Adj	0.8678139
RMSE	0.3249975

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Intercept	-0.249457	0.1633216	2.3329436	0.1267	-0.569562	0.0706474
Stem 21	0.1697574	0.0176114	92.911264	<.0001*	0.1352396	0.2042751

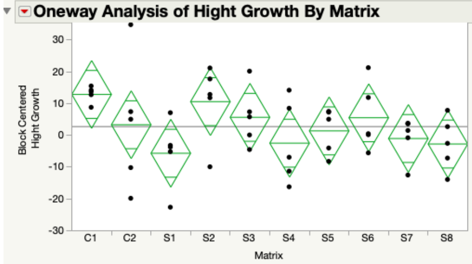
Normal Distribution Parameters	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Scale	0.3491033	0.0712604	24	<.0001*	0.2094354	0.4887711

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Stem 21	1	1	11.323383	92.911264	<.0001*

Figure 91: Generalized Regression Model for *Juncus roemerianus* with Parameter Number of Stems

Oneway Analysis of Hight Growth By Matrix



Oneway Anova

Summary of Fit

Rsquare	0.343007
Adj Rsquare	0.10576
Root Mean Square Error	11.7536
Mean of Response	2.756667
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Matrix	9	1620.0450	180.005	1.3030	0.2695
Tub	4	976.4478	244.112	1.7670	0.1569
Error	36	4973.2967	138.147		
C. Total	49	7569.7894			

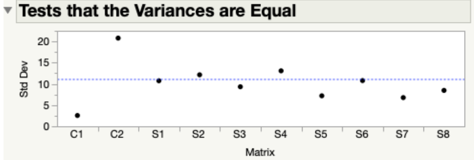
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
C1	5	12.867	5.2564	2.21	23.527
C2	5	3.333	5.2564	-7.33	13.994
S1	5	-5.633	5.2564	-16.29	5.027
S2	5	10.600	5.2564	-0.0604	21.260
S3	5	5.667	5.2564	-4.99	16.327
S4	5	-2.467	5.2564	-13.13	8.194
S5	5	1.400	5.2564	-9.26	12.060
S6	5	5.533	5.2564	-5.13	16.194
S7	5	-1.000	5.2564	-11.66	9.660
S8	5	-2.733	5.2564	-13.39	7.927

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1	5	12.866667	2.5425436	1.13706	9.7096819	16.023651
C2	5	3.3333333	20.784612	9.2951609	-22.47417	29.140837
S1	5	-5.633333	10.730179	4.7986821	-18.95661	7.6899441
S2	5	10.6	12.13439	5.4266641	-4.466835	25.666835
S3	5	5.6666667	9.3159108	4.166202	-5.900564	17.233898
S4	5	-2.466667	13.070985	5.845522	-18.69644	13.763104
S5	5	1.4	7.1832038	3.2124264	-7.519126	10.319126
S6	5	5.5333333	10.772745	4.8177179	-7.842796	18.909463
S7	5	-1	6.7592591	3.0228326	-9.392729	7.3927287
S8	5	-2.733333	8.456035	3.7816538	-13.23289	7.7662209

Tests that the Variances are Equal



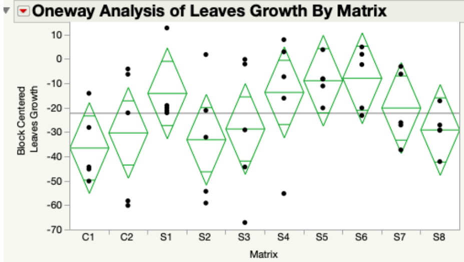
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
C1	5	2.54254	1.76800	1.62333
C2	5	20.78461	14.76133	14.44333
S1	5	10.73018	6.84400	6.34000
S2	5	12.13439	8.25067	7.39667
S3	5	9.31591	6.38800	6.38667
S4	5	13.07098	10.94533	10.03333
S5	5	7.18320	6.10133	5.39667
S6	5	10.77274	8.73200	7.70000
S7	5	6.75926	4.65067	4.13667
S8	5	8.45603	6.34133	6.32667

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	1.2960	9	40	0.2694
Brown-Forsythe	0.9876	9	40	0.4652
Levene	1.5505	9	40	0.1640
Bartlett	1.6950	9	.	0.0842

Warning: Small sample sizes. Use Caution.

