Fourchon Maritime Forest Ridge and Marsh Restoration

Vegetative Efforts

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A Report of the:

Barataria-Terrebonne National Estuary Program (BTNEP)

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and the Lafourche Parish Council

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1.0 INTRODUCTION

While Louisiana has the largest contiguous area of wetlands in the lower United States, it is also losing these wetlands at a breakneck pace. Indeed, the fastest disappearing landmass on earth is occurring within the two estuaries that make up the Barataria-Terrebonne National Estuary. Estuaries are some of the most ecologically productive places on the planet due to their changing salinity regimes and varying landforms.

Coastal Louisiana is losing a football field size area of land every hour. This means we are losing our coastal barrier islands, saline, brackish and fresh marshes, swamps, and chenier ridges that provide habitat for birds, fish and animals. Erosion, salt water intrusion, subsidence, storm events, and anthropogenic activities are the causes of this loss. Chenier ridges and maritime forests act as speed bumps in slowing storm surge during tropical events and provide critically important habitat for many species of Neotropical migratory songbirds. As these landforms are lost, so is the critical habitats over 338 migrating bird species depend upon travelling the Mississippi Flyway each spring and fall.

To combat this loss, new coastal habitats need to be recreated or restored. The Fourchon Maritime Forest Ridge and Marsh Restoration project was the first of its kind utilizing saline sediments to create a maritime ridge for the establishment of trees beneficial to Neotropical migratory songbirds. Use of the readily available surrounding saline sediments is problematic, however, in that they are not initially suitable for the non-halophytic trees selected for this project. Planning and measures then must be undertaken to mitigate for the salinity in the soil. Experimentally designed plantings were conducted utilizing a number of beneficial native woody species and cultural treatments and through statistical analysis of plant response and soil characteristics over time, we try to determine when soil conditions become suitable to support the establishment of the targeted woody species. Armed with this knowledge, future maritime ridge restoration projects created utilizing saline sediments may be able to determine the proper time for woody species establishment through soil sampling alone. Through the construction of maritime forest ridges along Louisiana’s coast, the “bones” of our salt marshes providing storm surge protection and habitat for the millions of Neotropical migratory birds as they pass through each year can be rebuilt and restored.

2.0 SITE LOCATION

The Fourchon Maritime Forest Ridge and Marsh Restoration project site (hereinafter referred to as Ridge and Marsh site if referring to the entire project site or just the Ridge if referring to just the ridge top) is approximately 56 acres of created marsh and ridge located immediately north of Port Fourchon, Louisiana (approximately 0.85 miles north of Flotation Canal), approximately 6.2 miles due south of Leeville, Louisiana, and approximately 11 miles ENE of Grand Isle, Louisiana (Figure 1). A proximal center-point GPS coordinate is 29 9' 37.00" N by 90 12' 36.50" W with the ridge linearly oriented in a due east-west direction. The Ridge and Marsh Site was constructed along the sunken ridge of Bayou Cochon in a saltmarsh that had subsided and eroded into open water. Prior to its construction, the open water area directly south of and adjacent to the ridge was restored to saltmarsh again as part of mitigation requirements for the Greater Lafourche Port Commission's port expansion. The Ridge and Marsh site itself is not mitigation, but a public service contribution provided by the Greater Lafourche Port Commission due to excess sediment availability above and beyond the mitigation requirements.

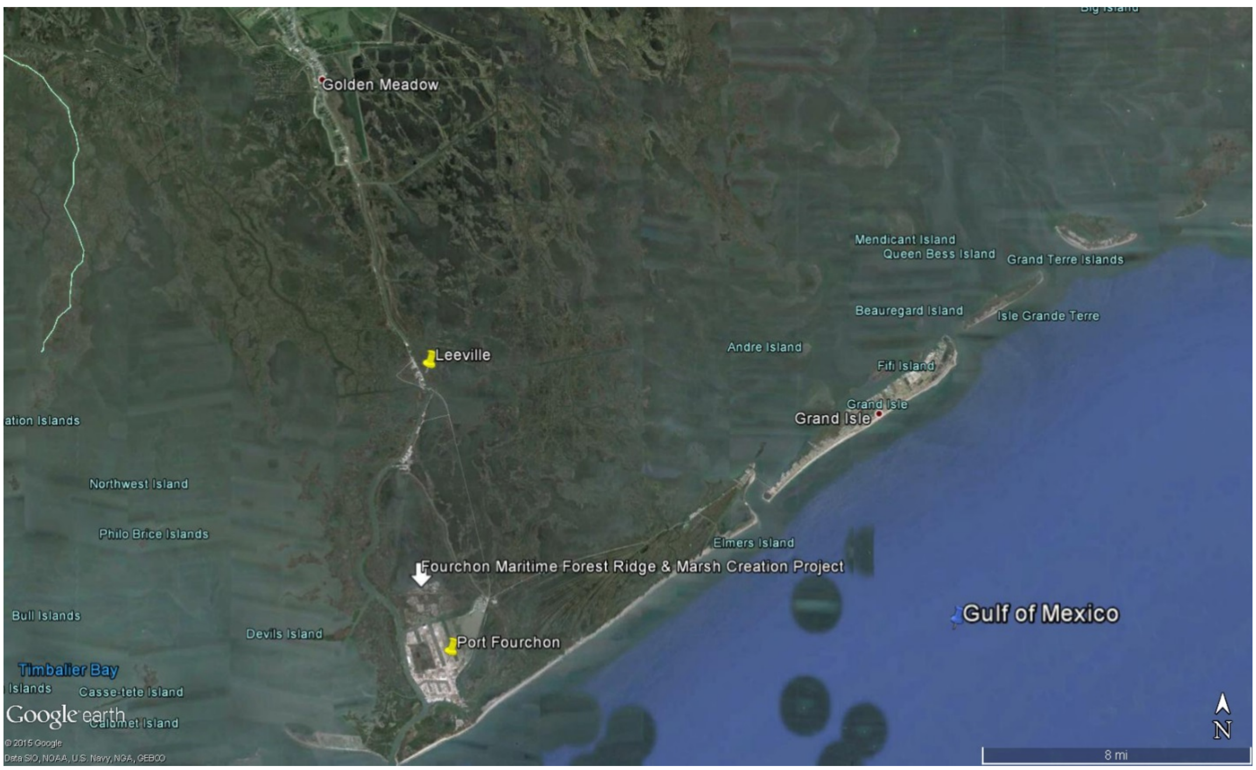

Figure 1 Aerial overview of project site location in SE Louisiana.

The Ridge and Marsh site is approximately 6,050 linear feet and approximately 400 feet wide. The 400 foot wide project footprint was originally created for a 200 foot wide ridge and slope section surrounded on either side by a 100 foot marsh apron section, but this ridge versus marsh dimensions varied considerably as construction realities presented themselves. The Ridge and Marsh site is further broken down into three sections named for the three different times sediment was pumped and shaped over a period of approximately five years to create what constitutes the Ridge and Marsh today. A first, short test section, we call the Old Ridge and Marsh was finished in spring 2003. This Old Ridge and Marsh section today is approximately 210 feet long by 400 feet wide and 0.82 acres in area (ridge top, 0.15 acres; marsh and ridge slope, 0.67 acres). The first phase of construction, we call the Middle Ridge and Marsh section, was finished in May 2005. The Middle Ridge and Marsh section is approximately 2,000 feet long by 400 feet wide and approximately 18.52 acres in area (ridge top, 5.83 acres; marsh and ridge slope, 12.69 acres). The second phase of construction and latest completed section, we call the Far Ridge and Marsh, was finished in the summer of 2008 (Figure 2). The Far Ridge and Marsh section is approximately 3,850 feet long by 400 feet wide and approximately 36.66 acres in area (ridge top, 7.37 acres; marsh and ridge slope, 29.29 acres). Unlike the previous two sections, because less material was ultimately available than originally thought for this section, the ridge itself only extends approximately 2,900 feet with the last 950 feet or so on the far western end only at marsh elevation (Figure 3). Total ridge top acreage for the entire Fourchon Maritime Ridge (Phases 1 & 2) then is approximately 13.35 acres with a total marsh apron and ridge slope area of approximately 42.65 acres.

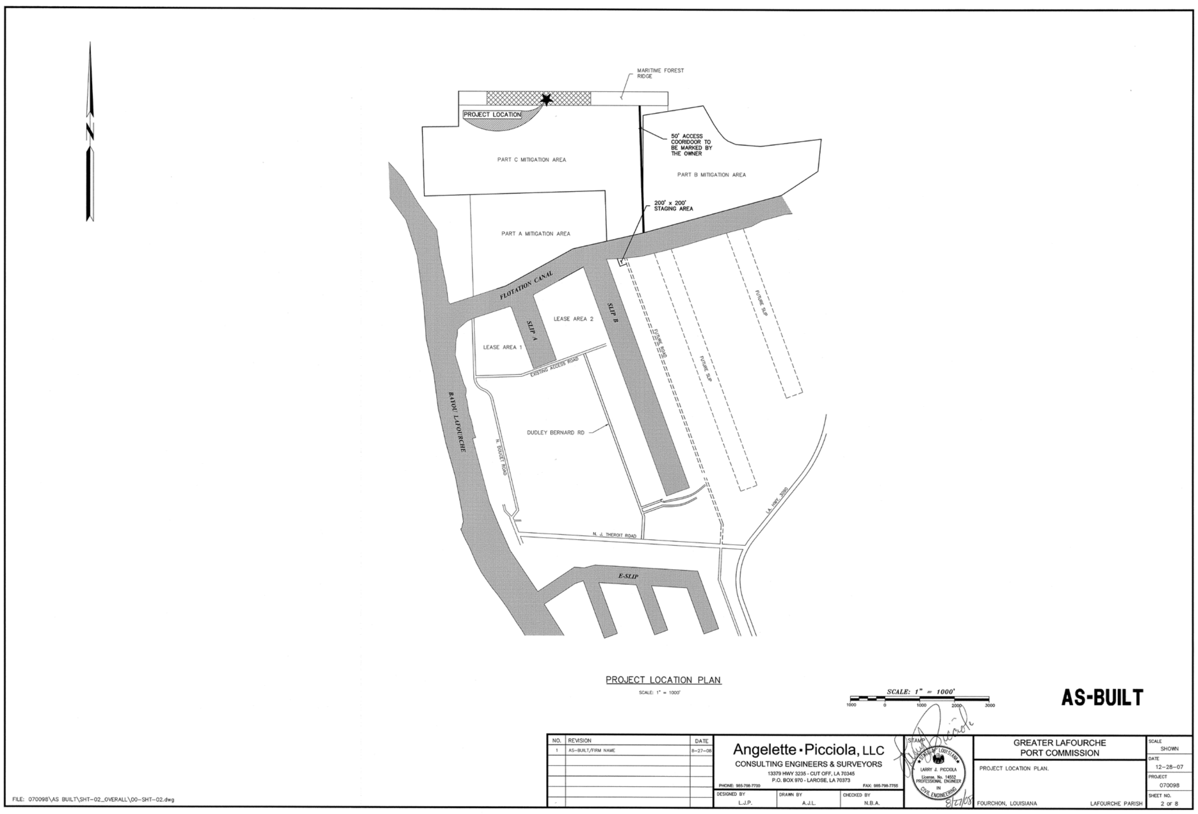

Figure 2 As-Built project location plan schematic for Phase Two completed in 2008.

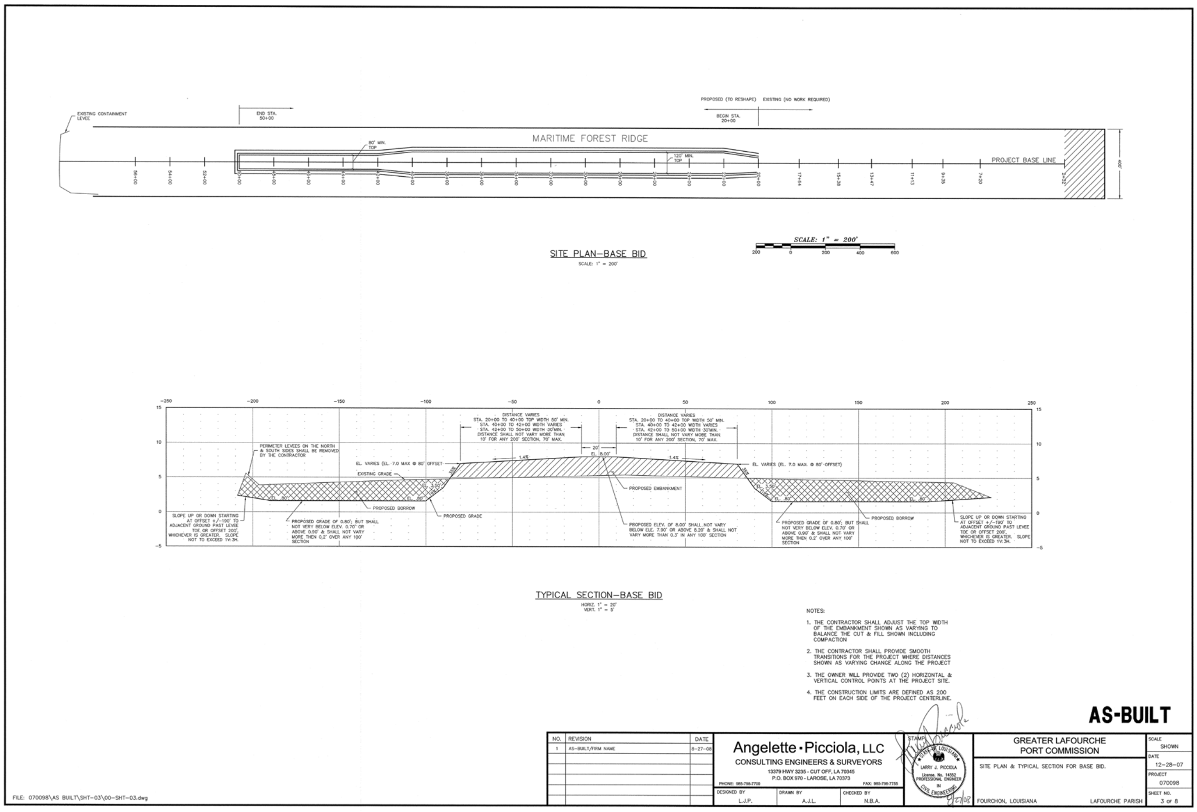

Figure 3 Site plan and typical section for base bid, Phase Two, August 27, 2008.

3.0 PROJECT SITE BACKGROUND

In the late 1990's, the Greater Lafourche Port Commission (GLPC), in an effort to meet increasing demand for boat slip space for companies servicing the oil and gas rigs in the Gulf of Mexico, began construction on a new slip in Port Fourchon. As with all projects that impact wetlands through the dredging of marsh sediment, mitigation of the damages to the marsh is required by law. However, the dredging of the slip and the volume of material that was to be moved exceeded that needed for mitigation. Needing to find something to do with this excess material, the GLPC fostered a partnership with the Barataria-Terrebonne National Estuary Program (BTNEP) to reestablish a chenier ridge and associated coastal marsh habitats along the submerged remnants of a former bayou north of the port and immediately adjacent to the recently created marsh mitigation. Figure 4 shows available imagery from Google Earth of the project area pre-construction (February 1998) through to January 2015.

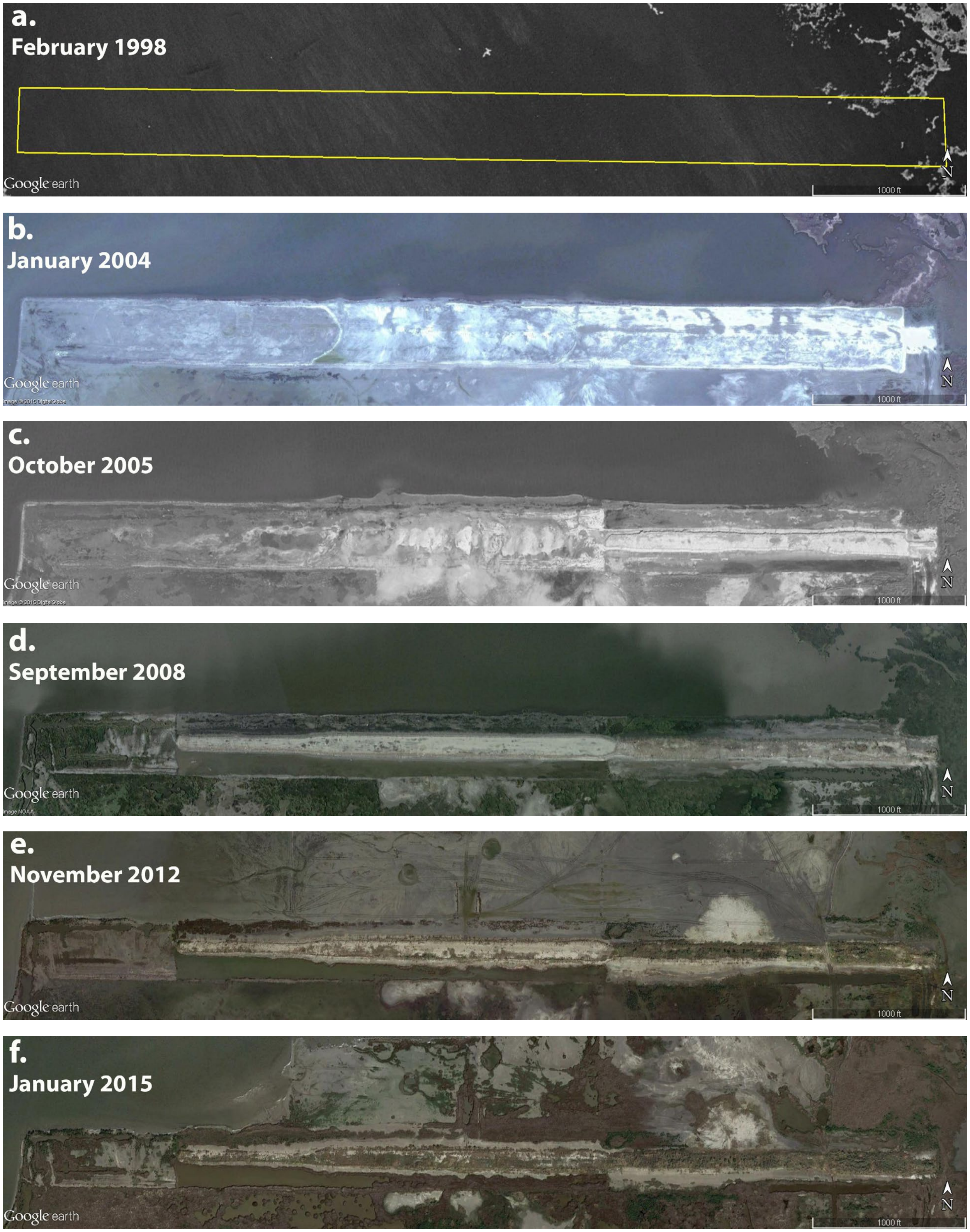

Figure 4 Chronological aerial images (a-f) from 1998 to 2015 of Phases 1 and 2 construction of the Fourchon Maritime Forest Ridge and Marsh Creation Project.

Initially, the maritime forest ridge and marsh restoration project served several purposes. First, it served to protect the recently created mitigation area immediately to the south of the ridge and second, it served as habitat for both fish and wildlife. Also, through the vegetative efforts that BTNEP implemented with hundreds of volunteers, it served to educate people from all over the nation first hand to Louisiana's biggest environmental problem --- coastal land loss.

Using in situ borrow material, an earthen containment dike was dug around the boundaries of a shallow open water site immediately north of the GLPC's mitigation site. The dredged slip material was then pumped via hydraulic dredge through a pipeline as a sediment slurry to the containment area. To get the ridge geometry to a final plus 8 feet in height and 200 foot in width after reworking with a bull dozer and excavator, the 400 foot wide containment area needed to be filled and constructed to an elevation of 4 feet. But because of problems with blowouts in the retention levees due to the pressure exerted on them from the 24 inch slurry pipe and problems with the subsurface in situ material the retention levees were built upon being highly organic and being pushed out by the new, heavier pumped in material, only 3 feet of height of sediment at most was ever obtained in this first area. Therefore, a decision was made to wait and pump a second lift of material, when it became available, to provide the necessary material needed to achieve the landscape desired and permitted for. In the meantime, it was decided to shape a 250 foot long section as an experiment to determine how the material would stack, the time involved in the process, and the equipment and costs needed when it finally became able to fully implement the first phase. This first short section, the Old Ridge and Marsh, was completed in the spring of 2003. BTNEP contracted the Natural Resources Conservation Service (NRCS) Plant Materials Center (PMC) in Golden Meadow to plant herbaceous and woody plants on the top, slopes and flanking edges of the ridge. Herbaceous plants included seashore paspalum, saltgrass, marshhay cordgrass and others. Woody plants included live oak, hackberry and American beautyberry.

As more sediment became available, the second lift of dredge materials was pumped onto the site. After dewatering and drying out, shaping of the first phase of the ridge began in February 2005. Final shaping of this section of the ridge, we call the Middle Ridge, was completed in May of 2005. Dimensions of the ridge and marsh varied across the site with the ridge and slopes 100 to 150 foot wide and the marsh platform flanking either side 125 to 150 foot wide for an overall width of 400 feet north to south and a 2,000 foot length west to east.

In order to try and stabilize the site as quickly as possible, BTNEP contracted with the NRCS PMC to provide plants and technical assistance for vegetative plantings on the ridge and marsh platforms. Multiple plantings were initiated between May 2005 and May 2006. Over 200 volunteers helped during these various plantings. Herbaceous species planted included smooth cordgrass, marshhay cordgrass, saltgrass and seashore paspalum. Woody species planted included salt matrimony vine, red mulberry, hackberry, live oak, American beautyberry, yaupon, wax myrtle and black mangrove. Grass seeding of the ridge was also implemented and included Sordan 79 (Sorghum-Sudangrass hybrid), German R strain millet, “Jose” tall wheatgrass, Alamo switchgrass, chloris, saltgrass and bitter panicum.

After additional pumping of sediment to the project site in late 2006 (Figure 5), Phase Two was shaped in 2008 and completed that summer (Figure 6). Similar to Phase One, with a project width of 400 feet, the overall footprint length was twice the size and the resulting ridge about 50% longer. Originally planned for 4,000 linear feet, less material was available than was originally expected making it necessary to reduce both the length and part of the width of the ridge. While the ridge feature ended up being roughly 2,900 feet long built to an initial 8 feet in elevation, the last 900 feet or so was considerably narrower than the first 2,000 feet. The first 2,000 feet added on to the first phase (Middle Ridge) was approximately 150 to 200 feet wide for the ridge and slopes with the flanking marsh aprons 100 to 125 feet wide each. For the last 900 feet of the ridge (the westernmost end of the ridge), the ridge width was approximately 125 to 150 feet wide with the flanking marsh aprons on either side approximately 125 to 138 feet wide. The last approximately 1,000 feet of the project site (westernmost end) included only the marsh feature and was pumped to an elevation of +1.6 feet.

Figure 5 Pumping earthen material to Phase Two site in 2006.

Figure 6 Excavators digging down fill to marsh elevation and stacking the material to build up the elevation of the ridge. South marsh apron of Far Ridge, May 29, 2008, looking west.

3.1 Soil Quality

The use of in situ saline marsh sediments for the creation of the Ridge caused many problems in getting non-halophytic native woody species to grow at the site. Soils that are too saline don't allow for non-adapted plants to absorb enough water. Plant roots naturally contain salts that help plants take up water from the soil. When the soil salinity gets as high as the roots, however, it becomes harder for water to enter the roots. If soil salinity gets really high, it can actually draw water from the plant roots back into the soil. At excessively high soil salinity concentrations, then, plants begin to wilt and die, no matter the amount of water they receive.

Salts in the soil on the ridge stay high because soil conditions don't allow the salts to leach out. Leaching is inhibited on the ridge because of poor soil structure due to compaction, clays, and high sodium content in the soil keeping the soil particles dispersed. This prevents soil particles from aggregating into larger particles. A larger space between soil aggregates allows for higher air and water permeability. Salts can also build up on the ridge in areas that pool water and don't drain quickly, which allows for a concentration and crusting of salts at the soil surface due to evaporation. Salts can also build up in depressions where water moves through the soil from higher areas and discharges as a seep into the depression. The soils on the Ridge are saline-sodic soils, which are saline soils containing higher concentrations of sodium salts relative to calcium and magnesium salts.

Because these Ridge soils pose such a dilemma in getting non-halophytic native woody species established on the ridge, a soil sampling regime was established on the Middle Ridge in May 2008 and the Far Ridge in January 2009 in order to begin to get an understanding of the soil characterization over time (Figure 7). Samples included three landforms (marsh, ridge slope, and ridge top) with sampling continued on a nearly biannual basis up until October 2015 with plans for a limited annual sampling beyond the funding of this Coastal Impact Assistance Program (CIAP) grant. Pairing soil sample results and analysis with plant response from experimental plantings, we were able to illustrate the effects these soils have on plant survival and growth parameters that can be useful in planning future woody species plantings on ridge creation projects using in situ saline marsh sediments.

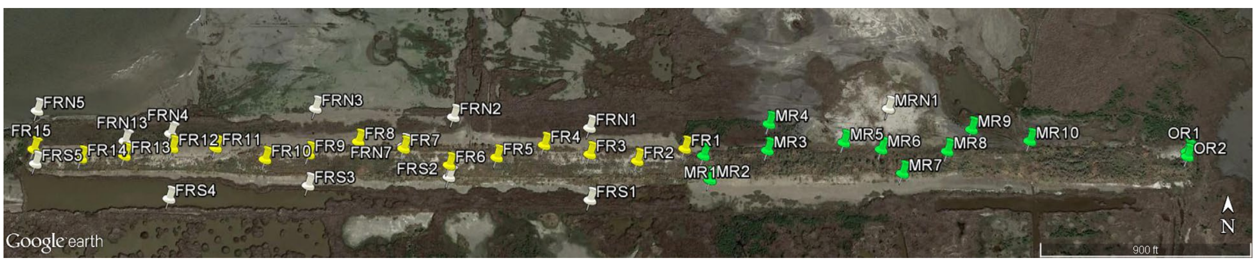

Figure 7 Aerial image of all soil sample locations taken at Fourchon Maritime Forest Ridge and Marsh Restoration. The first two letters for each soil sample site correspond to the part of the ridge it collected from: OR – Old Ridge; MR – Middle Ridge; and FR – Far Ridge.

3.2 The Far Ridge

Following completion of the Far Ridge in the summer of 2008, natural volunteer vegetative establishment was slow in coming. Hurricane Gustav, landing at Cocodrie, Louisiana, September 1, 2008, deposited a thick layer of wrack and debris on the south slope of the ridge (Figure 8). This resulted in very little erosion occurring over the years on the south side. Meanwhile, considerable erosion has occurred on the north side which did not benefit from wrack deposition. Precipitation from surface runoff caused rivulet formation on the ridge top as sediment moved off of the ridge, down the northern ridge slope and onto the northern marsh apron. Gulleys, big enough to stand in, began forming along the northern ridge slope. For years, during rain events a 2 to 3 inch layer of slushy “mud” would form on the surface in areas conducive to rapid erosion (Figure 9). Considerable effort through herbaceous plantings along the north slope and northern top edge of the ridge have slowed the erosion, but some areas along the north side have eroded considerably, especially along the narrower western end.

Figure 8 Wrack deposition on the south slope of the Far Ridge looking WSW, May 28, 2009.

Figure 9 Herbaceous planting along the top edge of Far Ridge, December 13, 2009, looking west.

Although the first 2,000 feet or so of the Far Ridge from the eastern end where it connects to the 2005 phase one Middle Ridge averaged approximately 110 feet of ridge top 4 months post-construction, the last 900 or so feet of the ridge to the western terminus, averaged approximately 64 feet. This narrowing of the ridge on the western end resulted from having less sediment than was anticipated when construction of this phase of the ridge began. This narrower ridge top section has exhibited an increase in erosion over the years and has led to a reduction in the establishment of herbaceous plants that could have reduced this erosion over time.

Seven years post-construction (2015), portions of this narrower western end still have little to any herbaceous vegetation established along the northern slope and northern top edge. The constructed 35% ridge slopes were not stable and have flattened considerably over the years as soil moved from the ridge top out onto the marsh apron. A wide unvegetated zone still remains from the tow of the ridge slope out into the high marsh (Figure 10). Repeated attempts to vegetate this area have failed in gaining vegetative establishment. However, successful smooth

Figure 10 Unvegetated zone between ridge slope to the right and high marsh on the left, December 2, 2015. North marsh apron looking east.

cordgrass (*Spartina alterniflora*) plantings in the lower marsh areas and the natural voluntary establishment of black mangrove (*Avicennia germinans*) from washed in propagules from the surrounding naturally occurring black mangroves have protected the northern slope from wave energy from the northern body of open water. Additionally, subsequent mitigative marsh creation by the GLPC begun in 2011 and finished in 2012 adjacent and to the north of this marsh apron has further solidified this protection. Even relatively stable areas (not particularly erosive) of the top of the Ridge have been resistant to plant establishment over the years post construction despite repeated herbaceous and woody plantings. It is not known why these areas remain bare, but condition of the soil is the most likely culprit with elevated salinity levels at the top of the list. Similar barren areas remained for years on the Middle Ridge as well, but have now, finally, largely succumbed to encroaching vegetation and repeated plantings.