Figure 92: One-Way ANOVA for Growth in Plant Height of *Borrichia frutescens* By Soil Matrixes

Oneway Analysis of Leaves Growth By Matrix



Oneway Anova

Summary of Fit

Rsquare	0.360527
Adj Rsquare	0.129606
Root Mean Square Error	20.52402
Mean of Response	-22.14
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Matrix	9	5012.020	556.891	1.3220	0.2601
Tub	4	3537.520	884.380	2.0995	0.1011
Error	36	15164.480	421.236		
C. Total	49	23714.020			

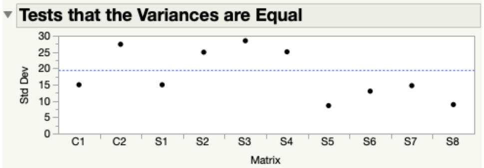
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
C1	5	-36.400	9.1786	-55.02	-17.78
C2	5	-30.200	9.1786	-48.82	-11.58
S1	5	-14.000	9.1786	-32.62	4.62
S2	5	-33.000	9.1786	-51.62	-14.38
S3	5	-28.600	9.1786	-47.22	-9.98
S4	5	-13.600	9.1786	-32.22	5.02
S5	5	-8.800	9.1786	-27.42	9.82
S6	5	-7.800	9.1786	-26.42	10.82
S7	5	-20.000	9.1786	-38.62	-1.38
S8	5	-29.000	9.1786	-47.62	-10.38

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1	5	-36.4	14.947508	6.6847289	-54.95978	-17.84022
C2	5	-30.2	27.368011	12.239346	-64.18187	3.7818734
S1	5	-14	14.94617	6.6841305	-32.55812	4.5581213
S2	5	-33	24.941692	11.154264	-63.9692	-2.030799
S3	5	-28.6	28.4508	12.723584	-63.92633	6.7263336
S4	5	-13.6	25.0549	11.204892	-44.70977	17.509767
S5	5	-8.8	8.5509064	3.8240816	-19.41735	1.8173526
S6	5	-7.8	12.981448	5.8054802	-23.9186	8.318597
S7	5	-20	14.688022	6.5686833	-38.23759	-1.762411
S8	5	-29	8.8678069	3.9658038	-40.01084	-17.98916

Tests that the Variances are Equal



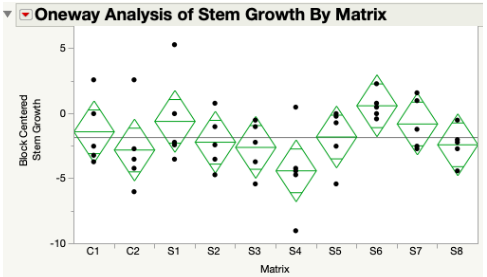
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
C1	5	14.94751	12.20800	10.62000
C2	5	27.36801	23.19200	21.58000
S1	5	14.94617	10.66400	7.38000
S2	5	24.94169	18.99200	18.82000
S3	5	28.45080	21.92800	21.82000
S4	5	25.05490	17.67200	16.42000
S5	5	8.55091	5.47200	5.38000
S6	5	12.98145	11.11200	10.02000
S7	5	14.68802	12.24800	11.02000
S8	5	8.86781	5.44800	5.42000

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	1.4705	9	40	0.1923
Brown-Forsythe	1.2449	9	40	0.2964
Levene	2.1303	9	40	0.0493*
Bartlett	1.3077	9	.	0.2266

Warning: Small sample sizes. Use Caution.

Figure 93: One-Way ANOVA for Growth in Number of Leaves of *Borrichia frutescens* By Soil Matrixes

Oneway Analysis of Stem Growth By Matrix



Oneway Anova

Summary of Fit

Rsquare	0.479525
Adj Rsquare	0.291575
Root Mean Square Error	2.619796
Mean of Response	-1.84
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Matrix	9	86.32000	9.5911	1.3974	0.2257
Tub	4	141.32000	35.3300	5.1476	0.0022*
Error	36	247.08000	6.8633		
C. Total	49	474.72000			

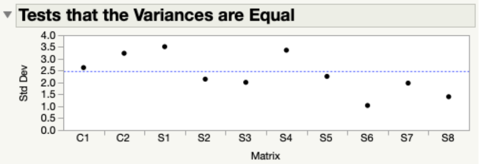
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
C1	5	-1.4000	1.1716	-3.776	0.976
C2	5	-2.8000	1.1716	-5.176	-0.424
S1	5	-0.6000	1.1716	-2.976	1.776
S2	5	-2.2000	1.1716	-4.576	0.176
S3	5	-2.6000	1.1716	-4.976	-0.224
S4	5	-4.4000	1.1716	-6.776	-2.024
S5	5	-1.8000	1.1716	-4.176	0.576
S6	5	0.6000	1.1716	-1.776	2.976
S7	5	-0.8000	1.1716	-3.176	1.576
S8	5	-2.4000	1.1716	-4.776	-0.024

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1	5	-1.4	2.6311594	1.1766903	-4.667016	1.867016
C2	5	-2.8	3.2346561	1.4465822	-6.816356	1.216356
S1	5	-0.6	3.5132606	1.5711779	-4.962289	3.7622892
S2	5	-2.2	2.1454603	0.959479	-4.863941	0.4639408
S3	5	-2.6	2.0107213	0.8992219	-5.09664	-0.10336
S4	5	-4.4	3.3649666	1.5048588	-8.578158	-0.221842
S5	5	-1.8	2.2611944	1.0112369	-4.607644	1.0076436
S6	5	0.6	1.0358571	0.4632494	-0.686187	1.8861865
S7	5	-0.8	1.9781304	0.8846468	-3.256173	1.6561733
S8	5	-2.4	1.4046352	0.628172	-4.144085	-0.655915

Tests that the Variances are Equal



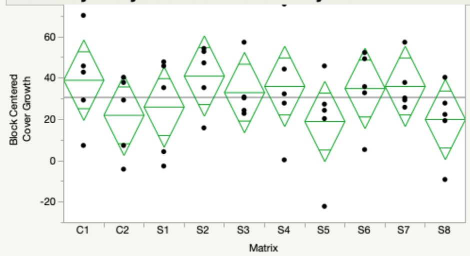
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
C1	5	2.631159	2.128000	1.900000
C2	5	3.234656	2.168000	2.020000
S1	5	3.513261	2.568000	2.240000
S2	5	2.145460	1.648000	1.600000
S3	5	2.010721	1.592000	1.520000
S4	5	3.364967	2.008000	2.000000
S5	5	2.261194	1.752000	1.540000
S6	5	1.035857	0.728000	0.700000
S7	5	1.978130	1.648000	1.560000
S8	5	1.404635	0.952000	0.920000

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	0.6204	9	40	0.7725
Brown-Forsythe	0.3391	9	40	0.9562
Levene	0.7207	9	40	0.6871
Bartlett	0.9429	9	.	0.4860

Warning: Small sample sizes. Use Caution.

Figure 94: One-Way ANOVA for Growth in Number of Stems of *Borrichia frutescens* By Soil Matrixes

Oneway Analysis of Cover Growth By Matrix



Oneway Anova

Summary of Fit

Rsquare	0.378815
Adj Rsquare	0.154499
Root Mean Square Error	21.48449
Mean of Response	30.7
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Matrix	9	3020.500	335.61	0.7271	0.6812
Tub	4	7113.000	1778.25	3.8525	0.0105*
Error	36	16617.000	461.58		
C. Total	49	26750.500			