At the end of 2015, through repeated herbaceous and woody vegetative plantings with the assistance of hundreds of volunteers over the years and through the natural, volunteer establishment of herbaceous plants and shrubs, the plant coverage of the Far Ridge is estimated at 85 to 90 percent (Figure 11).

Figure 11 Western end of Far Ridge looking east, December 2, 2015.

4.0 METHODS FOR WOODY VEGETATIVE FIELD STUDIES

4.1 Objectives

The objectives of the woody vegetative field studies were to: 1) establish a series of woody vegetative trials over time in order to determine plant response to the highly altered soils from a man-made ridge using in situ saline marsh sediments from the Port Fourchon expansion; 2) conduct this series of trials to determine if the addition of cultural treatments increased survival or plant growth response; 3) determine which woody species survived and grew best in these highly altered saline soils; and 4) determine the change in soil parameters over time that produces conditions suitable for increase in vegetative survival and other plant variables.

4.2 Woody Species Selection

Most of the woody species selected for this study originated from species that had been evaluated under a separate BTNEP/NRCS Plant Materials Center study entitled "An Accelerated Program of Woody Species Selection for Conservation, Restoration, and Neotropical Habitat Enhancement" which had focused on native trees known to grow along the Louisiana coast that were important to Neotropical migratory birds. Additional species selected came out of discussions from BTNEP's Bird Workgroup populated by various birders from the private and professional sectors and from governmental agencies. Ultimately, over the course of the six years experimental plantings were carried out for this project, ten species were utilized. These species were: live oak (*Quercus virginiana*), sand live oak (*Quercus geminata*), hackberry (*Celtis laevigata*), American beautyberry (*Callicarpa americana*), honeylocust (*Gleditsia triacanthos*), persimmon (*Diospyros virginiana*), roughleaf dogwood (*Cornus drummondii*), yaupon (*Ilex vomitoria*), Hercules' club (*Zanthoxylum clava-herculis*), and salt matrimony vine (*Lycium carolinianum*). Acorns and seeds for the selected species were collected throughout the year for grow out at BTNEP's Native Plant Nursery at the Nicholls State University Farm located in Thibodaux, Louisiana. All seeds were collected from coastal Louisiana with the exception of sand live oak, which is native to Louisiana but which no longer is naturally found in any substantial quantity, if at all. Still found in abundance along the Gulf Coast from Mississippi to Florida, BTNEP collected sand live oak acorns along the panhandle of Florida for use in this project. Sand live oak tolerates severe conditions found in maritime areas, even growing in the deep infertile sands found on the coastal dunes of barrier islands. Known for increased tolerance to salt spray and exceptional drought tolerance, it was expected that this species would perform as well or better than most of the species used in this project.

Whenever possible, acorns and seed were selected from coastal areas similar to the project area planted. By collecting seed in areas of maritime influence it is thought that they may be better adapted to the saline soils and harsh conditions found at the Ridge to which they were planted and which lies less than four miles from the Gulf of Mexico. Species collected immediately adjacent to the Gulf were live oak, sand live oak, hackberry, yaupon, and salt matrimony vine. The rest of the species were collected from coastal Louisiana parishes further inland. A seed and dates of collection list has been added as Appendix 1.

Live oak acorns were collected off the ground, while sand live oak acorns were collected off the trees. Both were floated and checked for weevils before potting (Figure 12). The rest of the woody species seeds were collected from the tree with the exception of persimmon which was collected mostly off the ground. Collected acorns and seeds were immediately brought back to BTNEP's nursery facility, cleaned by hand or macerated with a blender, prepared, and either directly potted, dry stored or cold stratified as necessary. Prior to potting the seed, seeds requiring scarification were scarified.

Acorns and seeds were potted in 2 inch diameter by 7 inch deep Deepots™ (D16L) conetainers (Figure 13). Potting medium used was PRO-MIX® BX MYCORRHIZAE™ which is 75-85%

Figure 12 Acorn weevil on sand live oak acorn, Santa Rosa Island, Escambia County, Florida, October 27, 2013.

Figure 13 Live oak seedlings growing out in Deepots™ (D16L) conetainers, April 4, 2011.

sphagnum moss with the addition of perlite, vermiculite, and limestone. Seedlings were fertilized either with 9 month Osmocote® Smart-Release® Plant Food Plus Outdoor & Indoor 19(N)-6(P)-12(K) or Miracle-Gro® 24(N)-8(P)-16(K) or both for the duration of grow out with no fertilization occurring during the dormant season. Plants were watered with an overhead irrigation system at least once a day (twice in the hot summer months). Potted seedlings were placed in trays and put on tables under a 60% shade cloth (Figure 14). Overwintering of seedlings remained under the shade cloth with seedlings covered and wrapped in plastic sheeting with heat lamps during the occasional freeze. Pesticides used as needed included Spectracide® Malathion Insect Spray Concentrate. Fungicide used as needed was Spectracide® IMMUNOX Multi-Purpose Fungicide Spray Concentrate.

Seedlings, remaining in their conetainers and trays, were transported to the Ridge by covered trailer to the boat launch, loaded onto boats, and then offloaded by hand at the ridge planting site. An All-Terrain Vehicle (ATV) with a trailer was used to transport plants from the boat offloading site to the planting sites. Cultural treatments were moved to the planting site by way of ATV as well.

Figure 14 Woody and herbaceous species growing out in the BTNEP shadehouse on the Nicholls State University Farm in Thibodaux, Louisiana, September 26, 2013.

4.3 Soil Amendment Treatments

For these woody species trial plantings, a control (no soil amendments) and three soil amendment treatments were used: bagasse, fertilizer, and gypsum.

Bagasse is a by-product of the sugar cane industry. It is the fibrous remains after the process of crushing the cane to extract the sugar. The bagasse used in this study had been sitting in a pile outside for over 20 years and was donated by Organic Processors, Thibodaux, Louisiana. The bagasse served as added organic material that would help retain soil moisture and nutrients in the plant root zone. Organic matter also helps particles in the soil bind together making it more porous to create spaces for air, water, and plant roots. Organic matter also provides nutrients to bacteria and other organisms in the soil which recycle nutrients in to forms readily available to be absorbed by the plants roots.

The fertilizer used for these plantings is a 21 gram 20(N)-10(P)-5(K) slow release orchard tablet from either Forestry Suppliers, Inc., Jackson, Mississippi or Scotts® Agriform, Scotts Miracle-Gro Company, Marysville, Ohio. The 20-10-5 two year release orchard tablets contained: Total Nitrogen (N) 20%, Available Phosphate (P) 10%, Soluble Potash (K) 5%, Chlorine (Cl) 1%, Free Sulfur (S) 2%, Total Iron (Fe) 2.5%, Total Manganese (Mn) 2%, Total Magnesium (Mg) 2.25%, Total Zinc (Zn) 0.18%. The fertilizer tablet provides essential nutrients for plants to flourish. Nitrogen promotes healthy leaf growth through the stimulation of chlorophyll production. Phosphorus promotes the root and stem development. Potassium stimulates early growth, increases protein production and improves water use efficiency.

The gypsum used was Pelletized Gypsum from MK Minerals, Inc., in Wathena, Kansas. The pelletized gypsum contained: Calcium (Ca) 20%, Sulfur (S) 16%, Calcium Sulfate ($CaSO_4$) 68%, Water Soluble Binder – lignosulfate 2%. Gypsum served to remove sodium in the soil and replace it with calcium. Gypsum also binds clay particles together to make larger particles, creating porous spaces for air, water, and plant roots. Gypsum also adds calcium and sulfur to the soil, important plant nutrients.

4.4 Experimental Plot Site Selections

The eight woody vegetative field trials conducted at the Ridge over the six year period (2009-2014) were planted in five different locations (Figure 15). The first woody trial, called the "Ring Planting", was the only trial that included replication sites on the Middle Ridge as well as the Far Ridge. This woody trial looked to compare survival and growth between the two ridges. The rest of the woody vegetation trials were located exclusively on the Far Ridge as these studies were done yearly in concurrence with soil sampling to ascertain plant response to soil conditions over time.

Figure 15 Aerial view of all vegetative trial planting locations planted on the Middle and Far Ridges from 2009-2014. Imagery date: January 25, 2015.

4.5 Ring Planting

The first experimental woody species trial planting is the only one that compared survival and growth between the Middle Ridge and the Far Ridge (Figure 16). The Middle Ridge construction was completed in May of 2005, while the Far Ridge was completed in August of 2008. This planting was executed on February 28, 2009 with a total of 114 trade gallon size plants obtained from the Golden Meadow NRCS PMC in Galliano, Louisiana, that were going to be discarded. These plants were considerably pot bound as they had been growing in the trade gallon containers for four years. Typical trade gallon use is for two years. The Middle Ridge was almost four years post-construction and considerably vegetated, mostly with herbaceous species and to a lesser extent some woody species as well (Figure 17). The Far Ridge was still completely barren of any vegetation less than half a year post-construction and yet to begin the 2009 growing season (Figure 18).

Three replications with no soil amendments were planted at each location on the Middle Ridge and Far Ridge. Each replication consisted of 19 trade gallon sized pots of four woody species: red mulberry, sand live oak, yaupon, and American beautyberry. Each replication started with a plant in the center with two rings of plants encircling it at five foot intervals. The inner ring of plants, five feet out from the center, had plants spaced approximately every five feet around the circumference for a total of six plants. The outer ring's plants were also spaced five feet apart around the circumference for another 12 plants. The species were randomly assigned to

Figure 16 Aerial view of Ring Planting location, planted February 28, 2009 on the Middle and Far Ridges. Middle Ridge replicates are labeled MRC1-3 and Far Ridge replicates labeled FRC1-3. Imagery date: September 4, 2008.

Figure 17 Pre-flagging Ring Planting plot on Middle Ridge prior to planting, February 17, 2009. Looking west.

Figure 18 Ring Planting plot on the Far Ridge, February 28, 2009. Looking west.

one of the 19 positions in the replication plot. Each plant location was delineated with a different color pin flag for future reference.

Planting technique for the Ring Planting included the use of gas drills with 7 inch diameter auger bits. Holes were augered to a depth of 7 inches. Four-year-old root bound woody plants were removed from the trade gallon containers. Roots were cut and pulled so as to stimulate new root growth and encourage roots to spread from root ball. Soil was placed back in the bottom of the hole as needed in order to get the top of the root ball at or just below the surrounding soil level. Additional soil was placed around the sides of the root ball and packed. Two 21 gram slow release orchard tablets containing 20(N)-10(P)-5(K) were placed beside the root ball for fertilizer. Additional soil was added around the sides of the root ball and further packed. Finally, a light covering of soil was added to the entire root ball and firmly packed. Plants were not watered as it was logistically not possible to do so.

Baseline growth data was taken immediately following completion of planting. End of growing season data was collected once at the end of the growing season on September 15, 2009. Vigor was assessed visually on a 9 point scale adopted from the NRCS with 1 having the greatest vigor and 9 being dead. All plants in the Far Ridge plots were recorded as dead. Growth measurements of height, spread, and basal stem diameter were measured from surviving plants in Middle Ridge plots and recorded as described in detail in section 4.10. For consistency of vigor measurements, end of growing season data collection was collected by a single crew of BTNEP staff. Field data measurements were then recorded in Microsoft® Excel Spreadsheets for use in future statistical analysis.

4.6 Woody Trial Block Plantings

Woody trial "block plantings" were planted exclusively on the 2008 Far Ridge ridge top. Replication plots for the woody trial block plantings consisted of 32 plants in 4 rows of 8 plants each (Figure 19). All plants and rows were on 8 foot centers with 12 feet between plots. Plots measured 24 feet by 56 feet. Four foot rebar was pounded into the earth and used to establish the corners. The rebar corners were 4 feet off the first and last lengthwise rows and in line with the plants at the beginning and end of the rows. The locations of the corners were then recorded with GPS. These measures, along with the plants being planted in a grid pattern, insured future finding of plots and plant locations in case of storm damage and as the ridge became increasingly vegetated over the project timeframe. Treatment plots and plants within treatment plots were completely randomized prior to planting. Quantities for soil treatment amendments used per plant (unless otherwise noted: see 2014 Block Planting, page 29) are one quart (32 oz.) of bagasse, one 21 gram orchard tablet fertilizer, and one cup (8 oz.) pelletized gypsum (equivalent to 40 tons per acre based on recommended application from initial soil sample analysis).

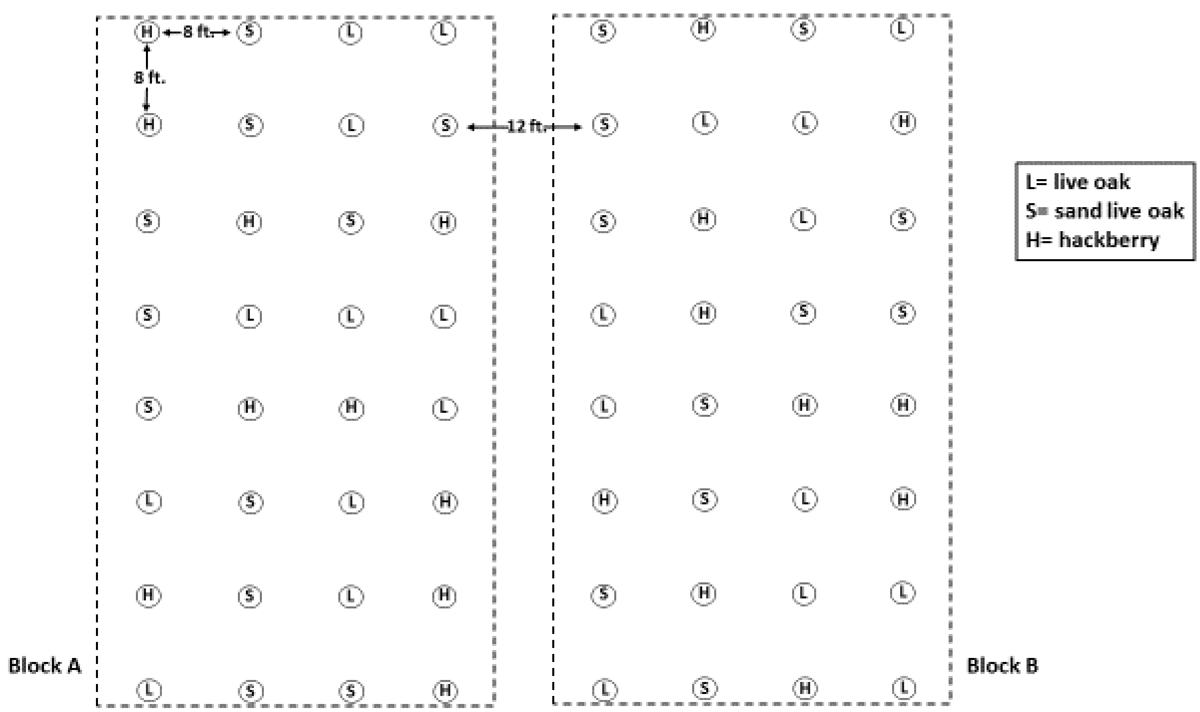

Figure 19 Schematic of example blocks within experimental block plantings. Species were randomized within each block and treatments were randomized among blocks.

Treatments for replicates varied according to experimental design. A control (no additives) and three treatments (bagasse, fertilizer, and gypsum) and various combinations of these three were used for the different block plantings listed below. The following is a description of a replicate of all 3 treatments (bagasse + fertilizer + gypsum); therefore, for a description of a replicate of only bagasse as a treatment, you would remove the description of the addition of the fertilizer and gypsum with everything else remaining the same.

> **Planting technique for the woody trial block plantings** included the use of gas drills with 7 inch diameter auger bits. Holes were augered to a depth of 7 inches. A third of a cup of the bagasse, used as organic matter for moisture retention, was placed at the bottom of the hole. One year old woody seedlings grown out in 2 inch by 7 inch Deepots™ (D16L) conetainers were removed from the Deepots™ and placed in the hole. Soil displaced while augering the holes was placed back in the bottom of the hole as needed in order to get the top of the root ball at or just below the surrounding soil level. Additional soil was placed around the sides of the root ball and packed to midway up the root ball. A 21 gram slow release fertilizer orchard tablet was placed beside the root ball. Additionally, one third of a cup of bagasse and half a cup of gypsum was placed in the hole. Additional soil was added around the sides of the root ball and further packed to almost up to the surrounding soil level. The last third of bagasse and the last half cup of gypsum were added around the root ball in the hole. Finally, a light covering of displaced in situ soil was added over the entire root ball and firmly packed. Plants were not watered as it was logistically not possible to do so.

4.6.1 2010 Block Planting - March 16, 2010

The first woody trial block planted on the Far Ridge, named the “2010 Block Planting”, is the westernmost woody trial planting site. Because the westernmost 900 foot end of the Far Ridge averaged about 64 feet of ridge top and the replication plots measured 24 feet by 56 feet, and because erosion of the ridge was already visibly taking place, the first 7 (A-G) plots were oriented lengthwise west to east (Figure 20). Once the plots got to the 900 or so feet in from the westernmost end of the ridge top, the ridge top began to average about 110 feet wide for the rest of the 2000 or so feet of ridge. Because of the widening of the ridge at this point, the plots were reoriented with the lengthwise side of the plot oriented south to north for the rest of the 17 plots (H-X). The entire 24 plots of this woody trial occupied about 1,100 linear feet of the ridge.

Figure 20 Aerial view of the 2010 Block Planting location planted on the Far Ridge March 16, 2010. Plots are labeled A to X. The four yellow rectangles show examples of approximate size and orientation of plots on the ridge. Imagery date: January 25, 2015.

This woody trial included 3 species (sand live oak, salt matrimony vine, and hackberry) totaling 32 plants per plot and 8 levels of soil amendments (bagasse, fertilizer, gypsum, bagasse x fertilizer, bagasse x gypsum, fertilizer x gypsum, bagasse x fertilizer x gypsum, and control) replicated 3 times for a total of 24 plots and 768 total plants (Figures 21, 22 & 23).

Treatment plots and plants within treatment plots were completely randomized prior to planting. This planting was implemented on March 16, 2010, utilizing volunteer help. Baseline growth data was taken immediately following completion of planting. End of growing season data was collected six times for this trial at the beginning of October in 2010, 2011, 2012, 2013, 2014, and 2015. Vigor was assessed visually on a 9 point scale adopted from the NRCS with 1 having the greatest vigor and 9 being dead. Height, spread, and basal stem diameter were measured and recorded as described in detail in section 4.10. For consistency in vigor measurements, end of growing season data collection was collected by a single crew of BTNEP staff. Field data measurements were then recorded in Microsoft® Excel Spreadsheets for use in future statistical analysis.

Figure 21 Augering holes for 2010 Block Planting, March 16, 2010.

Figure 22 Augering holes for 2010 Block Planting, March 16, 2010.

Figure 23 Cultural treatments being added to experimental plot at time of planting for 2010 Block Planting, March 16, 2010.

4.6.2 2011 Block Planting – March 10, 2011

The second woody trial block planted on the Far Ridge, named the "2011 Block Planting", was located immediately adjacent and to the east of the first woody trial location. Because it was decided to leave a section of the top of the Far Ridge to grow up initially, naturally and without an experimental woody block planting, this next planting was reduced in size by reducing the number of levels of soil amendments. This reduced the footprint from 24 plots to 15 plots. Since the entirety of this woody trial fell in the wider section of the Far Ridge, all of the plots were oriented south to north lengthwise with the first plot (A) to the west and running east to the last plot (O). Because the staging area for bringing plants and equipment up onto the ridge top had already been established, a break in the plots was put in, resulting in the last 4 plots beginning approximately 90 feet further east from the rest of the 11 plots (Figure 24). These plots were of the same size and dimensions of the 2010 Block Planting, being 24 feet in width and 56 feet in length.

This woody trial included 3 species (live oak, hackberry, and American beautyberry) totaling 32 plants per plot and 5 levels of soil amendments (bagasse, fertilizer, gypsum, bagasse x fertilizer x gypsum, and control) replicated 3 times for a total of 15 plots and 480 total plants. Treatment plots and plants within treatment plots were completely randomized prior to planting. This planting was implemented on March 10, 2011 utilizing volunteer help (Figure 25). Baseline growth data was taken immediately following completion of planting. End of growing season data was collected five times for this trial at the beginning of October in 2011, 2012, 2013,

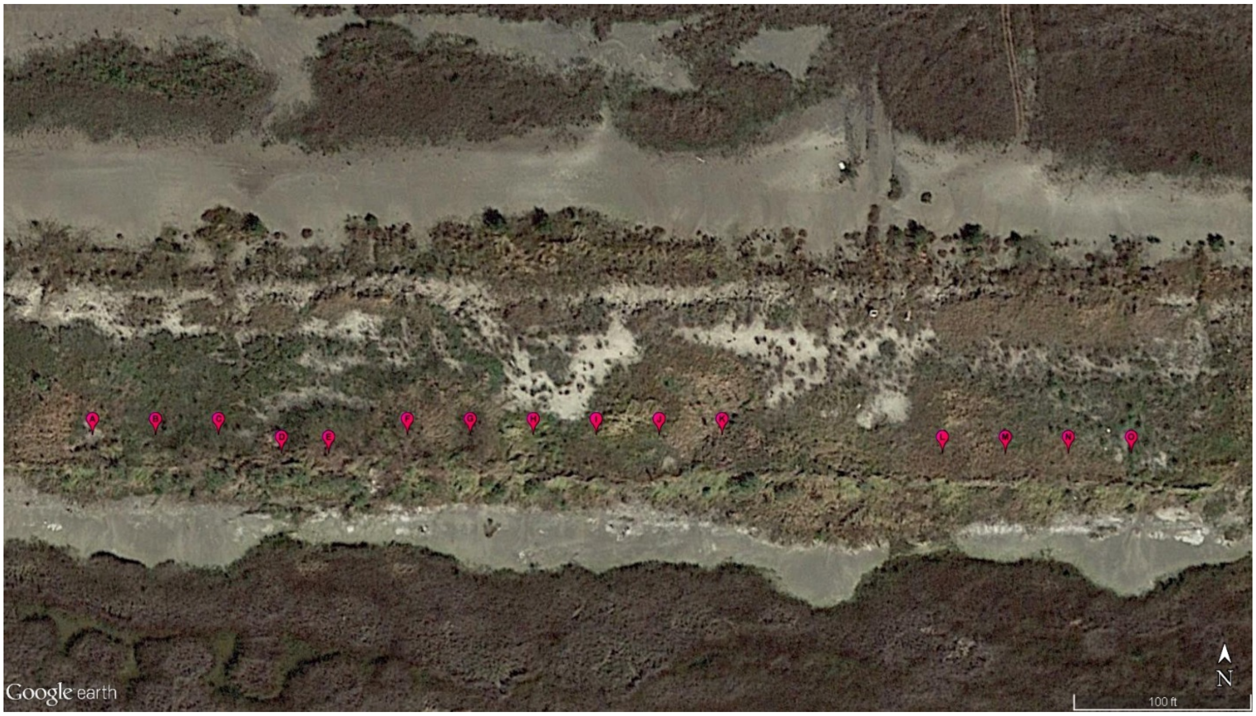

Figure 24 Aerial view of the 2011 Block Planting location planted on the Far Ridge March 10, 2011. Plots are labeled A to O. The Imagery date: January 25, 2015.

Figure 25 Packing up the gas drills and auger bits, 2011 Block Planting, March 10, 2011. Looking ESE.

2014, and 2015. Vigor was assessed visually on a 9 point scale adopted from the NRCS with 1 having the greatest vigor and 9 being dead. Height, spread, and basal stem diameter were measured and recorded as described in detail in section 4.10. For consistency in vigor measurements, end of growing season data collection was collected by a single crew of BTNEP staff. Field data measurements were then recorded in Microsoft® Excel Spreadsheets for use in future statistical analysis.

4.6.3 2012 Block Planting – February 23, 2012

The third woody trial block planted on the Far Ridge, named the “2012 Block Planting”, is located in the same exact plots as the 2011 Block Planting. Because the 2011 Block Planting had such extreme mortality and there was no more available space to do a large 15 plot planting on the Far Ridge, it was decided to do the planting in the same plots as the year before except instead of planting in the exact same locations (as there were some plants that did survive), for this planting all the plants were shifted over 1 foot to the east. Also, surviving plants from the previous year’s trial planting were reflagged with double pin flags and the current year’s planting was flagged different colors so as not to confuse the two. Additionally, as plans for a tidal creek to be dug through the middle of the ridge at the point where a gap was made in the 2011 Block Planting plots became known prior to this planting (although still not constructed at the time of this writing), the two plots on either side of the gap were abandoned and added onto the east end of the 2011 Block Planting plots (Figure 26). This gap area was widened, because it was feared that the size of the tidal creek and slope created from its creation might erode the previous adjacent plots on either side of the gap.

This woody trial included 3 species (live oak, sand live oak, and hackberry) totaling 32 plants per plot and 5 levels of soil amendments (bagasse, fertilizer, gypsum, bagasse x fertilizer x gypsum, and control) replicated 3 times for a total of 15 plots and 480 total plants (Figure 27). Treatment plots and plants within treatment plots were completely randomized prior to planting. This planting was implemented on February 23, 2012 utilizing volunteer help. Baseline growth data was taken immediately following completion of planting. End of growing season data was collected four times for this trial at the beginning of October in 2012, 2013, 2014, and 2015. Vigor was assessed visually on a 9 point scale adopted from the NRCS with 1 having the greatest vigor and 9 being dead. Height, spread, and basal stem diameter were measured and recorded as described in detail in section 4.10. For consistency in vigor measurements, end of growing season data collection was collected by a single crew of BTNEP staff. Field data measurements were then recorded in Microsoft® Excel Spreadsheets for use in future statistical analysis.

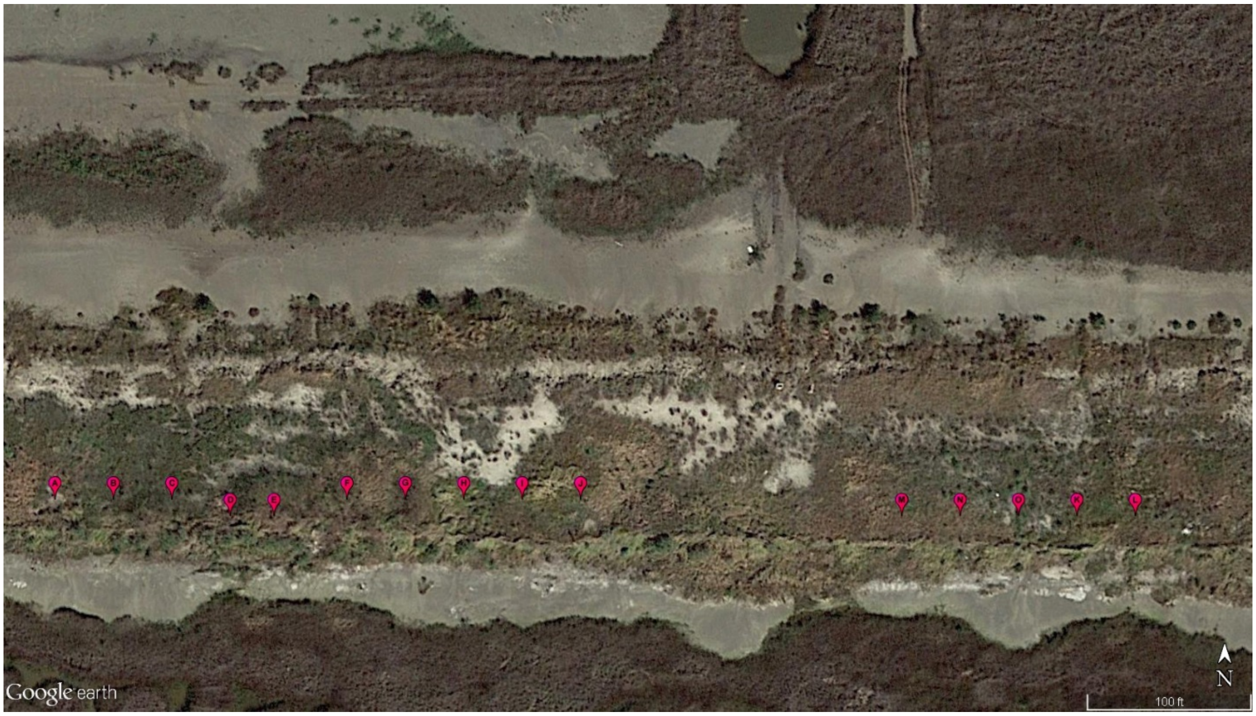

Figure 26 Aerial view of the 2012 Block Planting location planted on the Far Ridge February 23, 2012. Plots are labeled A to O. Plots K and L from 2011 Block Planting abandoned and added to the east of plot O. The Imagery date: January 25, 2015.

Figure 27 Adding treatments to the plant holes, 2012 Block Planting, February 23, 2012. Looking SW.

4.6.4 2013 Block Planting – January 28, 2013

The fourth woody trial block planted on the Far Ridge, named the “2013 Block Planting”, was located back in the first 15 plots of the 2010 Block Planting’s 24 plots, beginning with the first plot on the west and continuing to the east (Figure 28). As was the case in the 2012 Block Planting, being that there was no more available space to do a large 15 plot planting on the Far Ridge, it was decided to do the planting in the same plots as the first year’s planting, the 2010 Block Planting. Again, instead of planting in the exact same locations (as there were still some plants that did survive from the 2010 Block Planting), for this planting all the plants were shifted over 1 foot to the east. Also, surviving plants from the first year’s trial planting were reflagged with double pin flags and the current year’s planting was flagged different colors so as not to confuse the two.

This woody trial included 3 species (hackberry, live oak, and sand live oak) totaling 32 plants per plot and 5 levels of soil amendments (bagasse, fertilizer, gypsum, bagasse x fertilizer x gypsum, and control) replicated 3 times for a total of 15 plots and 480 total plants (Figure 29). Treatment plots and plants within treatment plots were completely randomized prior to planting. This planting was implemented on January 28, 2013 utilizing volunteer help. Baseline

Figure 28 Aerial view of the 2013 and 2014 Block Plantings’ location planted on the Far Ridge January 28, 2013 and March 26, 2014 respectively. Plots from left (west) labeled A to O are 2013 Block Planting. Plots labeled A to I on right (east) side of image are 2014 Block Planting. Plots for the 2013 and 2014 Block Plantings occupy the same plot location as the 2010 Block Planting. Imagery date: January 25, 2015.

Figure 29 BTNEP Staff showing volunteers how to add bagasse to plant hole. 2013 Block Planting, January 28, 2013. Looking ENE.

growth data was taken immediately following completion of planting. End of growing season data was collected three times for this trial at the beginning of October in 2013, 2014, and 2015. Vigor was assessed visually on a 9 point scale adopted from the NRCS with 1 having the greatest vigor and 9 being dead. Height, spread, and basal stem diameter were measured and recorded as described in detail in section 4.10. For consistency in vigor measurements, end of growing season data collection was collected by a single crew of BTNEP staff. Field data measurements were then recorded in Microsoft® Excel Spreadsheets for use in future statistical analysis.

4.6.5 2014 Block Planting – March 26, 2014

The fifth woody trial block planted on the Far Ridge, named the “2014 Block Planting”, was located back in the last 9 plots of the 2010 Block Planting’s 24 plots, beginning with the first plot immediately following the last plot of the 2013 Block Planting from the previous year and continuing east to the last block of the first year’s planting (see Figure 28 above). As was the case in the 2012 Block Planting and the 2013 Block Planting, being that there was no more available space to do a 9 plot planting on the Far Ridge, it was decided to do the planting in the same plots as the first year’s planting, the 2010 Block Planting. Again, instead of planting in the exact same locations (as there were still some plants that did survive from the 2010 Block

Planting), for this planting all the plants were shifted over 1 foot to the east. Also, surviving plants from the first year's trial planting were reflagged with double pin flags and the current year's planting was flagged different colors so as not to confuse the two.

This woody trial included 3 species (live oak, yaupon, and roughleaf dogwood) totaling 32 plants per plot and 3 levels of soil amendments (bagasse x fertilizer x gypsum, bagasse doubled x fertilizer doubled x gypsum doubled, and control) replicated 3 times for a total of 9 plots and 288 total plants (Figure 30). Treatment plots and plants within treatment plots were completely randomized prior to planting. Since there appeared to be no added benefits to the previous year's planting with the addition of treatments versus the control (no treatment) at the amounts originally used, it was decided to try doubling treatment amounts to see if this would increase survival and plant response versus the control. Therefore, some alterations to the planting techniques described above were implemented for this planting. First, all of the holes were increased in size to 10 ¾ inches in diameter. For the soil level amendment where the treatments were doubled, this meant that instead of one quart of bagasse, two quarts were used; instead of one 21 gram orchard fertilizer tablet, two were used; and instead of 1 cup of gypsum, two cups were used. This planting was implemented on March 26, 2014, utilizing volunteer help. Baseline growth data was taken immediately following completion of planting. End of growing season data was collected twice for this trial at the beginning of October in 2014 and 2015. Vigor was assessed visually on a 9 point scale adopted from the NRCS with 1 having

Figure 30 Staging plants for 2014 Block Planting, March 26, 2014. Looking north.

the greatest vigor and 9 being dead. Height, spread, and basal stem diameter were measured and recorded as described in detail in section 4.10. For consistency in vigor measurements, end of growing season data collection was collected by a single crew of BTNEP staff. Field data measurements were then recorded in Microsoft® Excel Spreadsheets for use in future statistical analysis.

4.7 Linear Ridge Planting – March 28, 2011

Additionally, after the 2011 Block Planting was implemented on March 10, 2011, a smaller planting was implemented on March 22 and 28, 2011, to add a diversity of species to the woody species planting trials. This planting was called the "Linear Ridge Planting" because it consisted of 6 plots of 30 plants in each plot in single rows running west to east immediately adjacent and south of the 2011 and 2012 Block Plantings' plots on the top of the ridge (Figure 31). Rebar was again used to delineate the beginning and end of each plot with pin flags used for plant locations on 8 foot centers.

Figure 31 Aerial view of Linear Planting (March 28, 2011) and Mini Block planting (March 20, 2012) locations on the Far Ridge. Linear Planting plots not labeled, only represented by yellow line. Mini Block Planting plots labeled A, B, and C on right (east) side of image. The Imagery date: January 25, 2015.

This woody trial included 3 species (Hercules' club, honeylocust, and persimmon) totaling 30 plants per plot and 2 levels of treatments (bagasse x fertilizer x gypsum, and control) replicated 3 times for a total of 6 plots and 180 total plants (Figure 32). Treatment plots and plants within treatment plots were completely randomized prior to the planting. The control replicates of this

Figure 32 Linear Ridge Planting parallel to the southern edge of the Far Ridge, March 22, 2011. Looking east.

planting were implemented utilizing volunteer help on March 22, 2011, and treatment replicates were implemented on March 28, 2011 by BTNEP staff. Baseline growth data was taken immediately following completion of planting. End of growing season data was collected twice for this trial at the beginning of October in 2011 and 2012. Data collection was abandoned after the end of growing season collection in 2012 once it was determined there were no remaining surviving plants. Vigor was assessed visually on a 9 point scale adopted from the NRCS with 1 having the greatest vigor and 9 being dead. Height, spread, and basal stem diameter were measured and recorded as described in detail in section 4.10. For consistency in vigor measurements, end of growing season data collection was collected by a single crew of BTNEP staff. Field data measurements were then recorded in Microsoft® Excel Spreadsheets for use in future statistical analysis.

4.8 Mini Block Planting – March 20, 2012

This small woody trial planted on the Far Ridge, named the "Mini Block Planting", was located immediately adjacent to the 2011 and 2012 Block Planting's plots and was a small trial instituted to increase the diversity of species being evaluated in the trials and consisted of only one level of soil amendments (fertilizer) and only 3 plots of 32 plants per plot for a total of 96 plants for the planting (see Figure 30 above). Four species were utilized for this planting: live oak, persimmon, American beautyberry, and honeylocust (Figure 33). Treatment plots and plants within treatment plots were completely randomized prior to planting. This planting was implemented on March 20, 2012, less than a month after the 2012 Block Planting utilizing

Figure 33 Honeylocust seedling in Mini Block Planting plot, March 20, 2012.

volunteer help. Baseline growth data was taken immediately following completion of planting. End of growing season data was collected four times for this trial at the beginning of October in 2012, 2013, 2014, and 2015. Vigor was assessed visually on a 9 point scale adopted from the NRCS with 1 having the greatest vigor and 9 being dead. Height, spread, and basal stem diameter were measured and recorded as described in detail in section 4.10. For consistency in vigor measurements, end of growing season data collection was collected by a single crew of BTNEP staff. Field data measurements were then recorded in Microsoft® Excel Spreadsheets for use in future statistical analysis.

4.9 Herbaceous Field Trial

One herbaceous field trial was implemented on the western end of the Far Ridge in November of 2009 to better ascertain what herbaceous species could be established on the ridge (Figure 34). This planting was laid out across the profile of the ridge from the north marsh apron up the north slope, across the ridge top, down the south slope and into the south marsh to see in what

Figure 34 Aerial view of Herbaceous Field Trial location planted November 11, 2009 on the Far Ridge. Plots are labeled A to F. Each plot had 3 rows (replicates) oriented north to south across the Far Ridge profile. The Imagery date: January 25, 2015.

zones the species would do best. Three species of herbaceous grasses were selected for the planting: seashore paspalum (*Paspalum vaginatum*), marshhay cordgrass (*Spartina patens*), and bitter panicum (*Panicum amarum*). One treatment (straw) and a control (no additives) were replicated three times for each species. Each treatment plot had rebar driven into the sand to delineate the beginning and end of each plot. Each treatment plot had 3 rows of 25 plants per row with each row representing one replicate. Plants were placed on 5 foot centers and marked with pin flags making each row 120 feet long. Each row began in the high marsh on the north side of the ridge and ended in the high marsh on the south side of the ridge. This marsh zone of the row was planted with 5 to 6 plants. Above the marsh zone, but below the ridge top, were the north and south ridge slopes. In this zone, 6 to 7 plants were planted. On the ridge top, 13 to 14 plants were planted. Plant numbers in each zone varied for each row as the topography of the ridge changed. Treatment plots and plants within treatment plots were completely randomized prior to planting. This planting was implemented on November 11, 2009, utilizing volunteer help (Figure 35). Baseline growth data was not taken at the time of planting while vigor was assumed a 1 (excellent). End of growing season data was collected only once for this trial at the beginning of October 2010. Vigor was assessed visually on a 9 point scale adopted from the NRCS with 1 having the greatest vigor and 9 being dead. Height, spread, and basal stem diameter were measured and recorded as described in detail in section 4.10. For consistency in vigor measurements, end of growing season data collection was collected by a single crew of BTNEP staff. Field data measurements were then recorded in Microsoft® Excel Spreadsheets for use in future statistical analysis.

Figure 35 Offloading plants from the boats for the Herbaceous Field Trial, November 11, 2009. On the north marsh apron looking east.

4.10 Data Collection Methods

Baseline data at the time of the plantings, as well as end of growing season data collections, were taken for all of the experimental plantings (Figure 36). Baseline data collected assumed a vigor of 1 (excellent or greatest) at time of planting as plants were selected from a larger quantity at the BTNEP Native Plant Nursery in Thibodaux, Louisiana, and only those exhibiting the greatest vigor were chosen to be included in the experimental plantings. Besides vigor, the other growth parameters measured were height (overall from the ground to the highest living portion of the plant whether it was a stem or leaf; measured in whole and half inch increments with a tape measure), spread (widest single axis of the plant when observed from overhead with the axis passing through the main stem of the plant; measured in whole and half inch increments with a tape measure), and basal stem diameter (measured with a digital caliper approximately 3 inches above the ground on the main stem of the plant and avoiding any branches; measured in millimeters rounding to 2 decimal places). Baseline data was collected with the help of volunteers.

End of growing season data collection was collected at the beginning of October each year for all vegetative field studies. Vigor was assessed visually on a 9 point scale adopted from the

Figure 36 Volunteers taking baseline data measurements, March 10, 2010.

NRCS with 1 having the greatest vigor and 9 being dead. Height, spread, and basal stem diameter were measured and recorded as described above. For consistency in vigor measurements, end of growing season data collection was collected by a single crew of BTNEP staff. Field data measurements were then recorded in Microsoft® Excel Spreadsheets for use in future statistical analysis.

4.11 Soil Collection Methods

Construction on the Far Ridge was completed in the fall of 2008. The first soil collection occurred in January 2009. Soil samples were collected approximately every 6 months with the exception of the spring 2012 and spring 2015 soil sampling periods. A total of 12 soil sample collections were taken: January 2009, August 2009, January 2010, August 2010, February 2011, October 2011, October 2012, May 2013, December 2013, May 2014, October 2014 and October 2015.

Soil samples along the top of the ridge were taken approximately every 200 feet (Figure 37). A crisscross pattern was employed on the ridge top in order to randomly capture the different land and soil features. A clean shovel was used for sampling. A hole was dug down to the top of the blade (approximately 9 inches) and then a uniform sample approximately 1 ½ to 2 inches thick was dug out. A drywall finishing knife was used to square the bottom and cut the side edges off of the sample, leaving a 2 ½ to 3 inch wide by 9 to 10 inch long sample. Soil samples were bagged in Ziploc® Freezer Gallon bags and labeled with a Sharpie®. Stakes were then located with a GPS and these positions were cataloged. These initial soil samples were taken and then marked with a wooden stake painted with an orange tip. Subsequent samples were taken 2 feet out from the wooden stake at compass heading positions, alternating positions for each sampling so as not to sample the same spot twice. These subsequent sample locations were marked with 2 orange pin flags.

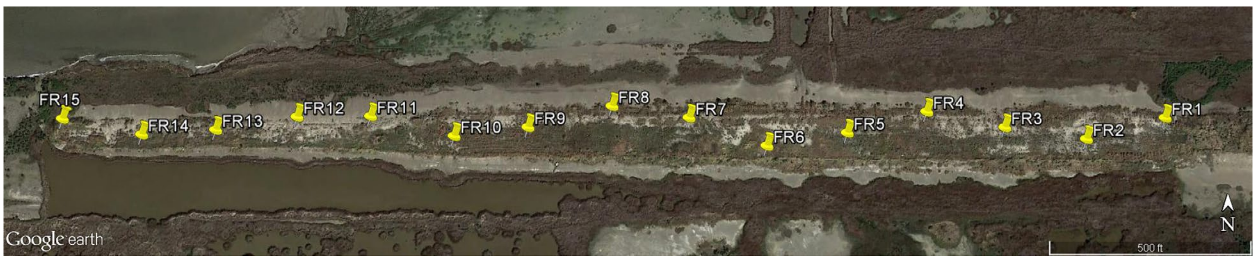

Figure 37 January 2015 aerial image of the 15 ridge top soil sample locations from the Far Ridge.

Bagged soil samples were immediately brought from the field to be dried in a covered area at our facility in Thibodaux, Louisiana (Figure 38). Once dried, samples were thoroughly mixed and then 2 cups of material was rebagged and sent off for soil analysis to A&L Analytical Laboratories, Inc., Memphis, Tennessee (samples collected from January 2009 until February 2011) or LSU Agricultural Center's Soil Testing and Wetland Soil Characterization Laboratories, Baton Rouge, Louisiana (samples collected October 2011 to October 2015).

The soil analysis package from the A&L Analytical Laboratories, Inc., included organic matter, cation exchange capacity, pH, soluble salts, and extractable elements i.e. P, K, Ca, Mg, S, Na Zn, Mn, Fe, Cu, boron (B), and nitrate (NO3-). Mehlich III (an acid extractant with the mixture of 0.2*N* CH3COOH + 0.25*N* NH4NO3 + 0.013*N* HNO3 +0.015*N* NH4F + 0.001*M* EDTA) was used to determine the concentration of extractable elements. The soil analyses from the LSU Agricultural Center's Soil Testing and Wetland Soil Characterization Laboratories included pH, electrical conductivity (EC), salinity, macro- and micronutrients. Salinity, conductivity, soluble salts, and pH were analyzed using a ratio of 1:2 for dry soil and distilled water. Electrical conductivity measures the ability of soluble salts to conduct electricity in water. The macro and micronutrients including phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg),

Figure 38 Drying soil samples in the greenhouse before bagging and shipping them off for analysis, August 7, 2009.

sulfur(S), sodium (Na), iron (Fe), copper (Cu), and zinc (Zn) were analyzed from the water soluble extract of the 1:2 soil and water ratio, and the element concentration was determined using ICP (Inductively Couple Plasma Spectrophotometer). Cation Exchange Capacity (CEC) and Sodium Adsorption Ratio (SAR) were calculated based on the element analyses. SAR is defined as the ratio of sodium to calcium plus magnesium. The calculations are based on molecular weight of each of the three elements and their respective valence and expressed as milliequivalent (meq) for CEC and an index value for SAR.

A problem was realized in 2011 with the analyses of the soil samples collected and analyzed by A&L Analytical Laboratories, Inc. between 2008 and 2011 as it was determined they were inappropriate for high saline coastal soils. The extractant used by A&L Analytical Laboratories, Inc. for most of the metal analysis, calculation of Sodium Adsorption Ratio, and calculation of Cation Exchange Capacity was Mehlich III (an acid extractant with the mixture of 0.2*N* CH_3COOH + 0.25*N* NH_4NO_3 + 0.013*N* HNO_3 +0.015*N* NH_4F + 0.001*M* EDTA). For coastal saline soils, the preferred extractant is distilled water rather than an acidic solution. Distilled water only extracts the dissolved salts in the soil, providing a closer measurement of the actual soil conditions and effects on plants. An acidic extractant, on the other hand, extracts acid-soluble cations from the mineral component of soils, such as calcium in shell and carbonates present in the Fourchon Ridge sediments. Although Mehlich III is commonly used in inland agricultural soils and is assumed to mimic the cation and nutrient extracting ability of plants, it is an inappropriate extractant for high saline coastal soils.

The objectives of Manoch Kongchum's research were to: 1) assay and interpret the physical and chemical analyses of all soil samples previously completed by A&L Analytical Laboratories, Inc. in 2011; and 2) assist BTNEP project managers in the implementation and analysis of the incomplete 2012, 2013, and 2014 soil sample series.

The major findings of Kongchum's study mainly establishes a baseline for the other work that is presented in the main body of this report that documents trends for all parameters over the course of the vegetative studies and data collected from 2009–2015. In general, across the overall sites sampled that included marsh soils and ridge top soils, the marsh soils can be classified as saline-sodic and the ridge top soils can be classified as high salinity and borderline sodic soils. For both Mehlich III and water extracts, older ridge soils experienced a decrease in sodium with a relative increase in calcium due to rainwater leaching of soluble sodium constituents over time. A&L Labs versus LSU Soils Lab methods were comparable for macro and micro nutrients in addition to EC, CEC and SAR.

The full results from these analyses are found in Appendix 2 in detail in the report entitled "Assessment and Evaluation of Soil Physical and Chemical Properties of Dredged Material in Constructed Wetland" by Manoch Kongchum. However, because of differences laid out in our caveats that precedes Manoch Kongchum's report, we have used results for EC and SAR for soil samples collected between October 2011 and October 2015 from LSU and not Manoch Kongchum for statistical analysis in this report (see Appendix 5).

4.12 Weather

After the condition of the soil, weather played the next most significant role in plant survival on the ridge. With most planting sites for coastal restoration plantings located in hard to reach places, in difficult areas to maneuver, and usually using prohibitively large quantities of plants, it is almost always logistically impossible to mechanically water these types of plantings. Besides the cultural treatments used in the experimental field trials, no care was afforded these plantings in order to better mimic standard planting procedures for most coastal restoration vegetative plantings.

The last few years have been fairly typical for rainfall. In 2011, however, Louisiana experienced a pronounced drought (Figure 39). The 2011 Block Planting and the Linear Ridge Planting, both implemented in March of 2011 were planted during a severe drought that eventually became a declared exceptional drought (the highest level) by mid-June. The drought was gone before the end of the growing season, but the effect of the drought on the plants was the greatest

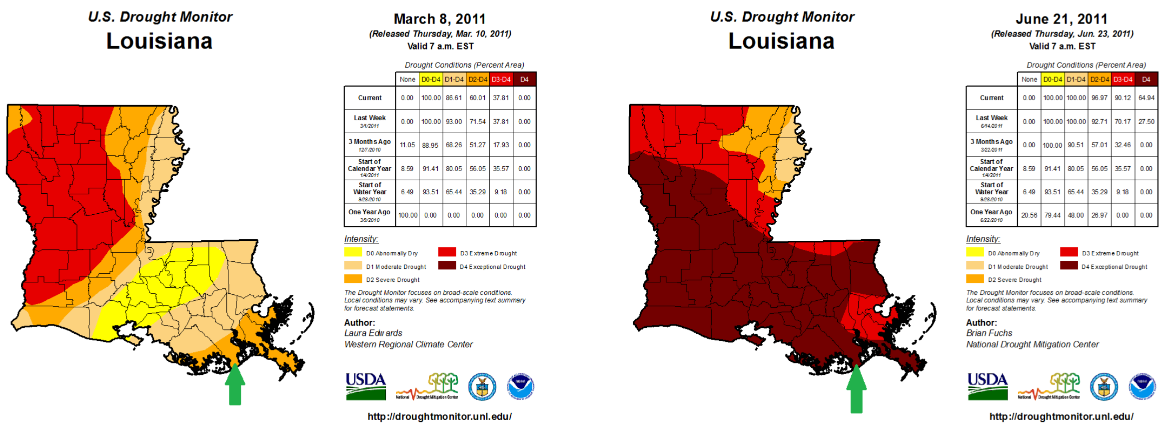

Figure 39 Drought maps at the time of the March 2011 plantings and in June 21, 2011. Green arrow indicates project location.

mortality exhibited in both of these plantings compared to any of the others. Even well-established plants on the Middle Ridge suffered and died during this event. In fact, the entire marsh surrounding the Ridge became a complete brown marsh event with all the smooth cordgrass dying off. Rainfall during this period at the Galliano, Louisiana, weather station 21.5 miles NNE of the Ridge recorded a 1.55 inch rainfall on March 10th, an additional 3 inch rain on March 30th, and then only 1.77 inches of precipitation over the next 92 days. Rainfall during this period at the Grand Isle, Louisiana, weather station 14.5 miles ENE of the Ridge recorded a 1.1 inch rain on March 10th, no rain on March 30th and only 3.3 inches of rain over the next 120 days.

All of the study years ended the growing season with no drought conditions and the only other years to be planted during a drought were 2009 (moderate drought) and 2012 (extreme drought).

Drought maps from all the planting and growth data collection years (2009-2015) are included in Appendix 3.

4.13 Non-Experimental Plantings

Most plantings implemented on the ridge were not part of vegetative trials but executed in order to reduce soil erosion and create habitat while obtaining at least an 80% vegetative coverage on the Ridge. At the time of this writing, December 2015, visual inspection of the vegetative coverage of the Ridge appears to be around 85 to 90%.

From 2009 to the end of 2015, 38 non-experimental plantings were implemented utilizing 753 volunteers with over 62,000 plants being planted on the Middle and Far Ridges. Since the Middle Ridge had already received numerous herbaceous plantings since its completion in 2005 and exhibited exceptional herbaceous coverage by 2009, all plantings on the Middle Ridge from 2009 on were woody species plantings. A total of 8,501 woody seedlings were planted on the Middle Ridge over the 7 year period. Post construction of the Far Ridge in the summer of 2008, establishment of herbaceous vegetation and woody seedlings was undertaken up until April of 2015. On the Far Ridge marsh aprons, 18,700 bare root plugs of smooth cordgrass were planted with the vast majority being planted on the exposed northern marsh apron. An additional 22,560 herbaceous plants were planted along the ridge slopes and up onto the ridge top margins. Finally, 12,305 woody seedlings were planted on the Far Ridge top.

All seeding, grow out, and plantings (experimental and non-experimental) had an educational component for the volunteers assisting BTNEP in the effort. Volunteers learned about the problems impacting coastal Louisiana and efforts being implemented to mitigate their impacts. Volunteers learned about the importance of these native woody species to Neotropical migratory songbirds. BTNEP's volunteers for this project, mostly college students, came from all across the nation and the knowledge we imparted to them about the importance of native woody species to Neotropical migratory songbirds was transferred back to their areas of origin. Educating people from around the nation about the impacts of Louisiana's land loss is important, because the cost and severity of the problem is going to require buy-in from the entire nation.

4.13.1 2009 to 2015 Ridge Plantings

28 February 2009: Thirty-nine volunteers assisted in planting a total of 4,185 woody seedlings on the Middle and Far Ridge sections. Of this total, 2,725 were conetainers: 1,150 live oak and 1,575 red mulberry. The rest, 1,460, were trade gallons: 400 American beautyberry, 400 red mulberry, 350 sand live oak, 250 yaupon holly, and 60 hackberry.

15 April 2009: A total of 336 live oak seedlings in 4" x 14" containers were planted on the Middle Ridge.

21 April 2009: A total of 200 hackberry bare root seedlings donated from Louisiana Department of Agriculture and Forestry (LDAF) were planted on the Middle Ridge.

11 November 2009: Seventeen volunteers assisted in an herbaceous planting on the Far Ridge top and slopes. A total of 4,450 4" containers were planted. Of this total, 1,850 were marshhay cordgrass, 1,850 seashore paspalum, 300 saltgrass, 150 bitter panicum and 300 coastal dropseed. An herbaceous establishment study was established also at this time across the profile of the ridge and is included in detail earlier in this report.

12 & 13 December 2009: A follow up herbaceous planting on the Far Ridge top and slopes was undertaken over two days in December 2009. Three volunteers came out and assisted on December 12th and another 20 came out on December 13th. A total of 4,000 4" containers were planted. Of this total, 2,000 were marshhay cordgrass and 2,000 were seashore paspalum.

9 March 2010: The southern marsh platform of the ridge was planted with 7,000 plugs of smooth cordgrass by 55 volunteers.

15 March 2010: A woody species planting of 1,045 conetainers was conducted on the Middle Ridge. Of this total, 603 were salt matrimony vine, 331 hackberry, 111 red mulberry and 48 honeylocust. This planting was assisted by 33 volunteers.

22 & 23 March 2010: Thirty-five volunteers helped plant a total of 2,075 4" woody species containers on the Middle Ridge. Of the 2,075 4" containers, woody species planted included 1,250 red mulberry, 450 hackberry and 375 live oak.

29 & 30 March 2010: Twenty-nine volunteers planted 4,000 plugs of smooth cordgrass on the northern marsh platform of the Far Ridge.

26 October 2010: Seven volunteers came out and helped plant 3,000 smooth cordgrass plugs on the north marsh platform of the Far Ridge.

29 October 2010: Thirteen volunteers helped plant 900 marshhay cordgrass and 500 seashore paspalum 4" containers on the slopes and the top of the Far Ridge.

14 December 2010: Seventeen volunteers helped plant 1,000 conetainers on the Middle Ridge of the following species: live oak, hackberry, honeylocust, and persimmon.

25 February 2011: Sixteen volunteers helped plant 775 salt matrimony vine conetainers on the slopes and top of the Far Ridge.

22 March 2011: Forty-two volunteers helped plant 2,000 4" containers of seashore paspalum on the slopes and top of the Far Ridge.

25 August 2011: Three volunteers and a large staff from BTNEP, NRCS and the Terrebonne/Lafourche SWCD came out and helped plant 2,000 marshhay cordgrass, 1,000 seashore paspalum, and 500 bitter panicum 4" containers on the top and north side of the Far Ridge.

6 October 2011: Twenty volunteers helped plant 2,000 smooth cordgrass bare root plugs on the north marsh platform adjacent to the Far Ridge and 1,500 bitter panicum 4" containers on the north slope and top of the Far Ridge.

30 October 2011: Twenty-three volunteers helped plant 2,700 smooth cordgrass bare root plugs on the north marsh platform adjacent to the Far Ridge.

13 March 2012: Twenty-eight volunteers helped plant 800 conetainers of woody plants on the Middle Ridge. The four species planted were live oak, sand live oak, honeylocust and persimmon.

20 March 2012: Thirty-four volunteers helped plant 675 conetainers of live oak, American beautyberry and honeylocust on the Far Ridge just east of the Mini Block Planting that was planted at the same time.

27 March 2012: Twenty-two volunteers helped plant 700 conetainers of salt matrimony vine on the Far Ridge. An additional 100 myrtle oak 4x14” containers were planted as well.

8 January 2013: Twenty-one volunteers helped plant 850 conetainers of woody seedlings on the westernmost end of the Far Ridge. 550 salt matrimony vine conetainers were planted along the top and northern slope of the ridge and 300 live oak conetainers were planted on top of the ridge.

11 March 2013: Fifteen volunteers helped plant 750 conetainers of live oak seedlings on the top of the eastern end of the Far Ridge. A slow release fertilizer was added to each hole.

12 March 2013: Thirty-five volunteers helped plant 500 conetainers of four species of woody seedlings on the top of the eastern end of the Far Ridge. The five species planted were: 200 salt matrimony vine, 100 hackberry, 50 persimmon, 100 live oak, and 50 honeylocust. A slow release fertilizer was added to each hole.

19 March 2013: Fourteen volunteers helped plant 500 conetainers of salt matrimony vine seedlings along the northern slope of the eastern end of the Far Ridge.

16 November 2013: Sixty volunteers helped plant 4,175 herbaceous and woody plants on the top and northern slope of the eastern end of the Far Ridge and the top and northern and southern slopes of the entire Middle Ridge. Woody species planted with fertilizer tablets on the Middle Ridge were: 150 trade gallons (TG) of live oak, 50 TG of American beautyberry, 40 TG of hackberry, 30 TG of honeylocust, and 25 TG of persimmon. Woody species planted with fertilizer tablets on the eastern end of the Far Ridge were: 600 conetainers of salt matrimony vine, 100 conetainers of yaupon, 100 conetainers of live oak, and 50 conetainers of persimmon. Herbaceous species planted were: 100 trade gallon pots of switchgrass, 232 4-inch pots of railroad vine, 100 4-inch pots of beach morning-glory, 598 4-inch pots of seashore paspalum,

1300 conetainers of seashore paspalum, 500 1-inch conetainers of seashore paspalum, and 200 conetainers of Gulf bluestem.