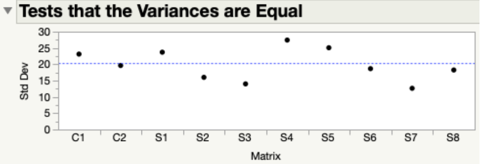
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
C1	5	39.0000	9.6082	19.51	58.486
C2	5	22.0000	9.6082	2.51	41.486
S1	5	26.0000	9.6082	6.51	45.486
S2	5	41.0000	9.6082	21.51	60.486
S3	5	33.0000	9.6082	13.51	52.486
S4	5	36.0000	9.6082	16.51	55.486
S5	5	19.0000	9.6082	-0.49	38.486
S6	5	35.0000	9.6082	15.51	54.486
S7	5	36.0000	9.6082	16.51	55.486
S8	5	20.0000	9.6082	0.51	39.486

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1	5	39	23.126284	10.342389	10.284926	67.715074
C2	5	22	19.623328	8.7758191	-2.36558	46.36558
S1	5	26	23.708121	10.602594	-3.43752	55.43752
S2	5	41	15.99453	7.1529714	21.140168	60.859832
S3	5	33	13.984813	6.2541986	15.635561	50.364439
S4	5	36	27.423986	12.264379	1.9486241	70.051376
S5	5	19	25.071398	11.21227	-12.13025	50.130252
S6	5	35	18.650067	8.3405635	11.842883	58.157117
S7	5	36	12.6323	5.6493362	20.314928	51.685072
S8	5	20	18.243492	8.1587376	-2.652287	42.652287

Tests that the Variances are Equal



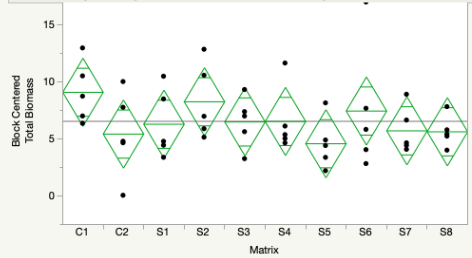
Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
C1	5	23.12628	16.64000	15.90000
C2	5	19.62333	16.44000	15.00000
S1	5	23.70812	20.24000	18.40000
S2	5	15.99453	12.44000	11.20000
S3	5	13.98481	9.68000	8.20000
S4	5	27.42399	19.16000	18.40000
S5	5	25.07140	16.52000	15.00000
S6	5	18.65007	12.84000	12.70000
S7	5	12.63230	9.16000	8.00000
S8	5	18.24349	12.04000	11.60000

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	0.4657	9	40	0.8888
Brown-Forsythe	0.3361	9	40	0.9574
Levene	0.5405	9	40	0.8360
Bartlett	0.4509	9	.	0.9076

Warning: Small sample sizes. Use Caution.

Figure 95: One-Way ANOVA for Growth in Percent Cover of *Borrichia frutescens* By Soil Matrixes

Oneway Analysis of Total Biomass By Matrix



Oneway Anova

Summary of Fit

Rsquare	0.255902
Adj Rsquare	-0.0128
Root Mean Square Error	3.290447
Mean of Response	6.5428
Observations (or Sum Wgts)	50

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Matrix	9	84.65213	9.4058	0.8687	0.5610
Tub	4	49.39429	12.3486	1.1405	0.3531
Error	36	389.77359	10.8270		
C. Total	49	523.82001			

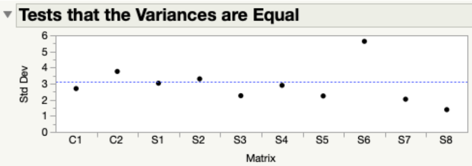
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
C1	5	9.08600	1.4715	6.1016	12.070
C2	5	5.42400	1.4715	2.4396	8.408
S1	5	6.28600	1.4715	3.3016	9.270
S2	5	8.25600	1.4715	5.2716	11.240
S3	5	6.48800	1.4715	3.5036	9.472
S4	5	6.53000	1.4715	3.5456	9.514
S5	5	4.57800	1.4715	1.5936	7.562
S6	5	7.44400	1.4715	4.4596	10.428
S7	5	5.71000	1.4715	2.7256	8.694
S8	5	5.62600	1.4715	2.6416	8.610