<u>19 November 2013:</u> Eight volunteers helped plant 2,220 herbaceous and woody plants on the top and northern slope of the central and western portions of the Far Ridge. Woody species planted with fertilizer tablets were: 300 salt matrimony vine, 100 conetainers of live oak, and 50 conetainers of persimmon. Herbaceous species planted were: 70 trade gallon pots of switchgrass, 150 4-inch pots of railroad vine, 50 4-inch pots beach morning-glory, 350 4-inch pots of seashore paspalum, 700 conetainers of seashore paspalum, 300 1-inch conetainers of seashore paspalum, and 150 conetainers of Gulf bluestem.

<u>20 November 2013:</u> Six volunteers helped plant 1,560 herbaceous and woody plants on the top and northern slope of the western portions of the Far Ridge. Woody species planted with fertilizer tablets were: 150 conetainers of salt matrimony vine, 150 conetainers of yaupon, 150 conetainers of persimmon, and 200 conetainers of live oak. Herbaceous species planted were: 30 trade gallon pots of switchgrass, 50 4-inch pots of railroad vine, 30 4-inch pots of beach morning-glory, 150 4-inch pots of seashore paspalum, 500 conetainers of seashore paspalum, 100 1-inch conetainers of seashore paspalum, and 50 conetainers of Gulf bluestem.

<u>10 March 2014:</u> Ten volunteers helped plant 650 conetainers of four species (live oak, hackberry, American beautyberry and salt matrimony vine) of woody seedlings on the top of the western end of the Far Ridge. A slow release fertilizer was added to each hole.

<u>12 March 2014:</u> Ten volunteers helped plant 850 conetainers of five species (live oak, hackberry, persimmon, yaupon and salt matrimony vine) of woody seedlings on the top of the eastern end of the Far Ridge. A slow release fertilizer was added to each hole.

<u>25 March 2014:</u> Ten volunteers helped plant 275 trade gallons of nine species (live oak, sand live oak, Hercules-club, hackberry, green ash, red mulberry, American beautyberry, honeylocust and persimmon) of woody seedlings on the easternmost to middle top of the Middle Ridge. A slow release fertilizer was added to each hole.

<u>26 March 2014:</u> Ten volunteers after planting the 2014 Block Planting helped plant an additional 312 conetainers of woody seedlings immediately south of the 2014 Block Planting on the Far Ridge and spreading out east and west of its footprint. The three species planted were yaupon, live oak and roughleaf dogwood. A slow release fertilizer was added to each hole.

<u>12 December 2014:</u> Eighteen volunteers helped plant 700 salt matrimony vine conetainers along the northern slope of the Far Ridge toward the western end. A slow release fertilizer was added to each hole.

17 March 2015: Fourteen volunteers planted 90 trade gallon sized woody plants on the Middle Ridge and 550 conetainers on the east end of the Far Ridge. Of the 90 trade gallon sized woody plants planted on the Middle Ridge 35 were yaupon, 25 live oak, 10 persimmon, 10 roughleaf dogwood, and 10 hackberry. The 550 conetainers planted on the Far Ridge included 300 live oak, 150 American beautyberry, and 100 hackberry.

24 March 2015: Eight volunteers helped plant 70 trade gallon sized live oaks on the Middle Ridge and 350 conetainers (200 live oak and 150 hackberry) on the western end of the Far Ridge.

1 April 2015: Eleven volunteers planted 200 trade gallons (80 live oak, 50 yaupon, 30 persimmon, 30 roughleaf dogwood, and 10 hackberry) on the Middle Ridge.

5.0 RESULTS & DISCUSSION

Statistical analysis for this report was conducted by Dr. Quenton Fontenot, Head and Professor of Biological Sciences, Nicholls State University, Thibodaux, Louisiana. Dr. Fontenot used SAS (Statistical Analysis System) developed by SAS Institute, Cary, North Carolina, for the following analyses for each section in this report. Effects of Cultural Treatments on Species Growth and Survival (5.1): Analysis of Variance (ANOVA) followed by a Tukeys *post hoc* analysis was used to delineate differences among treatments. Comparison of Year-to-Year Survival for Each Planting Year (5.2): Analysis of Variance (ANOVA) followed by a Tukeys *post hoc* analysis was used to delineate differences among treatments. Single Species Change in Height Comparison Among Planting Years (5.3): Correlation analysis to determine the relationship among height, spread, and BSD. Analysis of Variance (ANOVA) followed by a Tukeys *post hoc* analysis was used to delineate differences among treatments. Single Species Survival and Vigor Comparisons Among Planting Years (5.4): Analysis of Variance (ANOVA) followed by a Tukeys *post hoc* analysis was used to delineate differences among treatments. Survival by Orientation (5.5): Analysis of Variance (ANOVA) followed by a Tukeys *post hoc* analysis was used to delineate differences among treatments. Soil Quality (5.6): Analysis of Variance (ANOVA) followed by a Tukeys *post hoc* analysis was used to delineate differences among treatments. First Growing Season Survival and Soil Quality (5.7): Regression analysis to determine the relationship between survival and each soil quality variable. Herbaceous: Survival and Spread Comparisons Among Planting Positions (5.8): Analysis of Variance (ANOVA) followed by a Tukeys *post hoc* analysis was used to delineate differences among treatments.

5.1 Effects of Cultural Treatments on Species Growth and Survival

We analyzed the use of cultural treatments for all of the experimental plantings (2010-2014) conducted on the Far Ridge through their first two growing seasons (see Appendix 4). Woody species looked at collectively in all of the experimental plantings included live oak, sand live oak, salt matrimony vine, hackberry, American beautyberry, persimmon, honeylocust, yaupon, Hercules' club, and roughleaf dogwood. Cultural treatments consisted of a control (no additives), bagasse, fertilizer, gypsum, and various combinations of these additives. The soil treatments were added to the dug holes at the time of the plantings. Each planting was done in treatment blocks with the mean of each block used as a replicate. Survival and growth data (height, spread, basal stem diameter, and vigor) was collected at the time of planting as a baseline and at the end of each growing season (October) through 2015.

Results from statistical analysis demonstrated that there was no statistical benefit in adding treatments for survival and growth to these plantings. The high mortality exhibited in most of these plantings may have contributed to this outcome. However, even live oak planted in 2013 and 2014 that exhibited the highest survival rates (56% and 72% after first growing season respectively) and hackberry planted in 2013 with a survival rate of 59% after the first growing season, did not show any benefits in adding cultural treatments compared to the control. The only exception appears to be for salt matrimony vine in the 2010 planting for the first growing season only, with the addition of fertilizer increasing spread and the addition of bagasse increasing basal stem diameter.

5.2 Comparison of Year-to-Year Survival for Each Planting Year

Comparison of Year-to-Year Survival for Each planting Year comes from the main big block planting for each planting year from 2010-2014. For each planting year, year-to-year survival was compared among species. Table 1 (page 47) shows a side by side comparison of species and planting years with species survival at the end of each growing season up to the final growth/survival data collection in October 2015.

2010: The 2010 planting utilized three species: salt matrimony vine, hackberry, and sand live oak. Comparison of survival of all species for the 2010 planting year varied for every year except 2013 and 2015 (Figure 40). Salt matrimony vine, a salt tolerant, small evergreen shrub found naturally in the vicinity of the project site, had the greatest survival after the first growing season at 99%. Salt matrimony vine only lost one more plant over the next five growing seasons in 2013, being the most persistent species of the three and remaining with a 99% survival after five years. Hackberry survival the first year was significantly less than that of salt matrimony vine at only 20%, but was still significantly greater than that of sand live oak, which had the lowest survival at 2% (or just 3 plants out of 192). The next year, in 2011, the year of the

Table 1 Number of individual surviving plants (proportion of individuals of original planting that survived in parenthesis) for each species planted each year. N planted represents the total number of individuals planted that year for that species.

Species	Year Planted	N Planted	Approximate Time Since Planting					
			6 Months	**1.5 Years**	**2.5 Years**	**3.5 Years**	**4.5 Years**	**5.5 Years**
Hackberry	2010	335	66 (0.197)	23 (0.069)	19 (0.057)	18 (0.054)	17 (0.051)	14 (0.042)
Sand Oak	2010	192	3 (0.016)	3 (0.016)	2 (0.01)	2 (0.01)	1 (0.005)	1 (0.005)
Matrimony Vine	2010	241	239 (0.992)	239 (0.992)	239 (0.992)	238 (0.987)	238 (0.987)	238 (0.987)
Beautyberry	2011	150	1 (0.007)	1 (0.007)	1 (0.007)	1 (0.007)	1 (0.007)	-
Hackberry	2011	150	2 (0.013)	2 (0.013)	2 (0.013)	1 (0.007)	1 (0.007)	-
Live Oak	2011	180	7 (0.039)	7 (0.039)	7 (0.039)	6 (0.033)	6 (0.033)	-
Hackberry	2012	150	29 (0.193)	24 (0.16)	23 (0.153)	17 (0.113)	-	-
Live Oak	2012	165	33 (0.200)	31 (0.188)	31 (0.188)	31 (0.188)	-	-
Sand Oak	2012	165	17 (0.103)	17 (0.103)	15 (0.091)	12 (0.073)	-	-
Hackberry	2013	165	98 (0.594)	84 (0.509)	43 (0.261)	-	-	-
Live Oak	2013	165	92 (0.558)	88 (0.533)	80 (0.485)	-	-	-
Sand Oak	2013	150	46 (0.307)	44 (0.293)	24 (0.16)	-	-	-
Dogwood	2014	90	3 (0.033)	2 (0.022)	-	-	-	-
Live Oak	2014	99	71 (0.717)	57 (0.576)	-	-	-	-
Yaupon	2014	99	14 (0.141)	8 (0.081)	-	-	-	-

exceptional drought, only 35% of the first year surviving hackberries survived, significantly less than either salt matrimony vine or sand live oak. Survival for hackberry in the remaining years was 80% or higher after each growing season. Final overall survival for the 2010 planting after five growing seasons for hackberry was 4%. For sand live oak, two of the three first year surviving plants were lost over the next five years for a final survival of 1%. The severe saline-sodic soil conditions at the time of planting is the most likely cause for the high mortality of the two non-halophytic species, hackberry and sand live oak. The excessive drought the following year caused additional mortality to the hackberry. Salt matrimony vine, being a halophytic and xeric tolerant plant survived exceptionally well under these same conditions.

2011: The 2011 planting utilized three species: live oak, hackberry, and American beautyberry. Comparison of survival of all species for the 2011 planting year showed no differences in any of the years (Figure 41). All three species experienced extreme mortality by the end of the first growing season. Survival rates the first year for live oak, hackberry, and American beautyberry were 4, 1, and 1 percent respectively. At the end of 2015, live oak survival was down to 3% and the others remained at 1% each. The extreme mortality for all 3 species was most likely due to the exceptional drought experienced during their planting year and the high soil salinity and adverse soil conditions exhibited at that time.

2012: The 2012 planting utilized 3 species: live oak, hackberry, and sand live oak. Comparison of survival of all species for the 2012 planting year showed no variation in survival until 2015, the fourth growing season, when live oak had the greatest survival (Figure 42). All three species experienced heavy mortality by the end of the first growing season. Survival rates for the first year for live oak, hackberry, and sand live oak were 20, 19, and 10 percent respectively. The low survival rates were probably due to poor soil conditions exacerbated by an extreme drought at the time of the planting. Year-end survival of the remaining surviving plants was above 83% for all species for the next two years, but in 2015 hackberry and sand live oak survival dropped to 74 and 73 percent respectively. It is possible the moderate drought that started off the 2015 growing season caused the higher mortality seen in hackberry and sand live oak than was seen in the 2013 and 2014 growing seasons when no drought was recorded. Live oak, however, had significantly higher survival (100%) over the same year, 2015. Final overall survival at the end of 2015 for live oak, hackberry, and American beautyberry was 18, 11, and 7 percent respectively.

2013: The 2013 planting utilized 3 species: live oak, hackberry, and sand live oak. Comparison of survival of all species for the 2013 planting year varied at 6 months and 2.5 years (Figure 43). At 6 months (end of first growing season), sand live oak had the lowest survival. At 2.5 years (end of third growing season), live oak had the greatest survival. Hackberry and live oak survival broke the 50% survival barrier for the first time with hackberry at 59% and live oak at 56% at the end of the first growing season. Sand live oak had significantly lower survival at 31%. Survival of remaining plants for all three species at the end of the second growing season in 2014 was 85% or higher. The third and final growing season saw a significant drop in survival for both hackberry (51%) and sand live oak (53%) versus live oak (91%), as was similar for the 2012 planting year plants. It is possible the moderate drought that started off the 2015 growing season caused the higher mortality seen in hackberry and sand live oak than was seen in the 2014 growing season when no drought was recorded. Live oak appears to be more drought tolerant than the other two species in this environment. Final overall survival for the 2013 planting for live oak, hackberry, and sand live oak was 48, 25, and 15 percent respectively.

2014: The 2014 planting utilized 3 species: live oak, yaupon, and roughleaf dogwood. Live oak had significantly higher survival (72%) than yaupon (14%) and roughleaf dogwood (3%) at the end of the first growing season (Figure 44). There was no difference in survival for the second growing season (1.5 years) when survival ranged from a high of 80% for live oak to a low of 57% for yaupon. Final overall survival for the 2014 planting for live oak, yaupon, and roughleaf dogwood was 58, 8 and 2 percent respectively. Although soil conditions were improving over the planting years (as evidenced by the highest survival for live oak in a planting year for 2014), the high mortality for the yaupon and roughleaf dogwood species is probably due to a higher sensitivity to saline-sodic soils for these two species.

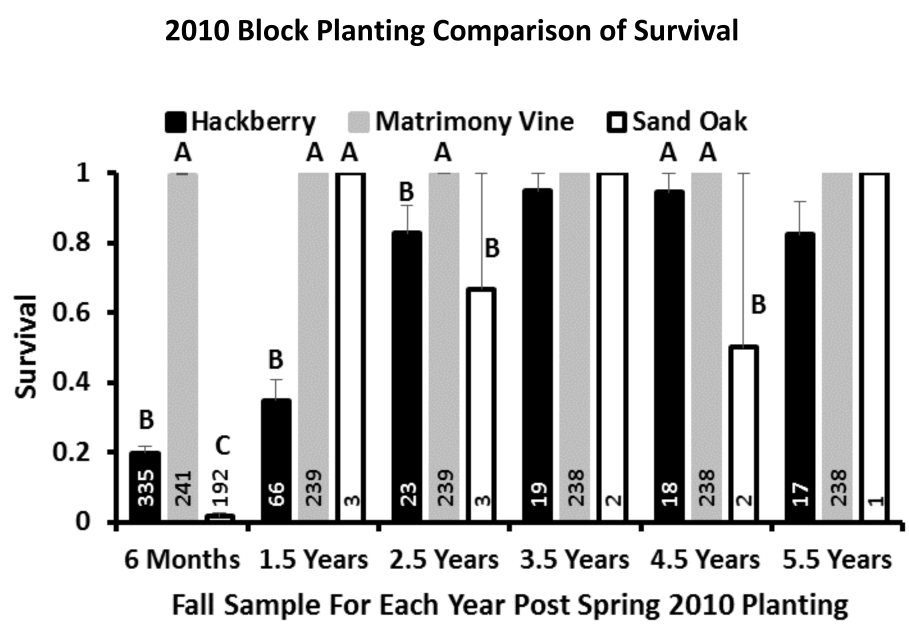

Figure 40 Mean (± SE) Survival for each species planted in 2010. Plants were planted in the spring and survival was calculated for each subsequent fall. Means with a similar letter within each year are not different. The numbers in the base of each column represent the number of plants used to calculate survival.

2011 Block Planting Comparison of Survival

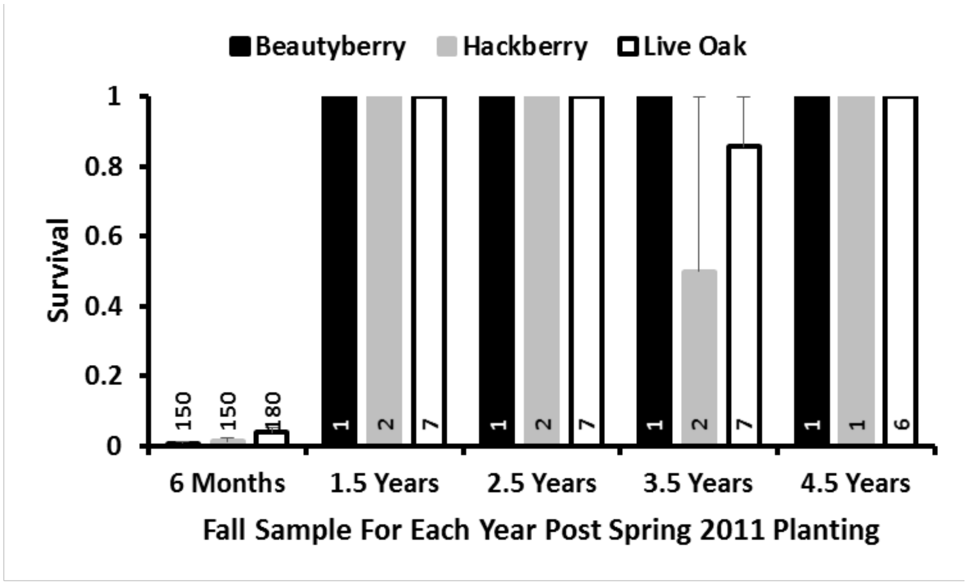

Figure 41 Mean (± SE) Survival for each species planted in 2011. Plants were planted in the spring and survival was calculated for each subsequent fall. Initial Survival was very low and did not differ among species for any sample period. The numbers in the base of each column represent the number of plants used to calculate survival.

2012 Block Planting Comparison of Survival

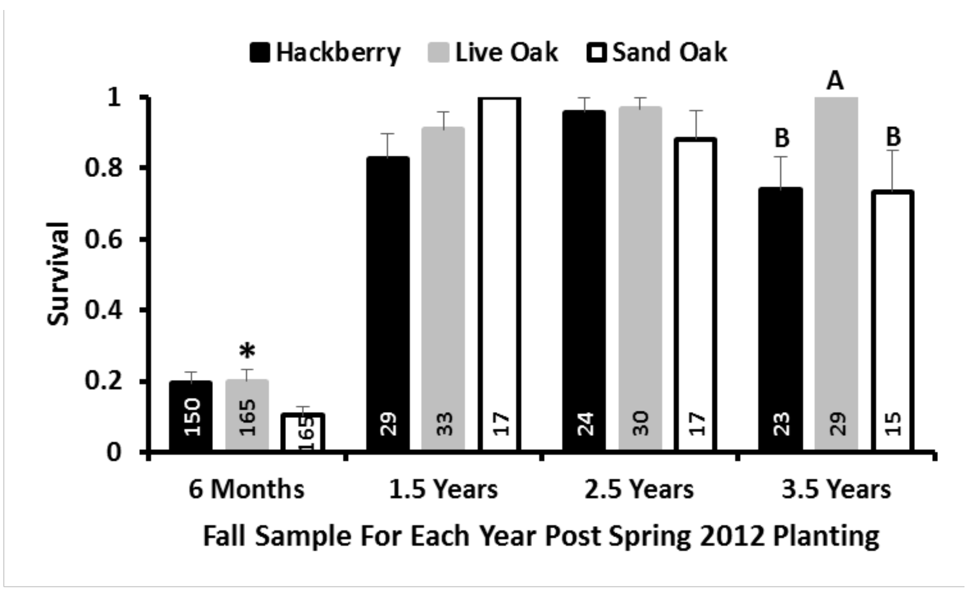

Figure 42 Mean (± SE) Survival for each species planted in 2012. Plants were planted in the spring and survival was calculated for each subsequent fall. Means with a similar letter within each year are not different. The asterisks indicates that Analysis of Variance detected a difference among treatments, but *post hoc* analysis could not delineate among the means. The numbers in the base of each column represent the number of plants used to calculate survival.

2013 Block Planting Comparison of Survival

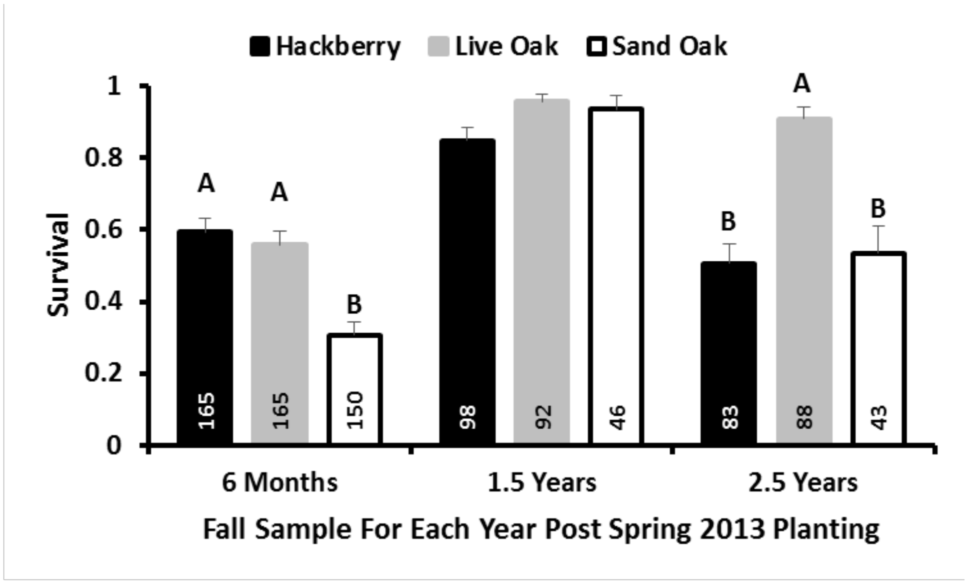

Figure 43 Mean (± SE) Survival for each species planted in 2013. Plants were planted in the spring and survival was calculated for each subsequent fall. Means with a similar letter within each year are not different. The numbers in the base of each column represent the number of plants used to calculate survival.

2014 Block Planting Comparison of Survival

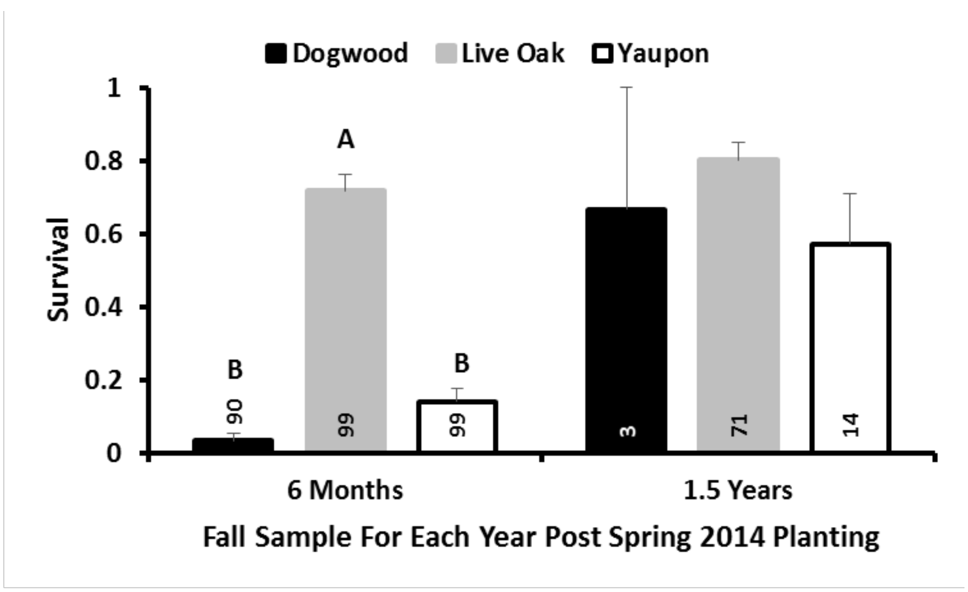

Figure 44 Mean (± SE) Survival for each species planted in 2014. Plants were planted in the spring and survival was calculated for each subsequent fall. Means with a similar letter within each year are not different. The numbers in the base of each column represent the number of plants used to calculate survival.

5.3 Single Species Change in Height Comparison Among Planting Years

Measurements of woody vegetation growth can include change in height, spread, and basal stem diameter (BSD). As a growing plant will increase in height, spread, and BSD over time it is reasonable to expect a degree of correlation among the three variables. We collected growth measurements of height, spread, and basal stem diameter for all surviving plants at the end of each growing season (2009-2015) for all experimental plantings. We compared the correlation between height and spread and between height and BSD for each species for each planting year. The correlation between height and spread was highly significant (all comparisons had a P Value less than 0.0001). The strength of the correlation (Pearson Correlation Coefficient) ranged from 0.4901 – 0.904 with a mean strength of correlation = 0.7262 (Table 2). All correlations between height and BSD were highly significant with all P Values < 0.0001. The strength of correlation ranged from 0.4453 – 0.9193 and averaged 0.7092. These results indicate that height, spread, and BSD change in proportion to each other. Although there is some variation among species and planting years, any of the three growth measurements will provide similar comparative information regarding growth over time. Therefore, because we found height, spread, and basal stem diameter to be highly correlated, we only used change in height as a measure in growth to reduce the amount of graphs and redundancy of this analysis. We report the stats of the rest of the variables in Table 2. Mean heights for each species were calculated from baseline measurements at the time of planting. The change in height at the end of the first growing season to below the baseline mean is due to dieback of plants from inhospitable soil and/or drought conditions.

Table 2 Pearson Correlation Coefficients for the correlation between height (in) and spread (in) and between height (in) and basal stem diameter (mm). All coefficients are significant at a P value of <0.0001.

Species	Planting Year	Height and Spread	Height and Basal Stem Diameter
Live Oak	2011	0.89047	0.91931
Live Oak	2012	0.86195	0.87709
Live Oak	2013	0.78287	0.73235
Live Oak	2014	0.49006	0.55556
Hackberry	2010	0.85329	0.61059
Hackberry	2011	0.56519	0.62644
Hackberry	2012	0.90464	0.91271
Hackberry	2013	0.58841	0.44525
Sand Oak	2010	0.67642	0.68075
Sand Oak	2012	0.67584	0.75487
Sand Oak	2013	0.69921	0.68586

Hackberry: We found no significant difference in change in mean height for hackberry for all of the plantings (2010-2013) over all of the growing seasons except for the fifth growing season (4.5 years) when the change in mean height increased significantly for planting year 2011 compared to planting year 2010 (Figure 45). However, since planting year 2011 only had one plant, the results are not statistically significant or meaningful. The change in mean height index generally increased over time for all planting years after an initial dieback the first growing season. Initial dieback for the first growing season ranged from 4 inches for planting year 2013 to 7.5 inches for planting year 2010. By the end of the third growing season, all planting years had regained their dieback height and averaged 6 inches taller than at the time of planting. By the end of the fourth growing season, all planting years averaged 19 inches higher than at the time of planting or 13 inches growth in one year.

Live Oak: Change in mean height for live oak was only significant at the end of the first growing season when the 2011 planting year lost more height than the 2014 planting year (Figure 46). This was probably due to the exceptional drought of 2011 causing the seedlings to dieback more than the 2014 planting year's first growing season when no drought was occurring. The change in mean height index generally increased over time for all planting years after an initial dieback the first growing season. By the end of the second growing season, all planting years had regained their dieback height and averaged 0.5 inches taller than at the time of planting. By the end of the third and fourth growing season, all planting years averaged together 11.5 and 34 inches higher, respectively, than at the time of planting.

Sand Live Oak: There was no significant difference in change in mean height for sand live oak for all planting years through all growing seasons (Figure 47). The change in mean height index generally increased over time for all planting years after an initial dieback the first growing season. Average dieback at the end of the first growing season for all planting years was 4.5 inches in height. By the end of the second growing season, all planting years had regained their dieback height and averaged 2.5 inches taller. By the end of the third and fourth growing season, all planting years averaged 11 and 15.5 inches higher, respectively, than at the time of planting.

Initial dieback after the first growing season manifested in one of two ways: dieback of some length of the tops of the main stem or death of the main stem and regrowth through new shoot(s) from the roots.

Hackberry Change in Height Comparison Among Planting Years

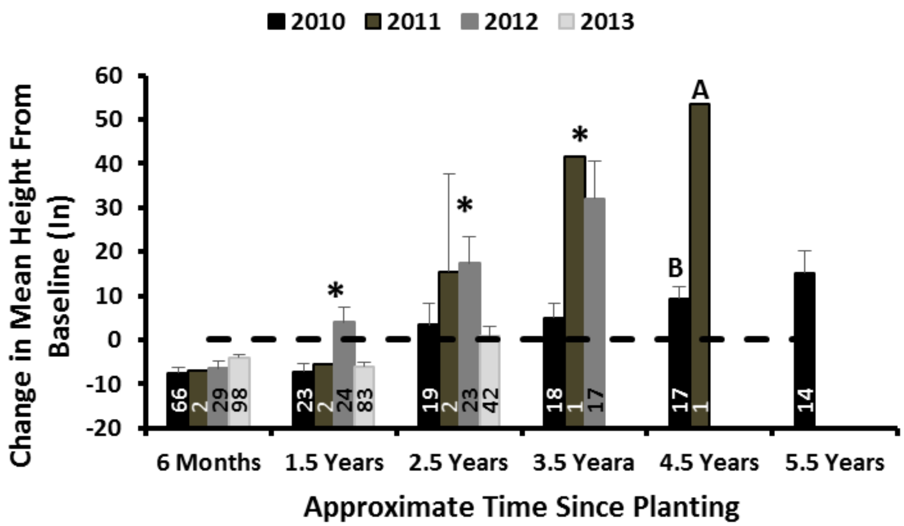

Figure 45 Mean (± SE) change in height for each sample period for each planting year as compared to the height at planting (baseline height = 0) for Hackberry. The horizontal dashed line represents the mean height at planting for each year. Means within a sample period that have a different letter are not similar. Asterisks mark groups that had a difference among treatments detected by Analysis of Variance, but the difference could not be delineated by *post hoc* tests.

Live Oak Change in Height Comparison Among Planting Years

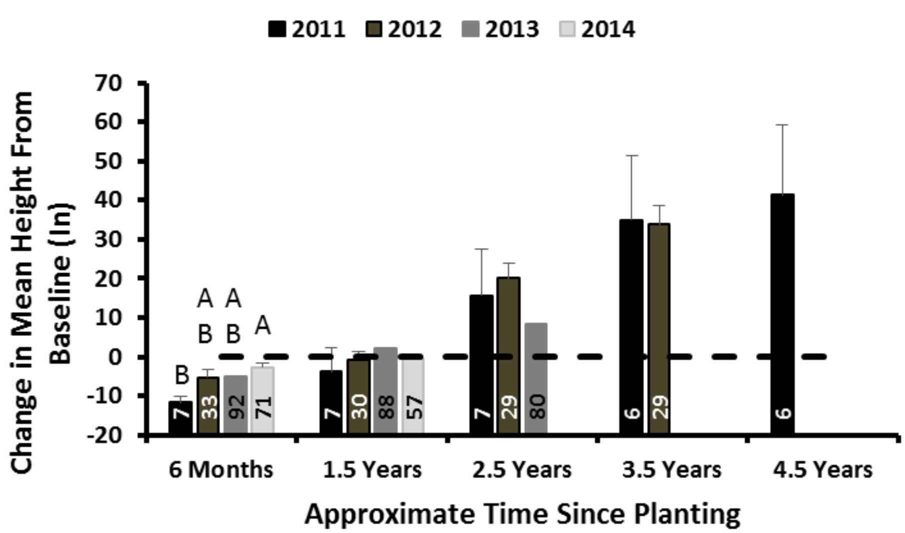

Figure 46 Mean (± SE) change in height for each sample period for each planting year as compared to the height at planting (baseline height = 0) for Live Oak. The horizontal dashed line represents the mean height at planting for each year. Means within a sample period that have a different letter are not similar.

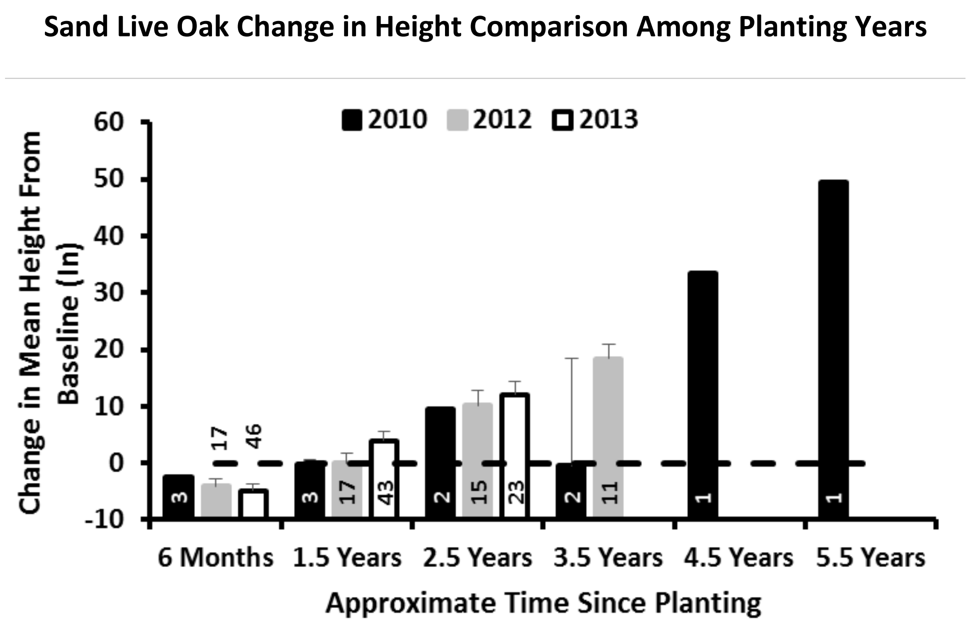

Figure 47 Mean (± SE) change in height for each sample period for each planting year as compared to the height at planting (baseline height = 0) for Sand Live Oak. The horizontal dashed line represents the mean height at planting for each year. Means within each sample period were similar.

5.4 Single Species Survival and Vigor Comparisons Among Planting Years

Of the ten woody species that were used over the course of all of the experimental woody trials at the Far Ridge, three species were used in 3 or more plantings in order to compare survival and growth response chronologically as soil conditions changed. Two species were planted 4 years consecutively: 1) hackberry: 2010, 2011, 2012 and 2013; and 2) live oak: 2011, 2012, 2013, 2014. The third species, sand live oak was planted 3 years: 2010, 2012 and 2013.

5.4.1 Hackberry Survival and Vigor: Comparison Among Planting Years

Hackberry survival 6 months post planting was greatest for the 2013 planting at 59% and lowest for the 2011 planting at 1% (Figure 48). The 2013 plantings high survival rate was probably due to improving soil conditions and 2011's poor survival mostly due to the exceptional drought of that year along with poor soil conditions. First year survival rate for 2010 and 2012 was 20 and 19 percent respectively. Although only 2 out of 150 Hackberry survived the 2011 planting at 6 months, both plants survived to the 2.5 year period. Because both plants from the 2011 planting survived, survival was 100% and among the highest survival rates of the four planting years at both 1.5 and 2.5 years. Beyond the 6 month mark, survival was relatively high for all plantings except the 2010 planting at 1.5 years (35%) and the 2013 planting year at 2.5 years (51%). Although not statistically different from 2012 and 2013, second growing season survival rate was lowest for the 2010 growing year (35%) as this was the year of the exceptional drought

(2011). The moderate drought at the beginning of 2015 may have contributed to the 2013 planting having the lowest survival rate (51%) of all the planting years for the third growing season.

Hackberry vigor varied among planting years at only the end of the first growing season (Figure 49). The least robust plants (highest vigor index) were recorded for the 2011 planting year, the year of the exceptional drought. The most robust plants (least vigor index) were recorded for the 2013 planting year. No differences for vigor were detected among the planting years beyond the first growing season, but the vigor index generally decreased over time for all planting years indicating that the maturing trees were improving their robustness.

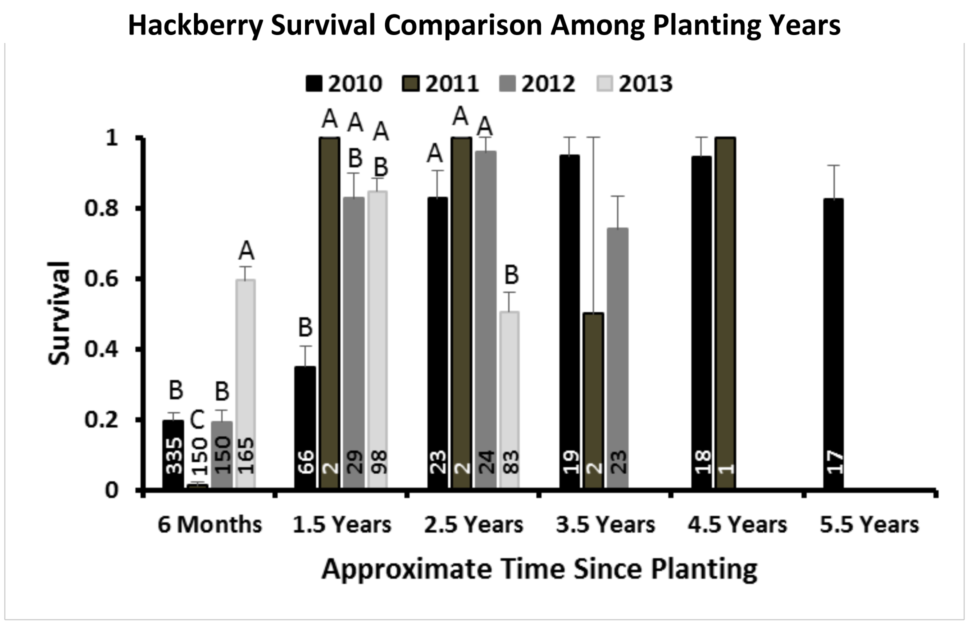

Figure 48 Mean (± SE) Hackberry Survival for each sample period for the 2010, 2011, 2012, and 2013 plantings. Means within a sample period that are marked with a different letter are not similar. Numbers inside of each column represent the number of trees used to calculate the mean value.

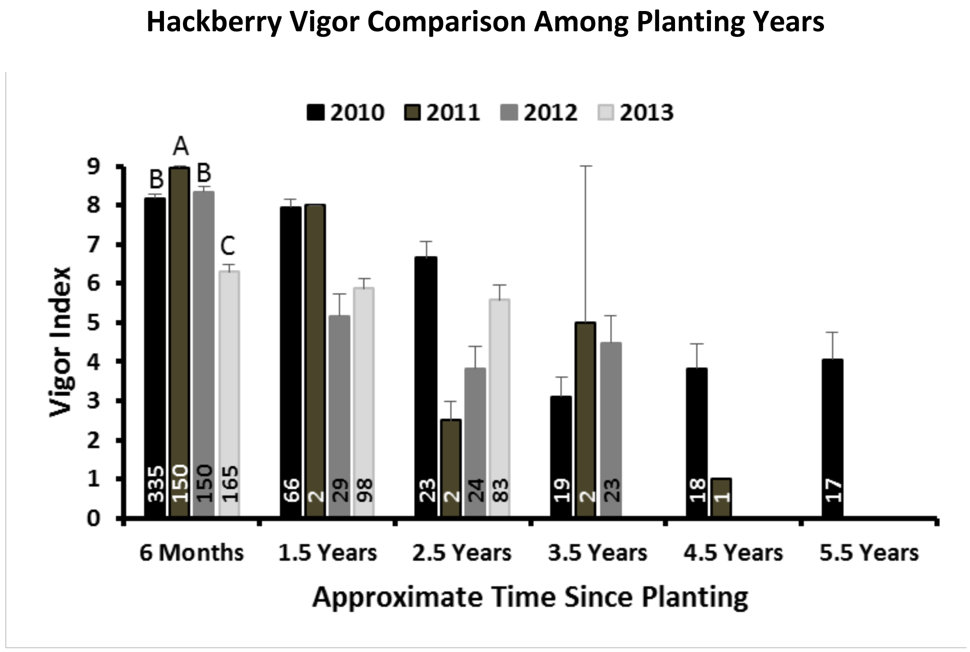

Figure 49 Mean (± SE) Hackberry Vigor for each sample period for the 2010, 2011, 2012, and 2013 plantings. Means within a sample period that are marked with a different letter are not similar. Numbers inside of each column represent the number of trees used to calculate the mean value.

5.4.2 Live Oak Survival and Vigor: Comparison Among Planting Years

Live oak survival varied among the planting years only for the first growing season with the lowest survival in planting year 2011 (4%) and with each following year having significantly higher survival than the year before: 2012 (20%), 2013 (56%), and 2014 (72%) (Figure 50). This trend of increasing survival through the planting years is most likely due to improving soil conditions. The extremely low survival in 2011 is probably due to the exceptional drought recorded that year and poor soil conditions. The improving but low survival in 2012 is likely due to the planting being implemented in an extreme drought and continued poor soil conditions. Beyond the first growing season, survival was relatively high for all plantings (80% or greater).

Live oak vigor varied among planting years for the first 3 growing seasons (6 months to 2.5 years after planting) (Figure 51). The most robust plants (lowest vigor index) for the first growing season (6 months) was for the 2014 planting with the least robust plants (greatest vigor index) in 2011, the year of the exceptional drought. The least robust plants (highest vigor index) for the second growing season (1.5 years) was the 2011 planting year that was probably due to the extreme drought that began the 2012 growing season. No differences for vigor were detected among the planting years beyond the third growing season (2.5 years), but the vigor index generally decreased over time for all planting years indicating that the maturing trees' vigor were improving.

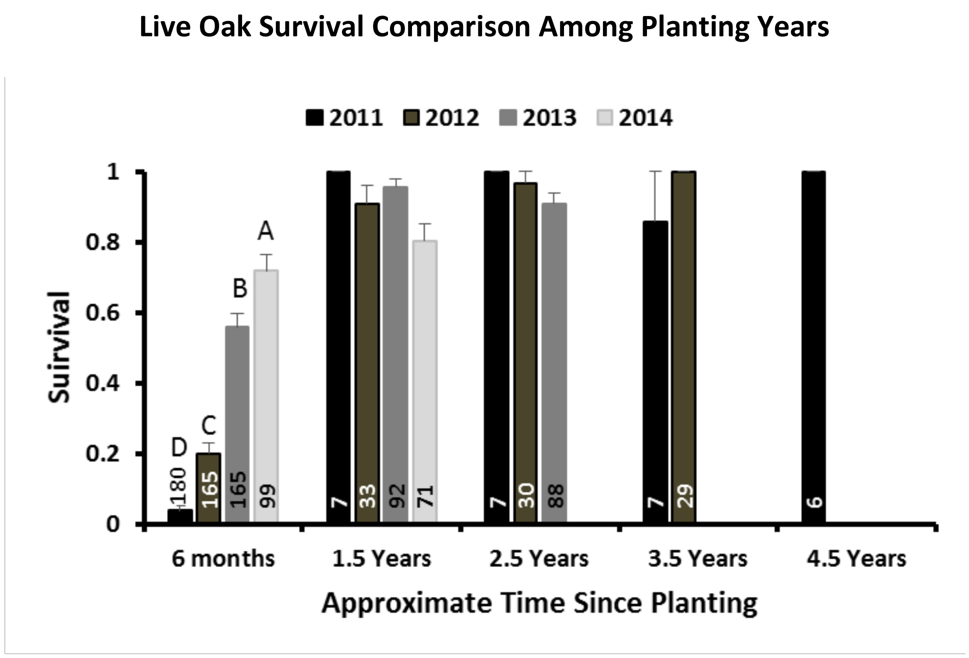

Figure 50 Mean (± SE) Live Oak Survival for each sample period for the 2011, 2012, 2013, and 2014 plantings. Means within a sample period that are marked with a different letter are not similar. Numbers inside of each column represent the number of trees used to calculate the mean value.

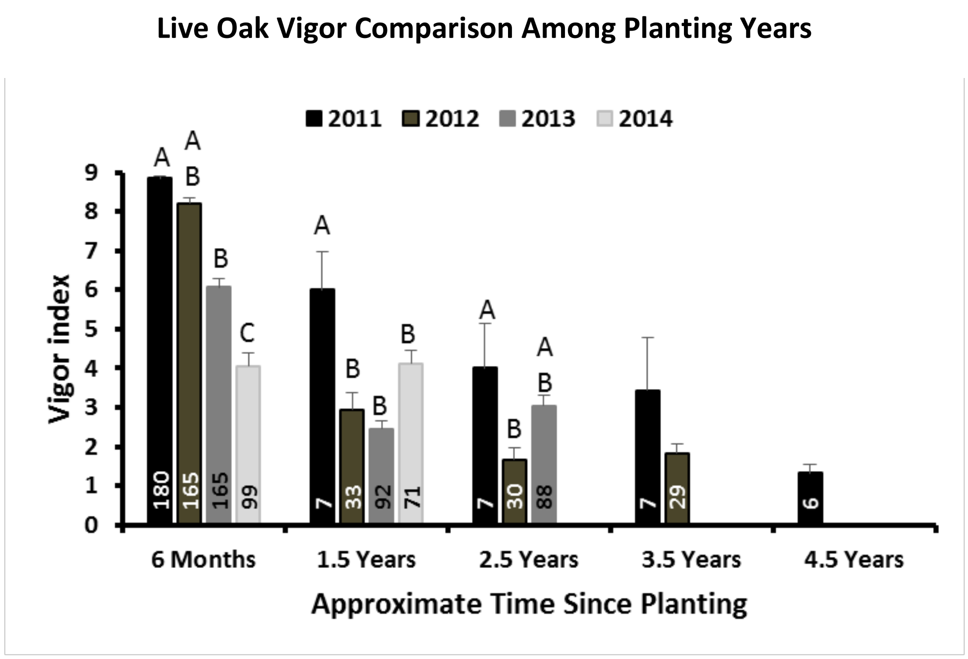

Figure 51 Mean (± SE) Live Oak Vigor for each sample period for the 2011, 2012, 2013, and 2014 plantings. Means within a sample period that are marked with a different letter are not similar. Numbers inside of each column represent the number of trees used to calculate the mean value.

5.4.3 Sand Live Oak Survival and Vigor: Comparison Among Planting Years

Sand live oak survival at the end of the first growing season (6 months) was greatest for the 2013 planting (31%) and lowest for the 2010 planting (2%) (Figure 52). This trend of increasing survival through the years is probably due to improving soil conditions. No statistical difference was seen in survival for the second growing season. For the third growing season, survival for 2012 (88%) was greater than the survival for 2013 (53%) which could be due to the moderate drought in 2015 affecting planting year 2013's third growing season survival. For the fourth growing season survival was highest for 2010 (100%), however the 2010 planting year only had two plants remaining.

Sand live oak vigor varied among planting years for the first 3 growing seasons (Figure 53). The 2013 planting year had the most robust plants (lowest vigor index) for the first growing season (6 months). The 2010 planting year had the least robust plants (greatest vigor index) for the second growing season (1.5 years). The 2012 planting year had the most robust plants (lowest vigor index) for the third growing season (2.5 years). No differences for vigor were detected among the planting years for the fourth growing season (3.5 years).

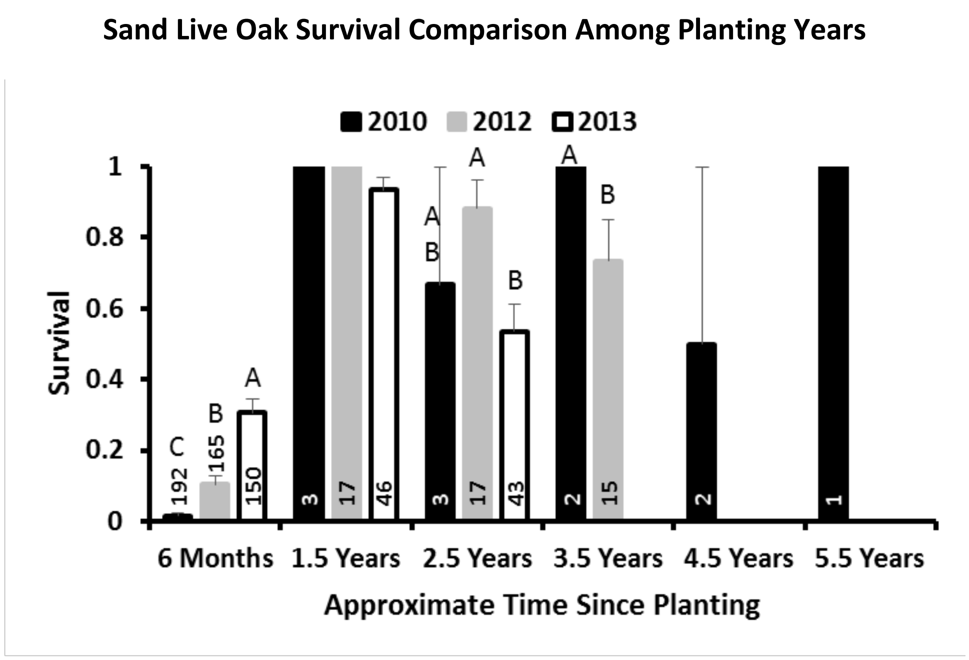

Figure 52 Mean (± SE) Sand Live Oak Survival for each sample period for the 2010, 2012, and 2013 plantings. Means within a sample period that are marked with a different letter are not similar. Numbers inside of each column represent the number of trees used to calculate the mean value.

Sand Live Oak Vigor Comparison Among Planting Years

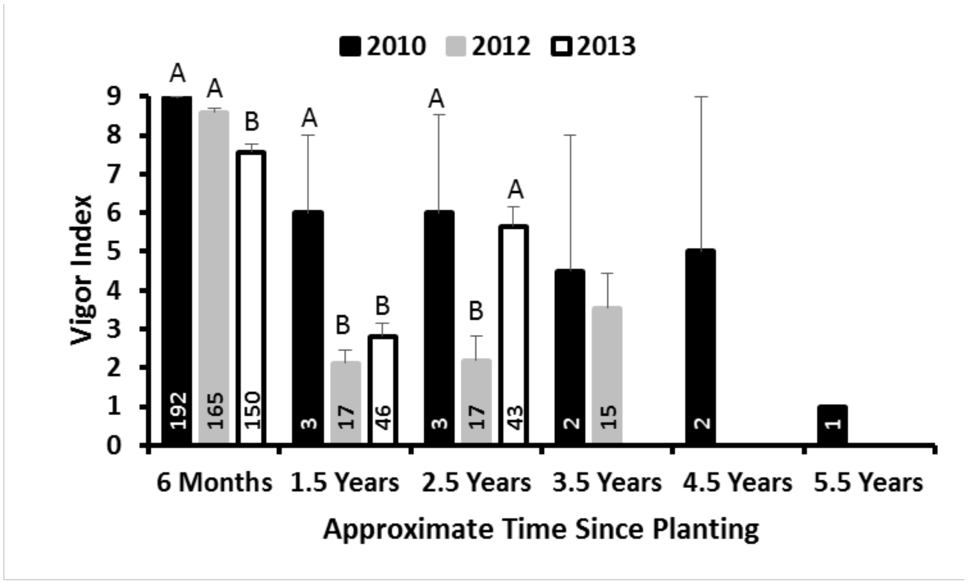

Figure 53 Mean (± SE) Sand Live Oak Vigor for each sample period for the 2010, 2012, and 2013 plantings. Means within a sample period that are marked with a different letter are not similar. Numbers inside of each column represent the number of trees used to calculate the mean value.

5.5 Survival by Orientation

Based on field observations that appeared to show better survival for woody seedlings planted on the south side versus the north side of the Far Ridge, we analyzed seedlings by row positions for the 3 species (hackberry, live oak, and sand live oak) planted at least 3 times in the experimentally designed block plantings for differences in survival. Because the 2010 and 2013 planting years planting area spanned across both the narrower western end of the Far Ridge and the wider eastern section of the Far Ridge, with the narrower western section exhibiting higher soil erosion within the planting blocks than in the wider eastern section of the Far Ridge, it was decided to analyze them separately.

Two planting years, 2010 and 2013, had a portion of the planting area located on the narrower western end. This narrower western end section of the Far Ridge visually exhibited more soil erosion than the wider eastern end section of the Far Ridge. Both sections exhibited considerably more soil erosion off the north side of the ridge compared to the south side. Plants planted on the north side of the ridge were compared to plants planted on the south side of the ridge for survival for the first two growing seasons.

For block planting years 2010 and 2013, a portion of the plantings experimental rectangular blocks were oriented with the long side horizontal (west to east) resulting in four rows with 8 plants in each row and another portion was oriented with the long side vertically (south to north) resulting in 8 rows with 4 plants in each row. These block orientations were necessary because of the topography of the planting site. The 4-rowed horizontal blocks were the result of the narrower ridge on the western end of the Far Ridge that had to be oriented with the longer side west to east in order to fit in this section. The 8-rowed vertical blocks were the result of the wider eastern section of the Ridge being able to accommodate the long side of the rectangle south to north across the top of the ridge. Because of the different topography, 4-row blocks were analyzed separately from 8-row blocks. Block planting years 2011, 2012, and 2014 were only located on the wider eastern section of the Far Ridge, so they were oriented vertically with the long side of the rectangle south to north. These plantings then were only analyzed with 8-row blocks.

Initial construction design of the Far Ridge had a high point in the center of the ridge that sloped off in two directions to the north and to the south. Horizontal and vertical block plots had equal amount of rows on the north side of the ridge and on the south side of the ridge. Therefore, the horizontal blocks had 2 rows on the north side of the ridge and 2 on the south side. The vertical blocks had 4 rows on the north side of the ridge and 4 rows on the south side of the ridge. The north side rows and the south side rows were then compared for survival as shown in the figures below (Figures 54 & 55).

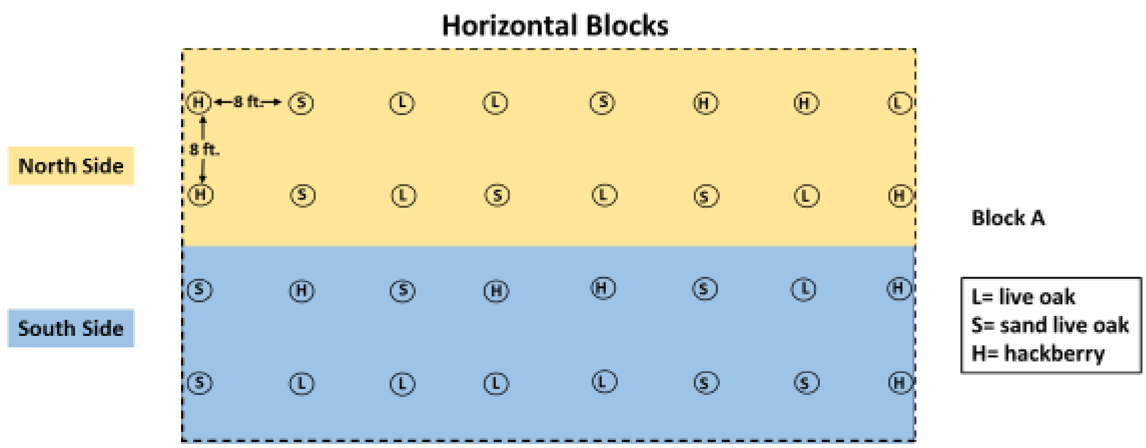

Figure 54 Example diagram of planting layout for horizontal blocks on ridge. Horizontal blocks compared plant survival for the two rows (8 plants each row) on the north side of the ridge versus plant survival for the two rows (8 plants each row) on the south side of the ridge.

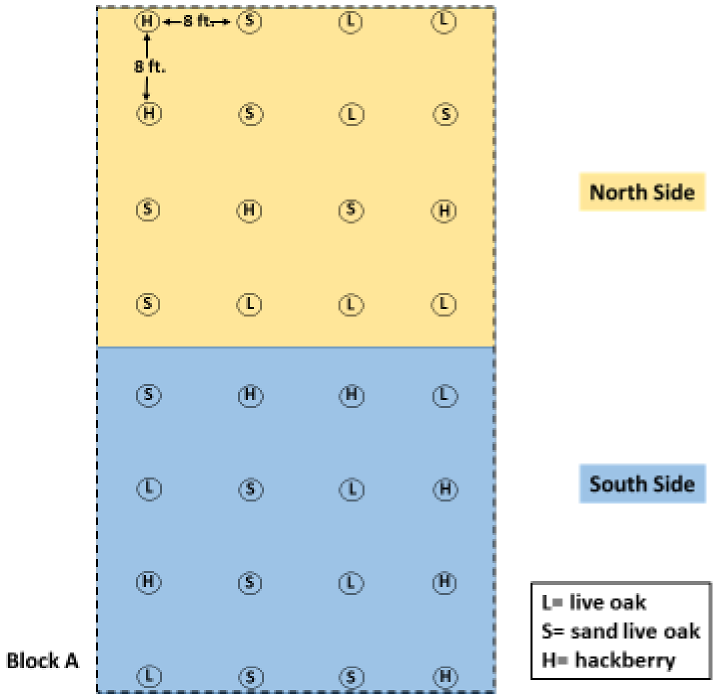

Figure 55 Example diagram of planting layout for vertical blocks on ridge. Vertical blocks compared plant survival for the four rows (4 plants each row) on the north side of the ridge versus plant survival for the four rows (4 plants each row) on the south side of the ridge.

5.5.1 Survival by Orientation – Far Ridge: Narrow Section

This section of the ridge was not of sufficient width on the top or crown to orient the planting blocks with the long side of the rectangle south to north, so these first 7 blocks were oriented with the long side of the rectangle west to east, resulting in 4 rows (west to east) of 8 plants in each row. The plants in the two northernmost rows were compared to the plants in the two southernmost rows for survival over the first two growing seasons.