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
C1	5	9.086	2.6921988	1.2039879	5.7431937	12.428806
C2	5	5.424	3.7549568	1.6792677	0.7616054	10.086395
S1	5	6.286	3.0262641	1.3533864	2.5283969	10.043603
S2	5	8.256	3.2934889	1.472893	4.1665934	12.345407
S3	5	6.488	2.2486114	1.0056096	3.6959802	9.2800198
S4	5	6.53	2.8921691	1.2934173	2.9388977	10.121102
S5	5	4.578	2.2329562	0.9986084	1.8054187	7.3505813
S6	5	7.444	5.6247893	2.5154823	0.4599016	14.428098
S7	5	5.71	2.0325802	0.9089975	3.1862184	8.2337816
S8	5	5.626	1.3833995	0.6186751	3.9082826	7.3437174

Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
C1	5	2.692199	2.099440	2.024200
C2	5	3.754957	2.748640	2.615000
S1	5	3.026264	2.539440	2.232600
S2	5	3.293489	2.739840	2.477800
S3	5	2.248611	1.658560	1.563000
S4	5	2.892169	2.032720	1.617800
S5	5	2.232956	1.531440	1.492200
S6	5	5.624789	3.886240	3.556400
S7	5	2.032580	1.628240	1.410200
S8	5	1.383400	0.919840	0.873600

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	0.8966	9	40	0.5371
Brown-Forsythe	0.5407	9	40	0.8359
Levene	1.1549	9	40	0.3492
Bartlett	1.0862	9	.	0.3689

Warning: Small sample sizes. Use Caution.

Figure 96: One-Way ANOVA for Total Biomass of *Borrichia frutescens* By Soil Matrixes

Standard Least Squares

Model Summary

Response	Below Biomass
Distribution	Normal
Estimation Method	Standard Least Squares
Validation Method	None
Mean Model Link	Identity
Scale Model Link	Identity

Measure	
Number of rows	50
Sum of Frequencies	47
-LogLikelihood	63.085073
Number of Parameters	4
BIC	141.57074
AICc	135.12253
RSquare	0.4417371
RSquare Adj	0.4163615
RMSE	0.926165

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Intercept	1.0036664	0.4319156	5.3998408	0.0201*	0.1571273	1.8502054
Stem 21	0.1611061	0.0383352	17.661524	<.0001*	0.0859705	0.2362417
Cover 21	0.0169734	0.0067878	6.2528745	0.0124*	0.0036696	0.0302772

Normal Distribution Parameters	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Scale	0.9572182	0.1038249	85	<.0001*	0.7537251	1.1607112

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Stem 21	1	1	16.182665	17.661524	0.0001*
Cover 21	1	1	5.7293002	6.2528745	0.0162*

Figure 97: Generalized Regression Model for *Borrichia frutescens* with Parameters Number of Branches and Percent Cover

Standard Least Squares

Model Summary

Response	Live Above Biomass
Distribution	Normal
Estimation Method	Standard Least Squares
Validation Method	None
Mean Model Link	Identity
Scale Model Link	Identity

Measure	
Number of rows	50
Sum of Frequencies	47
-LogLikelihood	77.003646
Number of Parameters	4
BIC	169.40788
AICc	162.95967
RSquare	0.6684881
RSquare Adj	0.6534194
RMSE	1.2453753

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Intercept	-1.586533	0.6420261	6.1065061	0.0135*	-2.844881	-0.328185
Hight 21	0.1002311	0.018343	29.858152	<.0001*	0.0642794	0.1361828
Stem 21	0.3491859	0.0487802	51.242025	<.0001*	0.2535784	0.4447933

Normal Distribution Parameters	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Scale	1.2871312	0.139609	85	<.0001*	1.0135027	1.5607598

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Stem 21	1	1	84.893013	51.242025	<.0001*
Hight 21	1	1	49.466206	29.858152	<.0001*

Figure 98: Generalized Regression Model for *Borrichia frutescens* with Parameters Height and Number of Branches