5.5.1.1 2010 Survival by Orientation – Far Ridge: Narrow Section

The 2010 planting year utilized two species we analyzed for survival by orientation on the narrower section of the Far Ridge: hackberry and sand live oak. There was no significant difference in survival for hackberry seedlings between the south and north orientations for either the first or second growing seasons (Figure 56). Approximately a year and a half post-construction of the ridge, soil conditions were still poor at the time of planting resulting in low survival after the first growing season for plants in both orientations (15% south vs. 16% north). Only the south side orientation had any survivors (14%) by the end of the second growing season.

Sand live oak survival exhibited no significant difference between the north and south orientations for either the first or second growing seasons (Figure 57). All but one sand live oak seedling on the north orientation died by the end of the first growing season. Approximately a year and a half post-construction of the ridge, soil conditions were still poor at the time of planting resulting in low survival after the first growing season for plants in both orientations.

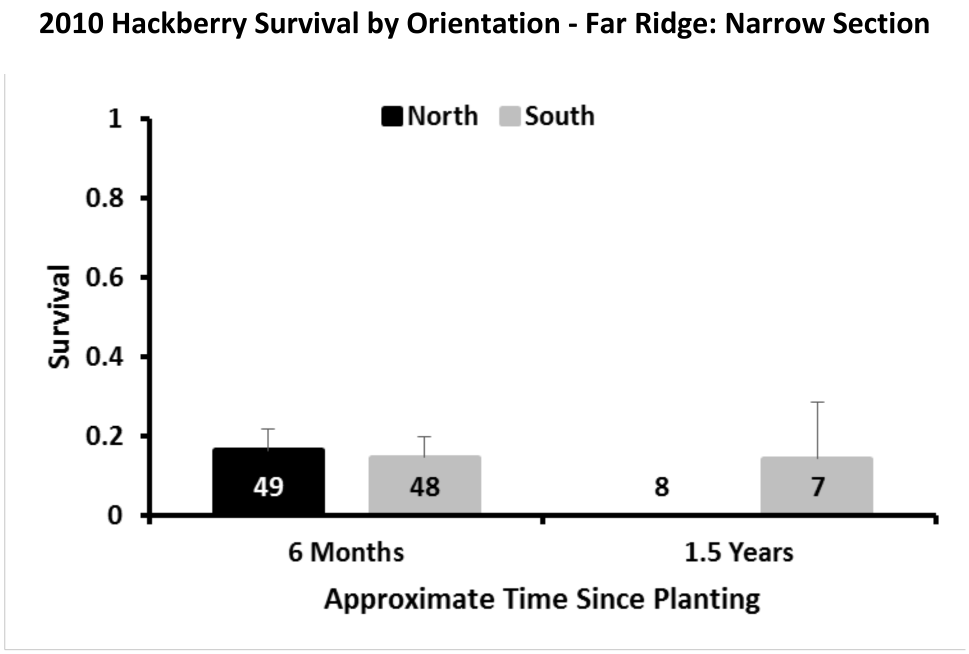

Figure 56 Mean (± SE) survival for Hackberry planted in 2010 in a horizontal block and sampled 6 months and 1.5 years after planting for each orientation. Means within each sample period are similar but only the South side had survivors by 1.5 years. The number at the base of each column represents the number of individuals used to calculate the mean value.

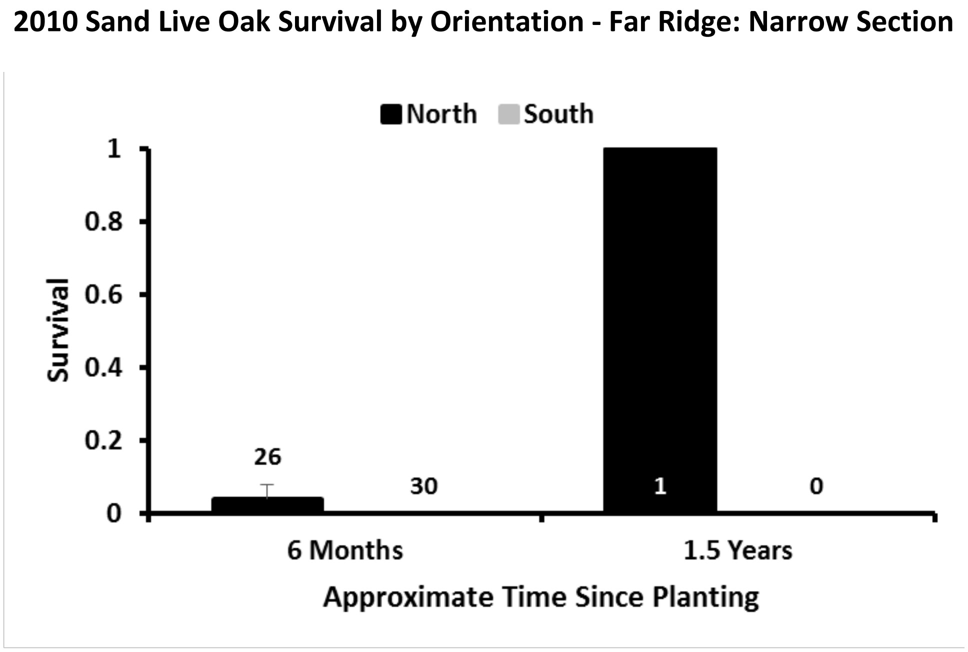

Figure 57 Mean (± SE) survival for Sand Live Oak planted in 2010 in a horizontal block and sampled 6 months and 1.5 years after planting for each orientation. No Sand Live Oak planted on the South side survived to 6 months. The number at the base of each column represents the number of individuals used to calculate the mean value.

5.5.1.2 2013 Survival by Orientation – Far Ridge: Narrow Section

The 2013 planting year utilized three species we analyzed for survival by orientation on the narrower section of the Far Ridge: hackberry, live oak, and sand live oak. Hackberry survival in the two rows on the south side of the Far Ridge was significantly greater (59%) than survival of hackberry seedlings planted in the two rows on the north side of the Far Ridge (33%) at the end of the first growing season (Figure 58). No significant difference was seen in survival of hackberry seedlings in the second growing season.

Live oak survival for the south oriented seedlings was significantly greater (66%) than the survival of the live oaks planted on the north side (21%) at the end of the first growing season (Figure 59). There was no difference at the end of the second growing season.

Sand live oak survival for the south oriented seedlings was significantly greater (42%) than the survival of the sand live oaks planted on the north side (14%) at the end of the first growing season (Figure 60). There was no difference at the end of the second growing season.

Survival was significantly greater for all 3 species of plants planted on the south side compared to the north side after the first growing season. The greater survival for the south side orientation is probably mostly due to less soil erosion around the plants and also to greater soil moisture retention in the rooting zone. No significant difference was seen in survival of any of the 3 species planted at the end of the second growing season as all species at both orientations had survival in excess of 80%. No difference in survival between orientations at the end of the second growing season is probably due to advantages of the plants already being established and rooted in place from the first growing season.

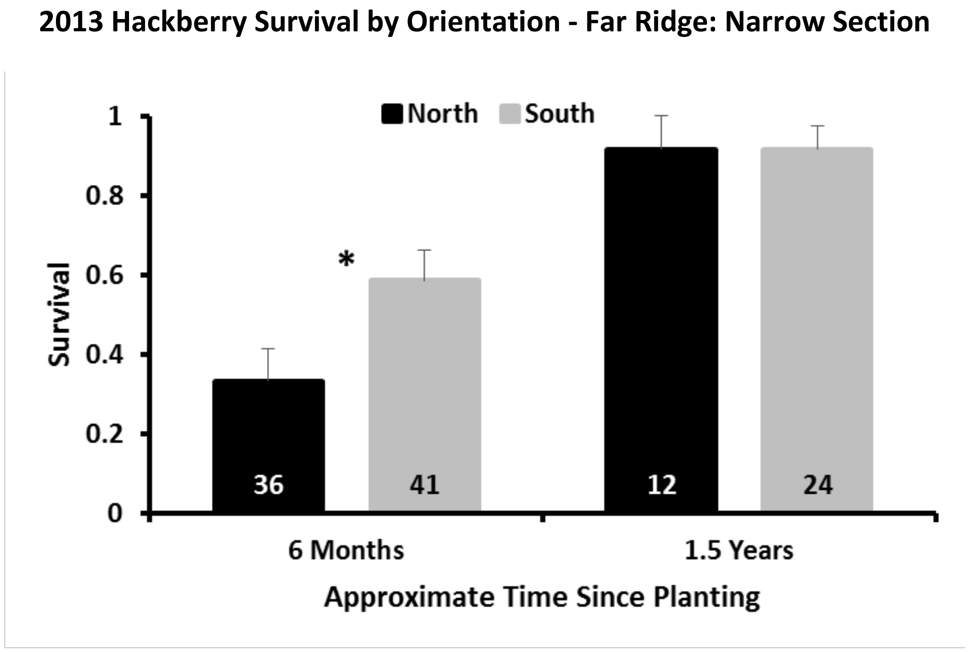

Figure 58 Mean (± SE) survival for Hackberry planted in 2013 in a horizontal block and sampled 6 months and 1.5 years after planting for each orientation. The asterisk indicates a difference in survival between the two locations within each time period. The number at the base of each column represents the number of individuals used to calculate the mean value.

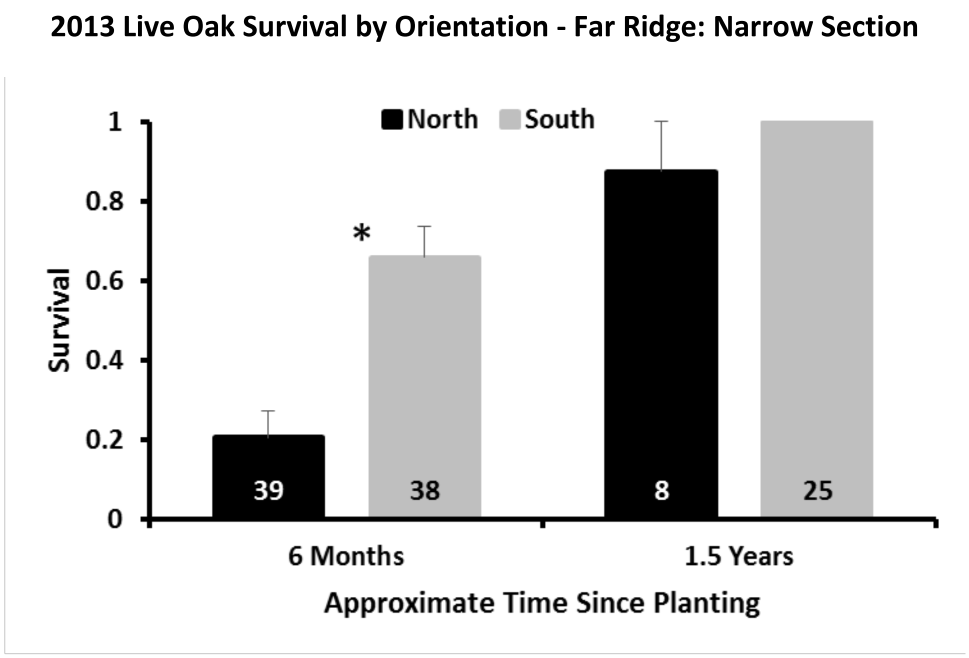

Figure 59 Mean (± SE) survival for Live Oak planted in 2013 in a horizontal block and sampled 6 months and 1.5 years after planting for each orientation. The asterisk indicates a difference in survival between the two locations within each time period. The number at the base of each column represents the number of individuals used to calculate the mean value.

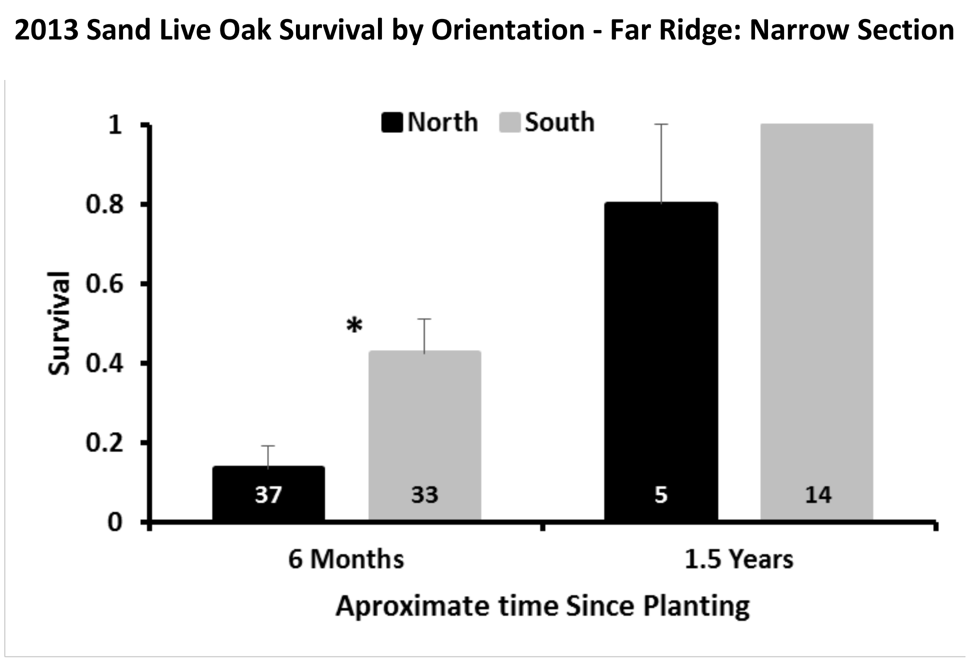

Figure 60 Mean (± SE) survival for Sand Live Oak planted in 2013 in a horizontal block and sampled 6 months and 1.5 years after planting for each orientation. The asterisk indicates a difference in survival between the two locations within each time period. The number at the base of each column represents the number of individuals used to calculate the mean value.

5.5.2 Survival by Orientation – Far Ridge: Wide Section

This section of the ridge was of sufficient width on the top or crown to orient the planting blocks with the long side of the rectangle south to north, resulting in 8 rows (west to east) of 4 plants in each row. The plants from the four northernmost rows were compared to the plants of the four southernmost rows for survival over the first two growing seasons.

5.5.2.1 2010 Survival by Orientation – Far Ridge: Wide Section

The 2010 planting year utilized two species we analyzed for survival by orientation on the wider section of the Far Ridge: hackberry and sand live oak. There was no significant difference in survival for hackberry seedlings between the north and south orientations for the first growing season. Hackberry survival at the end of the first growing season was 26% for the south orientation and 17% for the north orientation (Figure 61). However, survival for hackberry seedlings planted on the south side was significantly greater (55%) than hackberry seedlings planted on the north side (25%) by the end of the second growing season. Poor soil conditions were likely the cause for low survivorship after the first growing season at both orientations. The greater survivorship of hackberry seedlings at the south orientation versus the north orientation was probably due to reduced soil erosion and better soil moisture retention in the planting area of the south orientation.

Sand live oak survival exhibited no significant difference between the north and south orientations for either the first or second growing seasons (Figure 62). Only one sand live oak seedling at each orientation survived till the end of the first growing season making survival for each 1%. Both seedlings remained at the north and south side orientations by the end of the second growing season. Approximately a year and a half post-construction of the ridge, soil conditions were still poor at the time of planting and likely the cause of the mortality of both species.

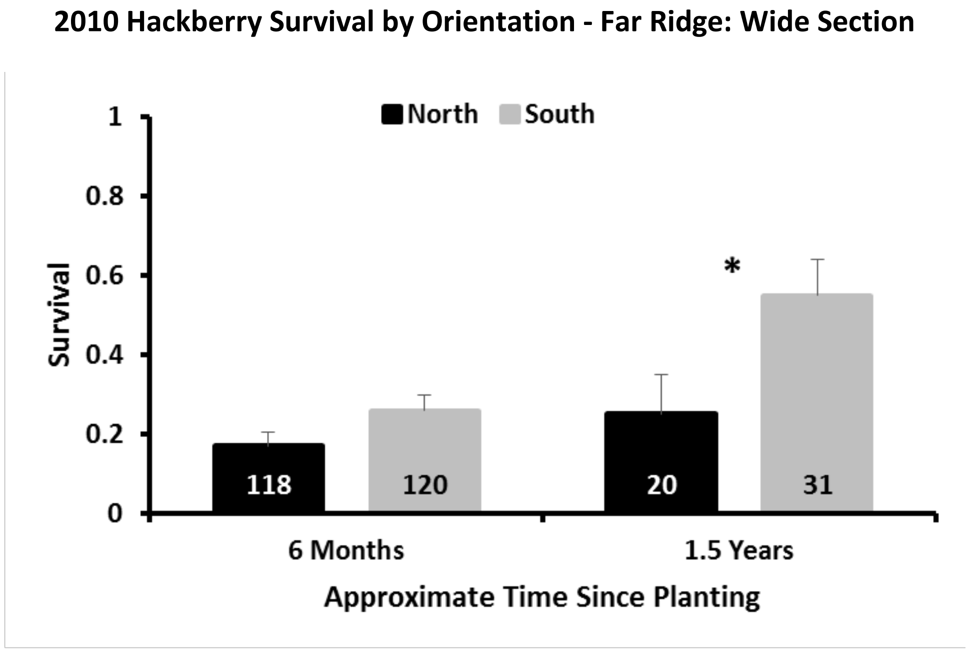

Figure 61 Mean (± SE) survival for Hackberry planted in 2010 in a vertical block and sampled 6 months and 1.5 years after planting for each orientation. The asterisk indicates a difference in survival between the two locations within each time period. The number at the base of each column represents the number of individuals used to calculate the mean value.

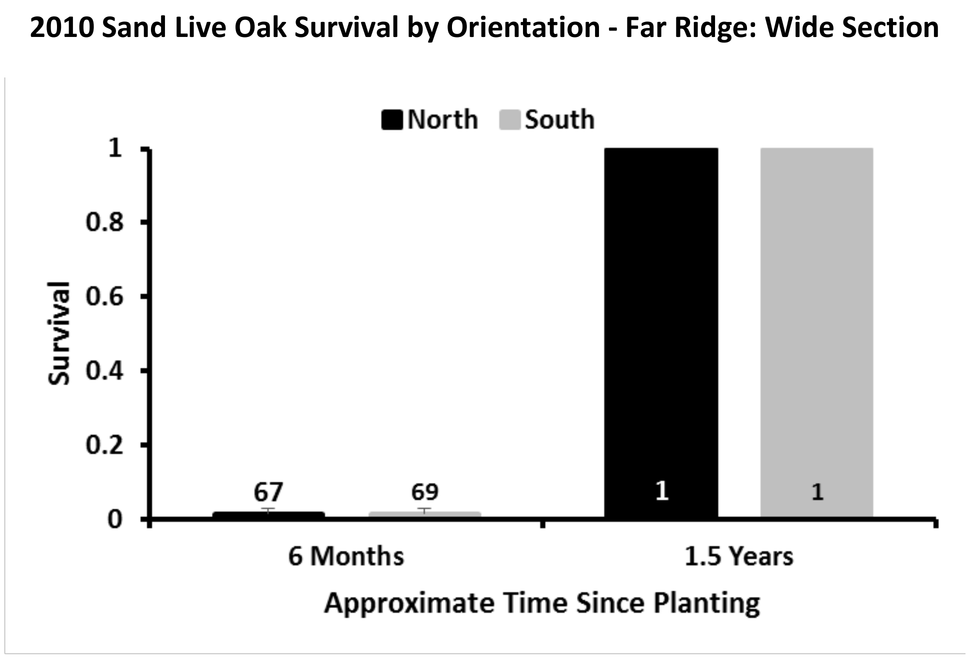

Figure 62 Mean (± SE) survival for Sand Live Oak planted in 2010 in a vertical block and sampled 6 months and 1.5 years after planting for each orientation. The number at the base of each column represents the number of individuals used to calculate the mean value.

5.5.2.2 2011 Survival by Orientation – Far Ridge: Wide Section

The 2011 planting year utilized two species analyzed for survival by orientation on the wider section of the Far Ridge: hackberry and live oak. There was no significant difference in survival after the first growing season for either hackberry or live oak as almost all of the seedlings at both orientations died (hackberry: south 3% vs, north 0%; live oak: 6% south vs. 2% north) (Figures 63 & 64). The extreme mortality for this planting year for both species is likely due to continued poor soil conditions and to the exceptional drought during the growing season. The few surviving plants from both species all survived to the end of the second growing season, however.

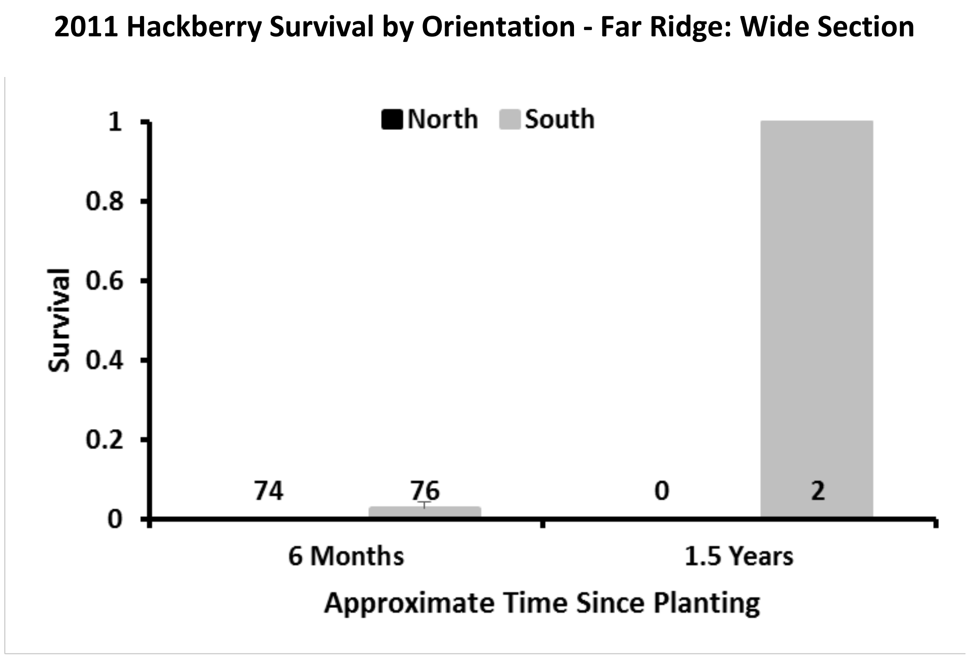

Figure 63 Mean (± SE) survival for Hackberry planted in 2011 in a vertical block and sampled 6 months and 1.5 years after planting for each orientation. There were no survivors on the North side after 6 months. The number at the base of each column represents the number of individuals used to calculate the mean value.

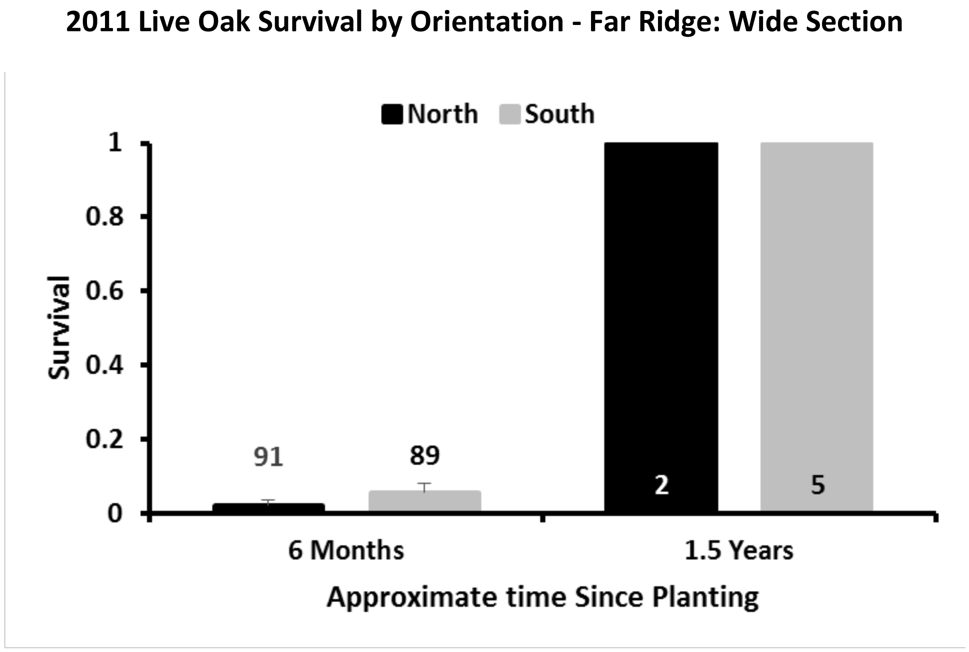

Figure 64 Mean (± SE) survival for Live Oak planted in 2011 in a vertical block and sampled 6 months and 1.5 years after planting for each orientation. Means within each sample period are similar. The number at the base of each column represents the number of individuals used to calculate the mean value.

5.5.2.3 2012 Survival by Orientation – Far Ridge: Wide Section

The 2012 planting year utilized three species analyzed for survival by orientation on the wider section of the Far Ridge: hackberry, live oak, and sand live oak. Hackberry survival exhibited no significant difference between the north and south orientations for the first or second growing seasons (Figure 65). First growing season survival was 25% for the south orientation and 13% for the north orientation. Survival at the end of the second season was greater than two thirds for both orientations.

Survival of live oak seedlings planted on the south side (32%) of the Far Ridge was significantly greater after the first growing season than live oak seedlings planted on the north side (8%) (Figure 66). There was no significant difference in survival between the north and south orientations after the second growing season with both greater than 85%.

Sand live oak survival of seedlings planted on the south side (18%) of the Far Ridge was significantly greater after the first growing season than sand live oak seedlings planted on the north side (3%) (Figure 67). There was no significant difference in survival between the north and south orientations after the second growing season as they were both 100%.

Although there was no difference in survival between orientations for hackberry, the greater survivorship of live oak and sand live oak seedlings at the south orientation versus the north orientation was probably due to reduced soil erosion and better soil moisture retention in the planting area of the south orientation. And although soil conditions were improving with each passing year, the general poor first season survival of all species was probably due to an extreme drought at the time of the planting and continued poor soil conditions. Rain did follow a couple of weeks after planting, but only enough to reduce it to a moderate drought which then persisted until late July. Established plants fared better for the second growing season with all 3 species survival better than two out of three.

2012 Hackberry Survival by Orientation - Far Ridge: Wide Section

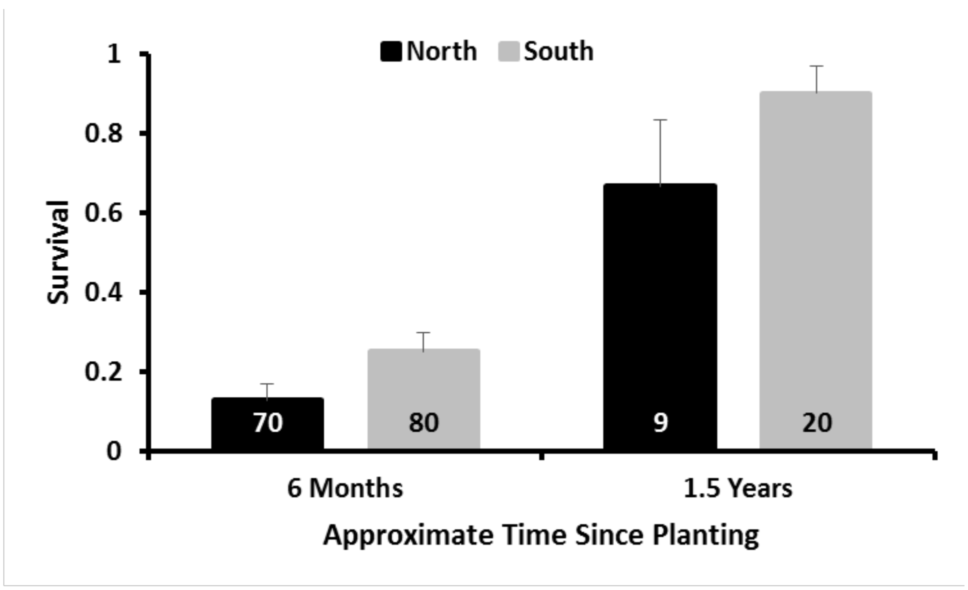

Figure 65 Mean (± SE) survival for Hackberry planted in 2012 in a vertical block and sampled 6 months and 1.5 years after planting for each orientation. Means within each sample period are similar. The number at the base of each column represents the number of individuals used to calculate the mean value.

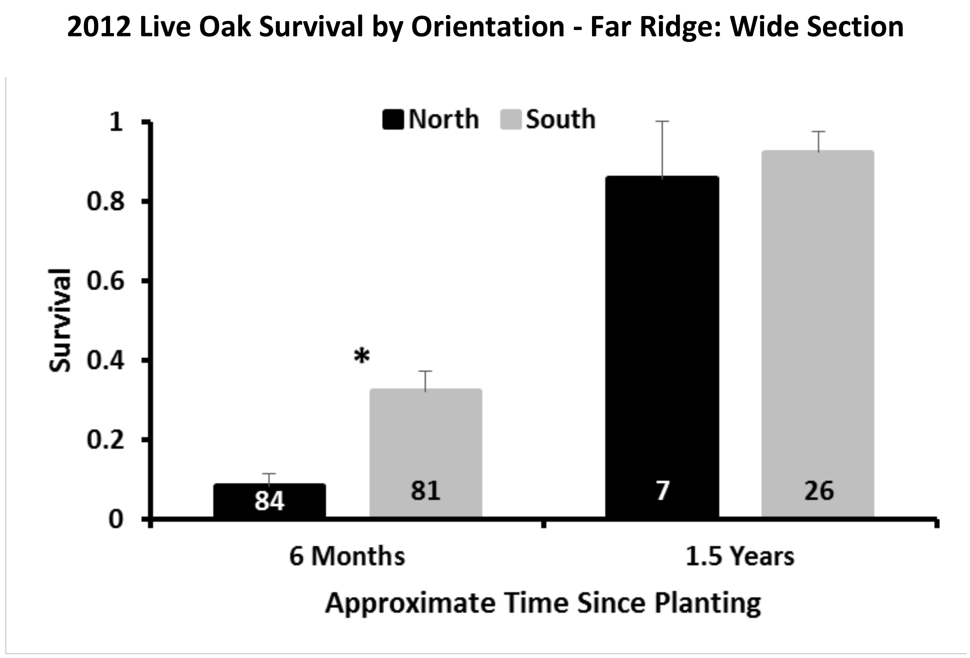

Figure 66 Mean (± SE) survival for Live Oak planted in 2012 in a vertical block and sampled 6 months and 1.5 years after planting for each orientation. The asterisk indicates a difference in survival between the two orientations within each time period. The number at the base of each column represents the number of individuals used to calculate the mean value.

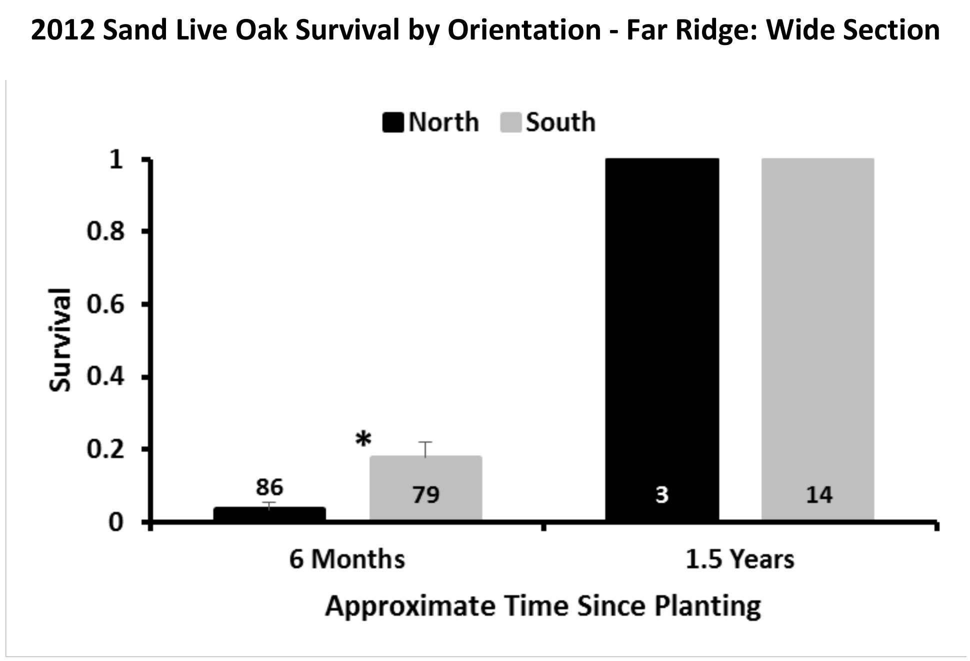

Figure 67 Mean (± SE) survival for Sand Live Oak planted in 2012 in a vertical block and sampled 6 months and 1.5 years after planting for each orientation. The asterisk indicates a difference in survival between the two locations within each time period. The number at the base of each column represents the number of individuals used to calculate the mean value.

5.5.2.4 2013 Survival by Orientation – Far Ridge: Wide Section

The 2013 planting year utilized three species analyzed for survival by orientation on the wider section of the Far Ridge: hackberry, live oak, and sand live oak. Hackberry survival exhibited no significant difference between the north and south orientations for the first growing season (72% south vs. 69% north) (Figure 68). However, survival of hackberry seedlings on the north side (93%) was significantly greater than the seedlings located on the south side (70%) after the second growing season. This instance of the north orientation's survival being significantly greater after the second growing season than the south side's orientation is the only instance through all the planting years for either growing season.

There was no significant difference in live oak survival between orientations for the first (63% south vs. 71% north) or second growing seasons (96% south vs. 94% north) (Figure 69).

There was also no significant difference in sand live oak survival between orientations for the first (28% south vs. 39% north) or second growing seasons (91% south vs. 94% north) (Figure 70).

First year survival for all 3 species improved significantly from previous year's plantings. Survival for hackberry and live oak both exceeded 50% for the first time and at both orientations. Sand live oak survival, although improved, did not exceed 50% at either orientation. The absence of a difference in survival at orientations for the first growing season across all species could be due to a reduction of soil erosion off the north side as the slope begins to level off, the absence of a drought and improved soil quality.

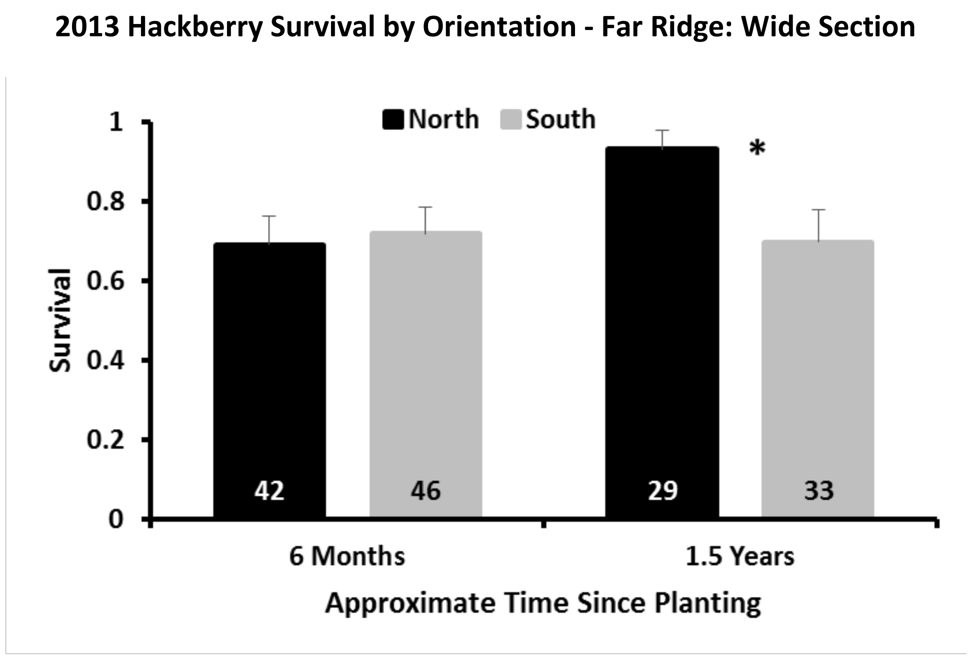

Figure 68 Mean (± SE) survival for Hackberry planted in 2013 in a vertical block and sampled 6 months and 1.5 years after planting for each orientation. The asterisk indicates a difference in survival between the two locations within each time period. The number at the base of each column represents the number of individuals used to calculate the mean value.

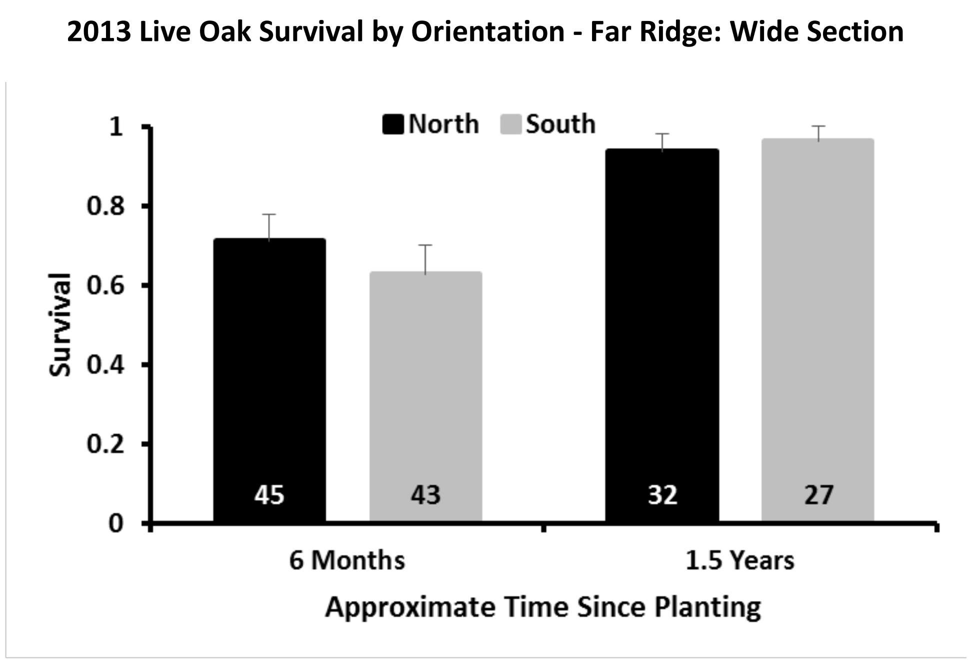

Figure 69 Mean (± SE) survival for Live Oak planted in 2013 in a vertical block and sampled 6 months and 1.5 years after planting for each orientation. Means within each sample period are similar. The number at the base of each column represents the number of individuals used to calculate the mean value.

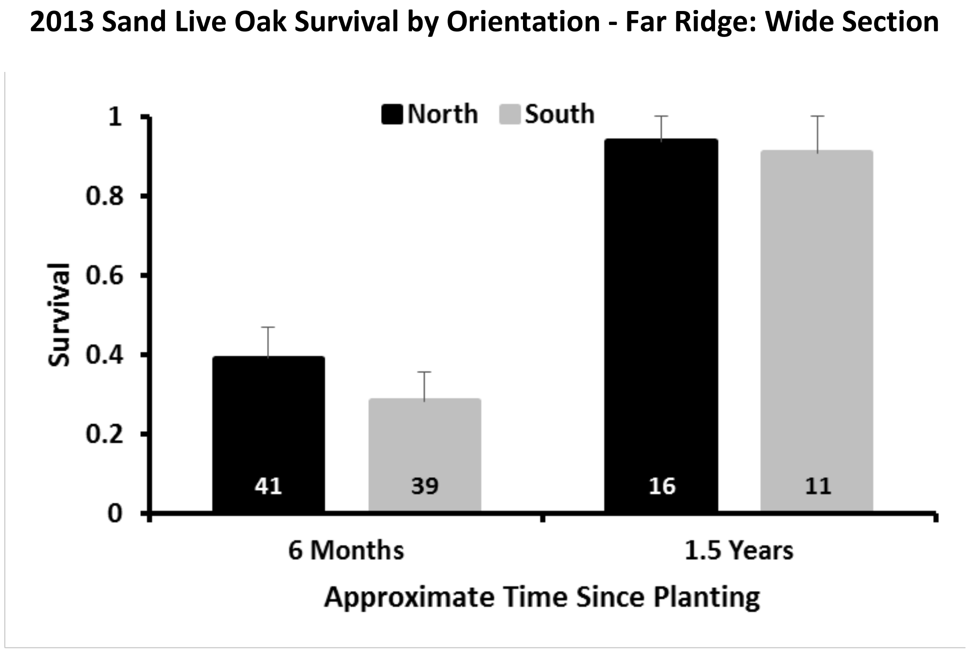

Figure 70 Mean (± SE) survival for Sand Live Oak planted in 2013 in a vertical block and sampled 6 months and 1.5 years after planting for each orientation. The number at the base of each column represents the number of individuals used to calculate the mean value. All means for each sample period were statistically similar.

5.5.2.5 2014 Survival by Orientation – Far Ridge: Wide Section

The 2014 planting year analyzed only live oak seedlings for survival by orientation on the wider section of the Far Ridge. Live oak survival was significantly greater in the south orientation (80%) versus the north orientation (63%) for the first growing season (Figure 71). There was no significant difference between orientations for the second growing season (80% for both). The 2014 planting year was the highest overall survival for live oak and the highest survival for orientation (south) of all the planting years with live oak. Increase in plant survival was directly related to a decrease in sodium in the soil rooting zone, improved soil conditions, adequate fresh water, and absence of drought.

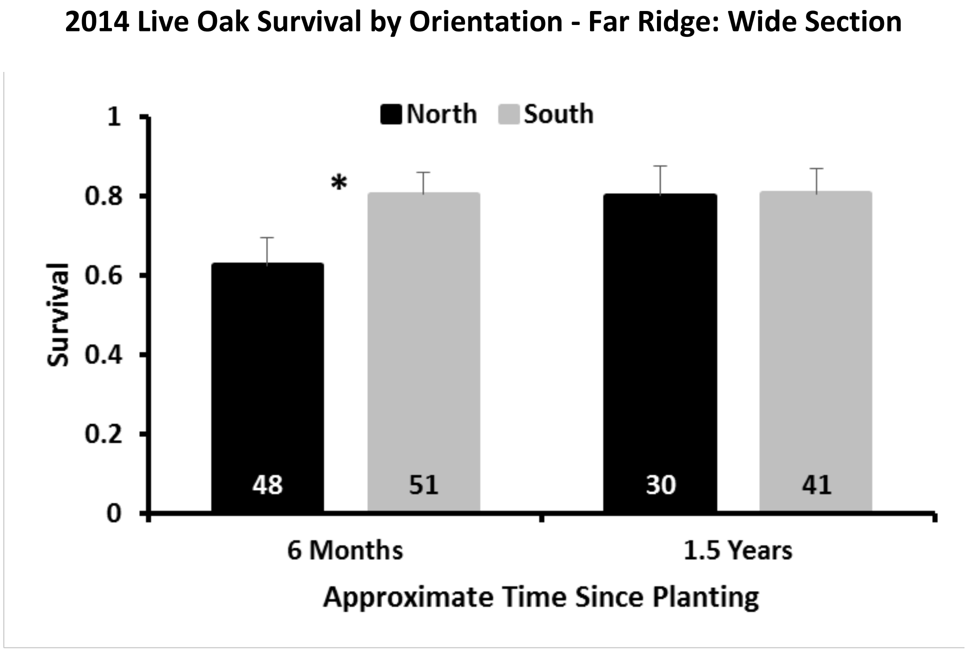

Figure 71 Mean (± SE) survival for Live Oak planted in 2014 in a vertical block and sampled 6 months and 1.5 years after planting for each orientation. Means within each sample period are similar. The number at the base of each column represents the number of individuals used to calculate the mean value.

5.6 Soil Quality

We compared Electrical Conductivity (EC), Soluble Salts (Salts), Sodium (Na), Sodium Adsorption Ratio (SAR), and Cation Exchange Capacity (CEC) on the Far Ridge among sample years with ANOVA and Regression (Figures 72-81) using a mean of all 15 soil samples collected from the top of the Far Ridge. Using the mean gave a better representation of the soil across the ridge overall as a single value, similar to a composite sample, however, there was considerable variation in the results among the 15 sample locations across the top of the Far Ridge. For comparison of the individual sampling locations see Appendix 2.

None of the variables showed a significant difference among years, but all 5 variables had a significant decreasing trend over time based on regression analysis. This decreasing trend indicates that the sodium in the rooting zone of the ridge is being leached and transported out of the rooting zone, leading to improved qualities in chemical and physical properties of the soil for plants. As a result, soil quality on the Far Ridge is improving over time.

Sampling Years Mean EC

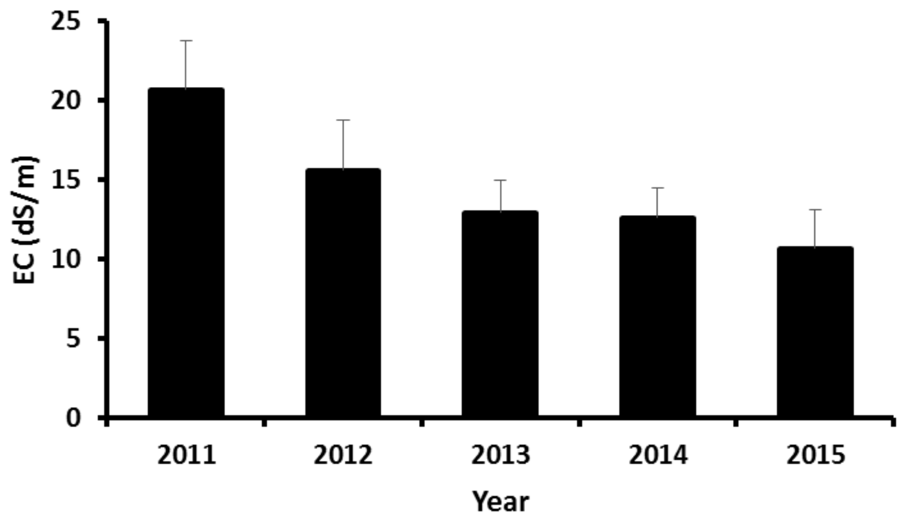

Figure 72 Mean (±SE) EC on the Far Ridge for each year. Means that share a similar letter are not different.

Sampling Years Relationship to EC

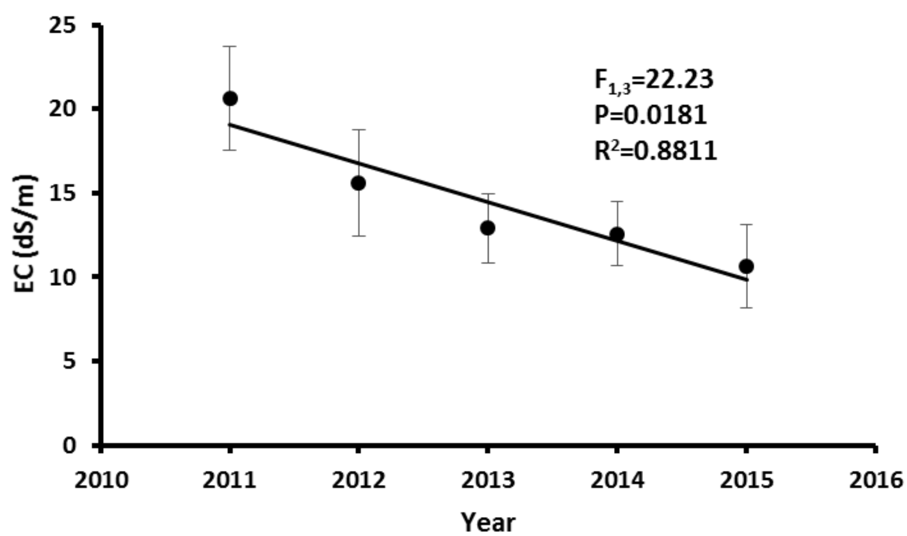

Figure 73 Relationship between EC (±SE) and sample year for the Far Ridge.

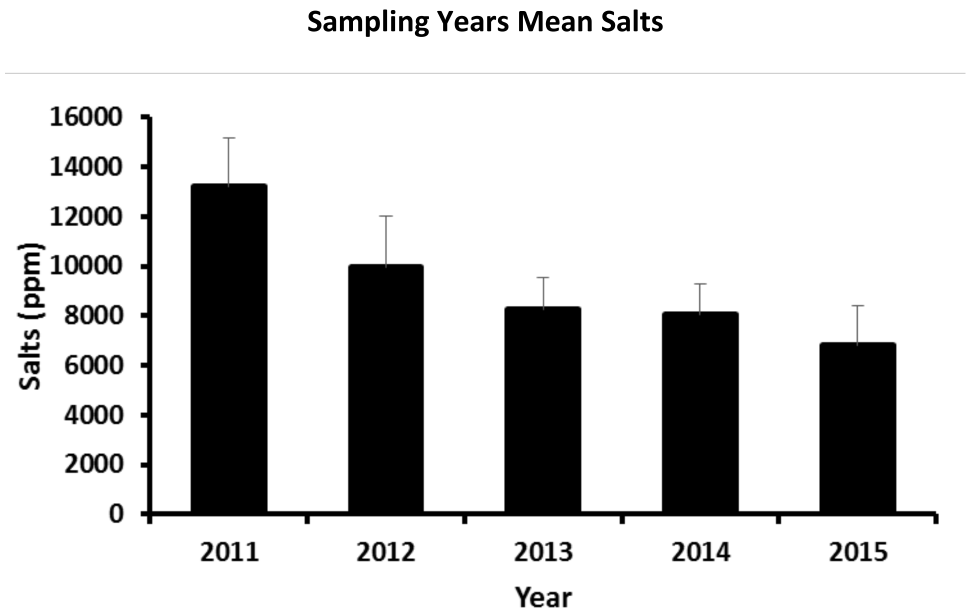

Figure 74 Mean (±SE) Salts on the Far Ridge for each year. No differences were detected among years.

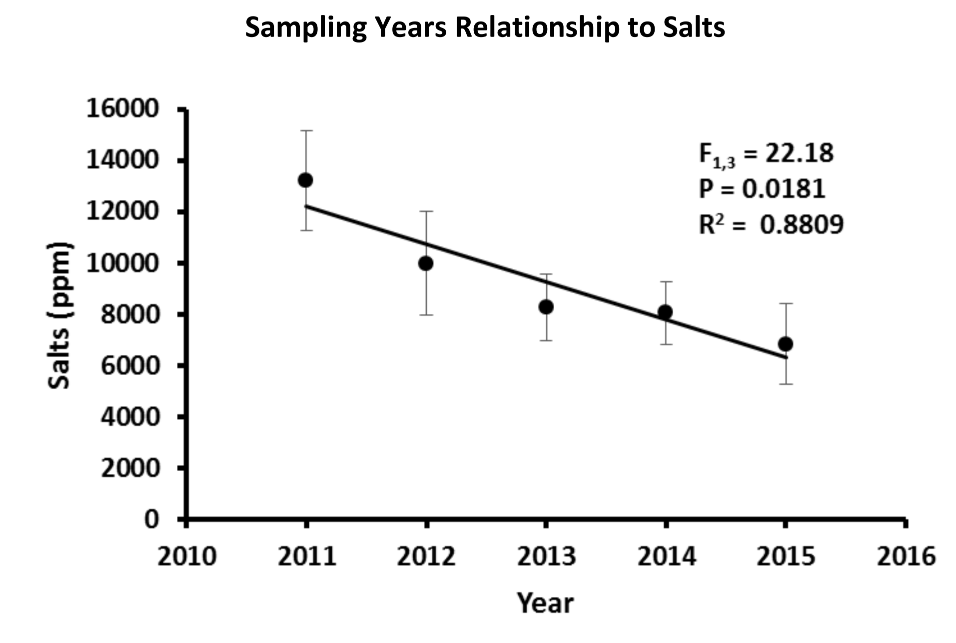

Figure 75 Relationship between Salts (±SE) and sample year for the Far Ridge.

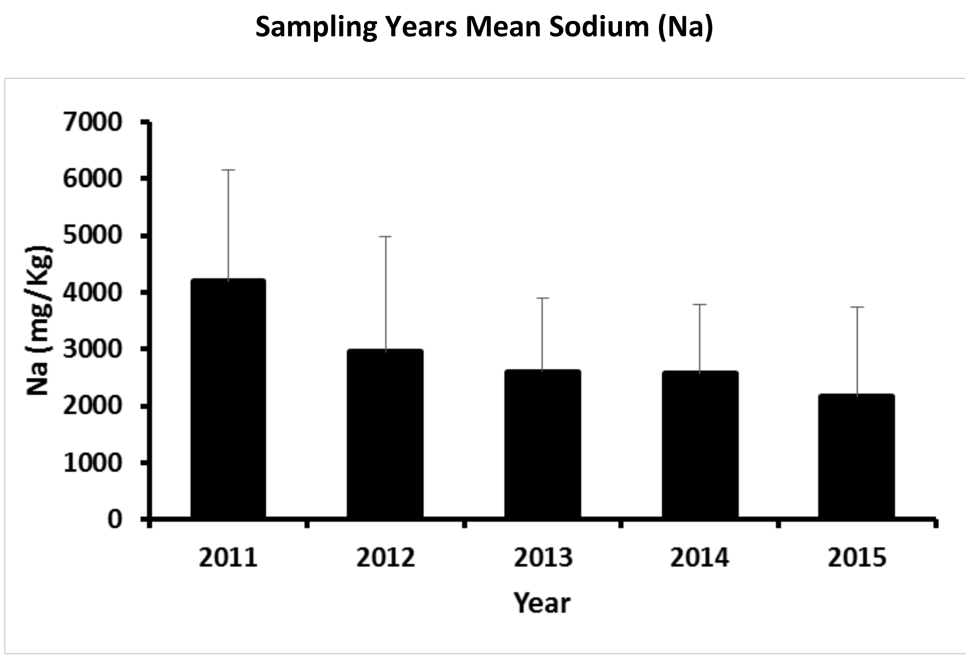

Figure 76 Mean (±SE) Na on the Far Ridge for each year. No differences were detected among years.

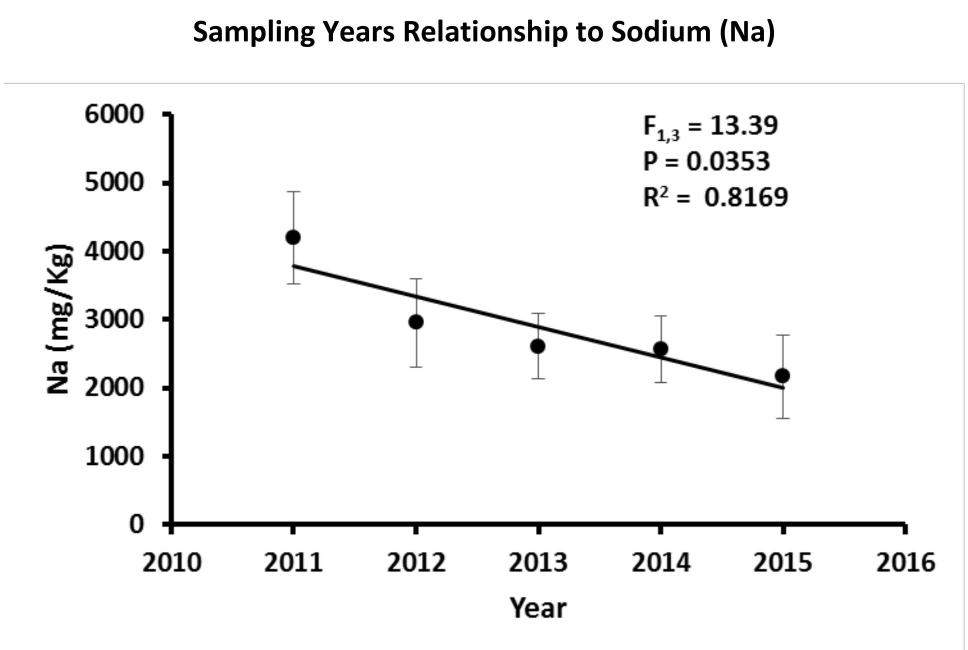

Figure 77 Relationship between Na (±SE) and sample year for the Far Ridge.

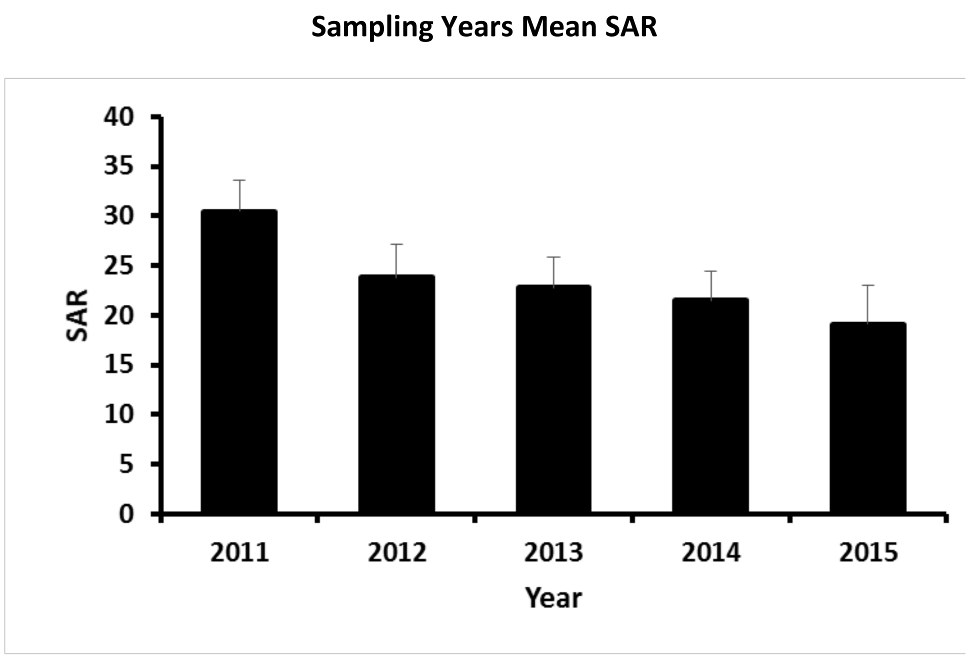

Figure 78 Mean (±SE) SAR on the Far Ridge for each year. No differences were detected among years.

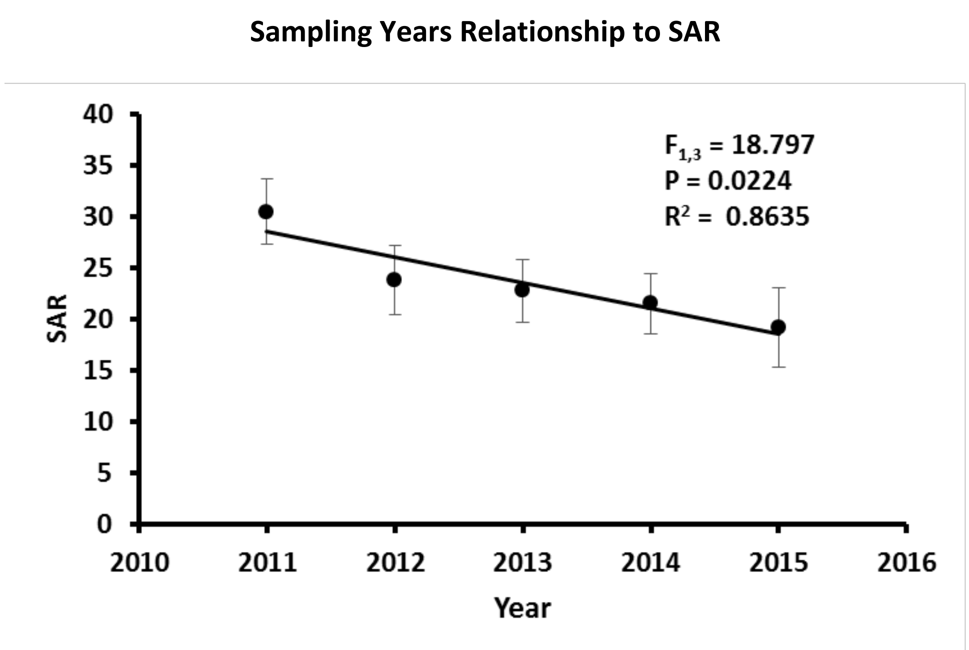

Figure 79 Relationship between SAR (±SE) and sample year for the Far Ridge.

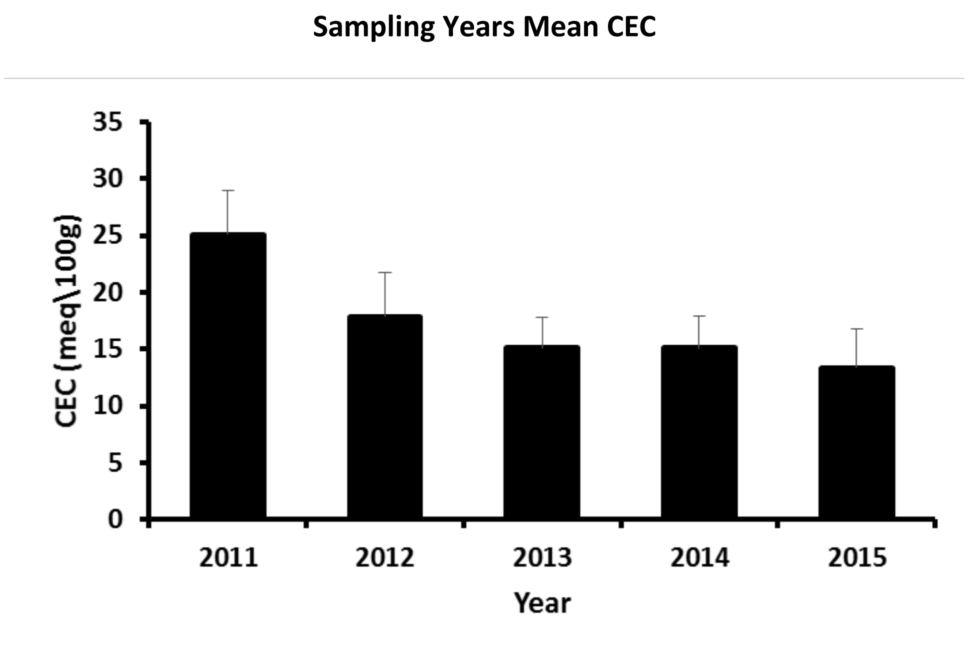

Figure 80 Mean (±SE) CEC on the Far Ridge for each year. No differences were detected among years.

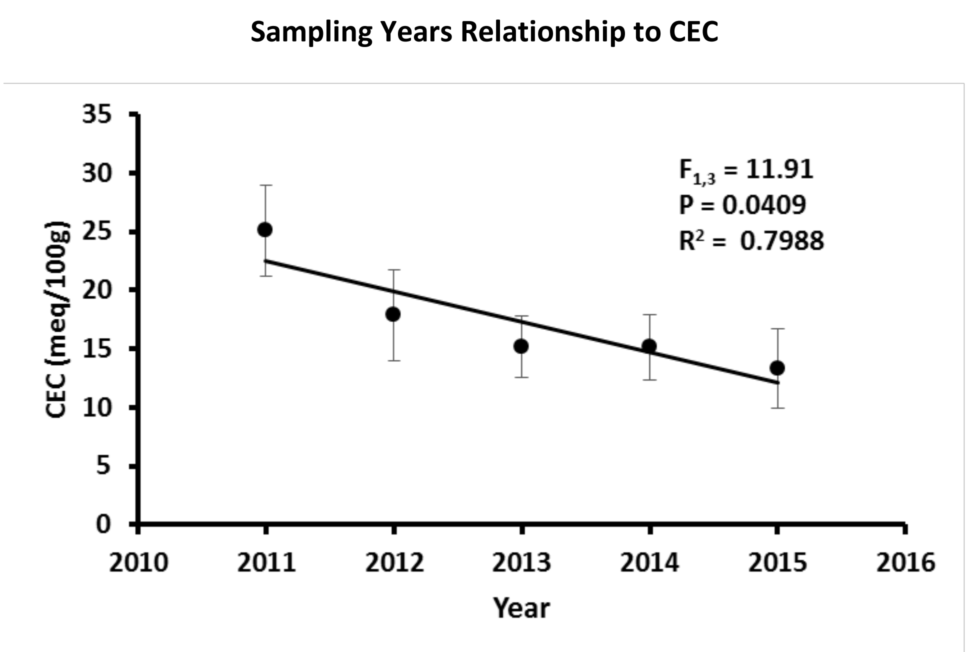

Figure 81 Relationship between CEC (±SE) and sample year for the Far Ridge.

5.7 First Growing Season Survival and Soil Quality

The most evident characteristic describing successful establishment of woody vegetation on a newly created ridge appears to be survival during the first growing season. Live oak, sand live oak, and hackberry were the only species planted multiple years and therefore allow an assessment of first growing season survival compared to soil quality over time. Although survival during the first growing season varied among the three species for some planting years, it appears that soil quality had a similar effect on survival for all three species (Figures 82-86). All five soil quality variables (EC, Salts, Na, SAR, and CEC) were highly variable within each year, but demonstrated a decreasing trend in values over time. The decreasing level of all five soil quality variables was significantly related to the increase in first growing season survival over time for hackberry, live oak, and sand live oak. In addition, all three species' survival tended to group close to each other for each year, indicating that soil quality had a similar effect on survival across all species.

We used an exponential regression curve to provide a best fit for a comparison of hackberry and live oak species to the five soil parameters. With the exponential regression curve, each of the five parameters had very high R-square values indicating that each one explained almost all of the variability in survival. The exponential relationship then can be used to predict survival for these species at known soil quality parameter values.

Therefore, it appears that first growing season survival is directly related to soil quality and the soil quality should be assessed prior to planting on future created ridges to ensure a hospitable environment for newly planted woody species. Although all 5 soil quality variables had a significant relationship to survival, EC and Salts have the highest correlations to survival and, as a result, are the best predictors of vegetative survival.

Results from the linear regression and the exponential regression for first growing season survival and soil quality are discussed in the following sections (5.7.1 & 5.7.2).

5.7.1 First Growing Season Survival and Soil Quality: Linear Regression

Regression analysis was used to assess the relationship between first growing season survival for hackberry, live oak, and sand live oak to each of the five soil quality parameters (EC, Salts, Na, SAR, and CEC). LSU Agricultural Center's Soil Testing and Wetland Soil Characterization Laboratories data from October 2011 to October 2015 was used for the five soil quality parameters analysis. The survival of all three species for each year were pooled as a single data base for each regression analysis to assess the survival of woody species in general compared to soil quality.

Each regression analysis indicated an inverse relationship between survival and each soil quality variable (Figures 82-86). Although all three species tended to group by year, sand live oak generally had a lower survival than hackberry and live oak. Out of five soil quality variables, EC and Salts had the highest R^2 values (both at 0.6943) indicating that EC and Salts had the highest influence on survival. (EC and Salts are interchangeable in that Salts are 640 times the EC value and that EC is 640 times less than the Salts value.) SAR had the lowest R^2 (0.5588) indicating the least level of influence on survival.

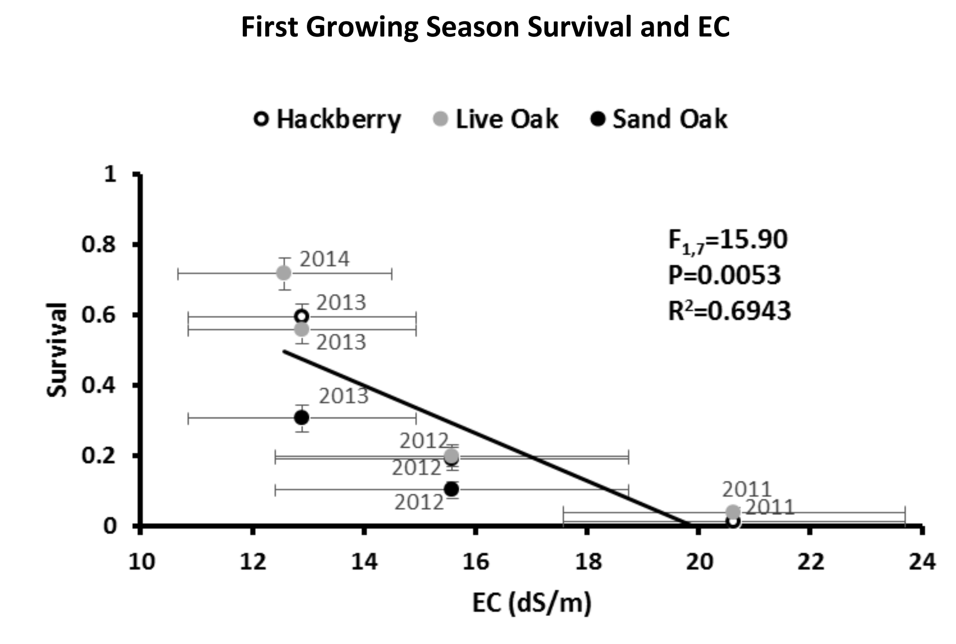

Figure 82 Linear relationship between mean (±SE) first growing season Survival of Hackberry, Live Oak, and Sand Live Oak for each planting year and mean (±SE) EC for each planting year.

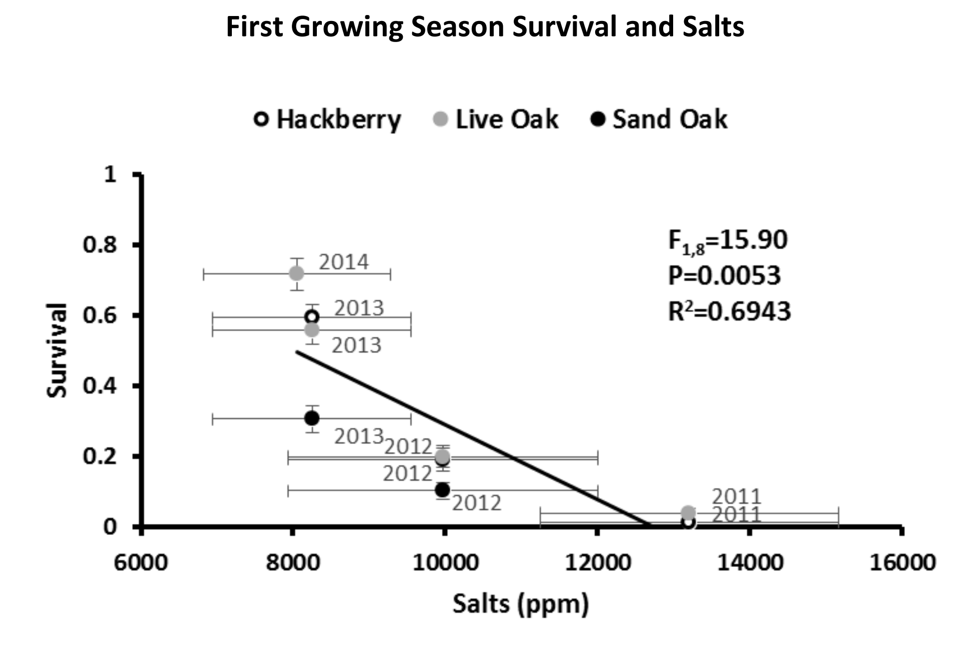

Figure 83 Linear relationship between mean (±SE) first growing season Survival of Hackberry, Live Oak, and Sand Live Oak for each planting year and mean (±SE) Salts for each planting year.

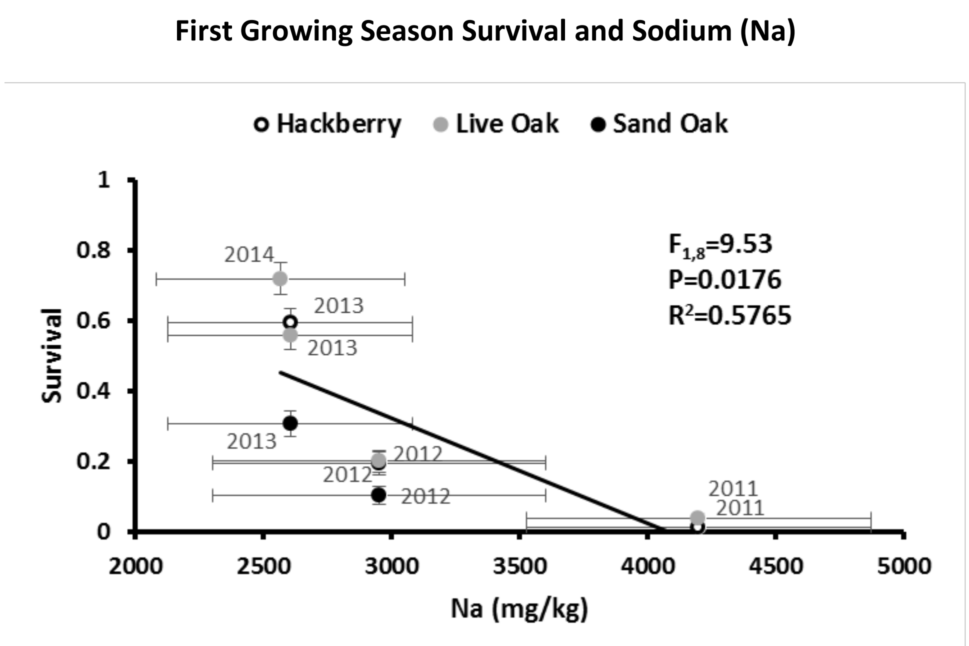

Figure 84 Linear relationship between mean (±SE) first growing season Survival of Hackberry, Live Oak, and Sand Live Oak for each planting year and mean (±SE) Na for each planting year.

First Growing Season Survival and SAR

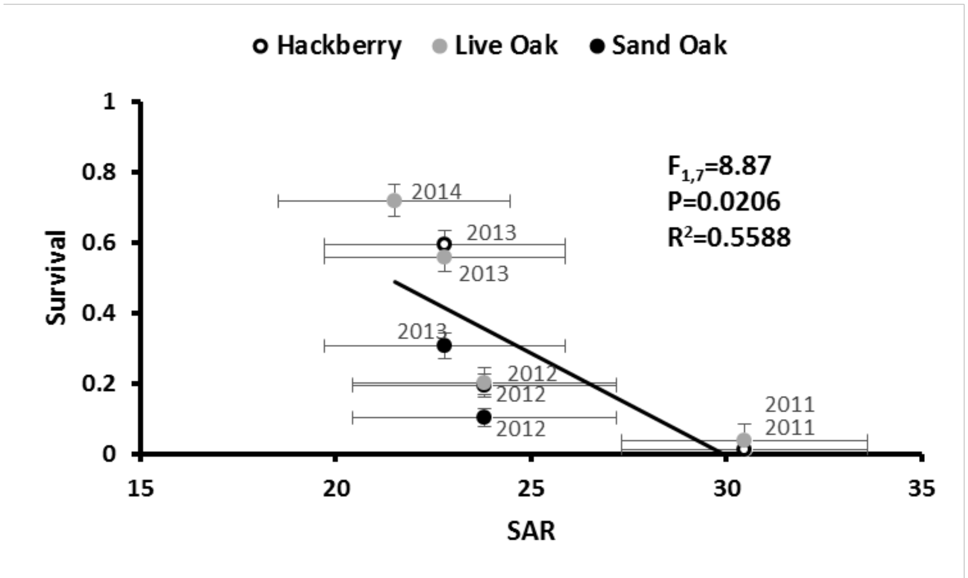

Figure 85 Linear relationship between mean (±SE) first growing season Survival of Hackberry, Live Oak, and Sand Live Oak for each planting year and mean (±SE) SAR for each planting year.

First Growing Season Survival and CEC

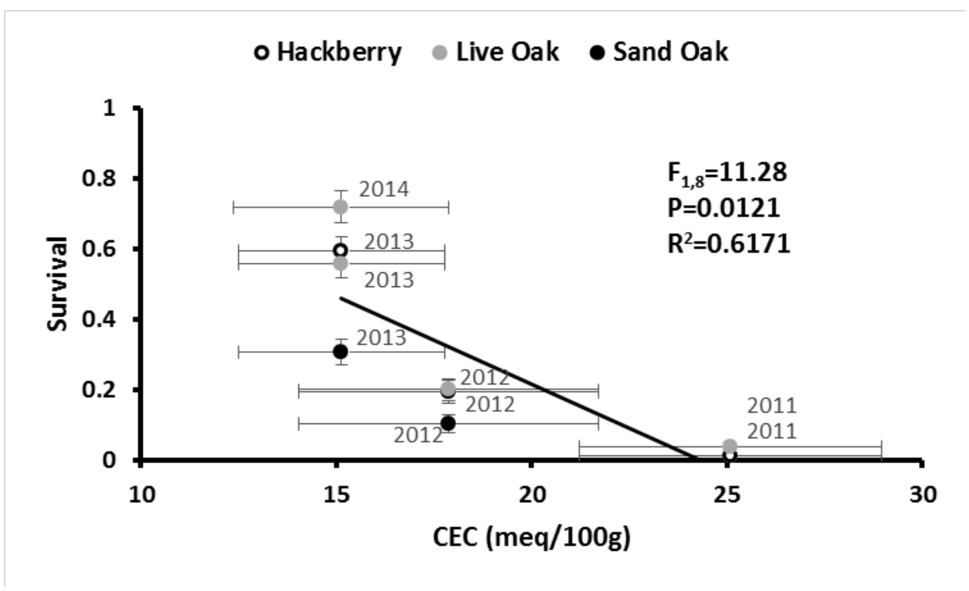

Figure 86 Linear relationship between mean (±SE) first growing season Survival of Hackberry, Live Oak, and Sand Live Oak for each planting year and mean (±SE) CEC for each planting year.

5.7.2 First Growing Season Survival and Soil Quality: Exponential Regression

To determine the relationship between each soil quality parameter and end of first growing season survival, we used both a simple linear regression and exponential regression models to determine best fit of the survival estimates of Live Oak and Hackberry of each year planted. (Sand live oak was dropped from this regression model as it is expected this species is not likely to be used in future restoration projects similar to this one.) Although the linear regression model revealed a significant relationship between survival and each soil quality parameter, the exponential regression model produced a much higher R-square value than the linear models did (Figures 87-91). Therefore, we used the exponential regression model to estimate the level of each soil quality parameter that would be expected to have 50% survival for Live Oak and Hackberry. All five soil quality variables had very high R^2 values indicating that each of the soil quality variables explained almost all the variability in vegetative survival. Survival for these species, then, can be predicted very well using any of the soil quality variables for these types of restoration sites that use soil from saline sources.

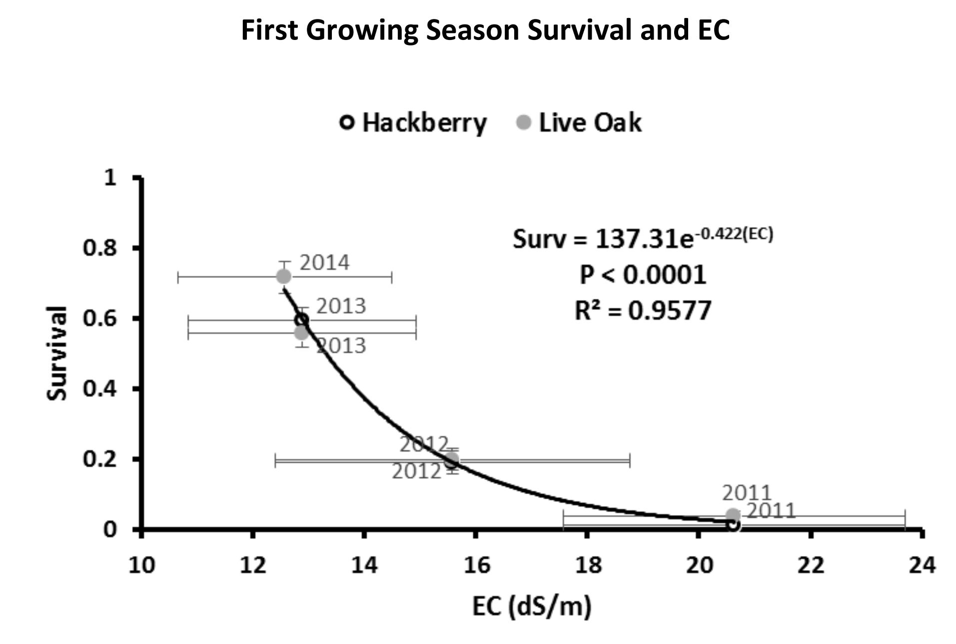

Figure 87 Exponential relationship between first growing season Survival (±SE) and EC (±SE) for Hackberry and Live Oak combined. The year indicates the year of planting.

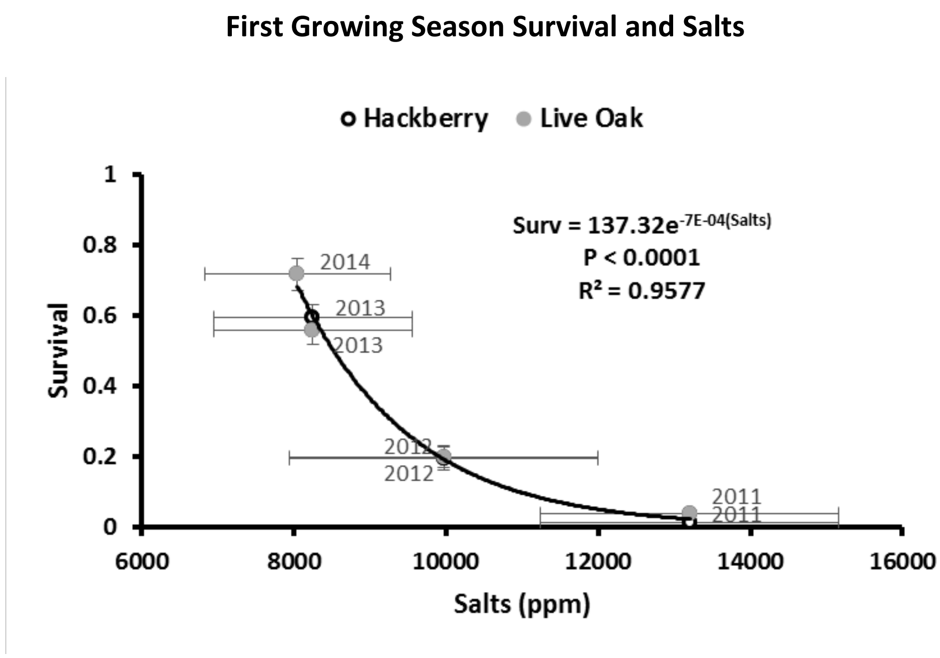

Figure 88 Exponential relationship between first growing season Survival (±SE) and Salts (±SE) for Hackberry and Live Oak. The year indicates the year of planting.

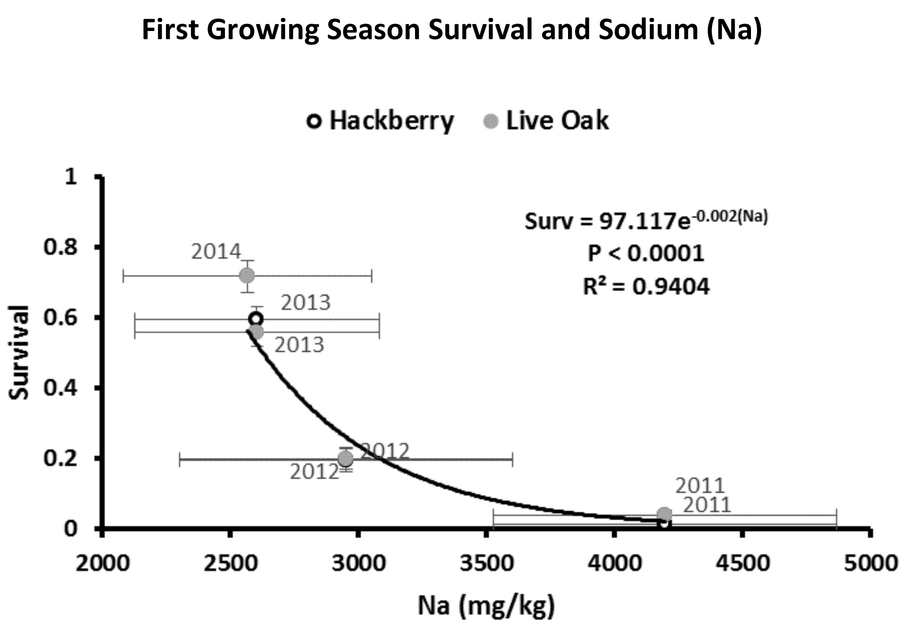

Figure 89 Exponential relationship between first growing season Survival (±SE) and Na (±SE) for Hackberry and Live Oak combined. The year indicates the year of planting.

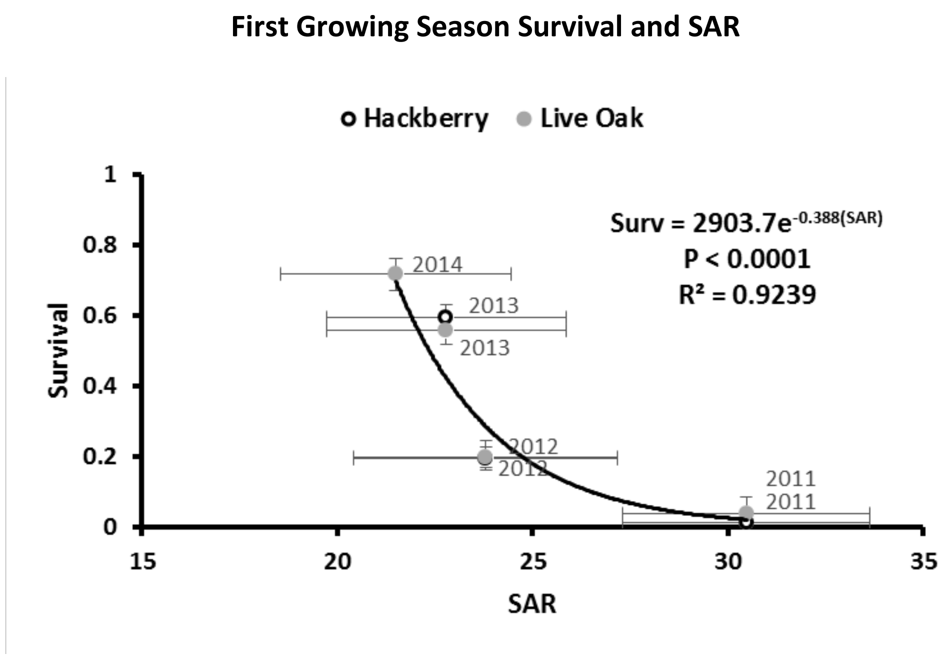

Figure 90 Exponential relationship between first growing season Survival (±SE) and SAR (±SE) for Hackberry and Live Oak. The year indicates the year of planting.

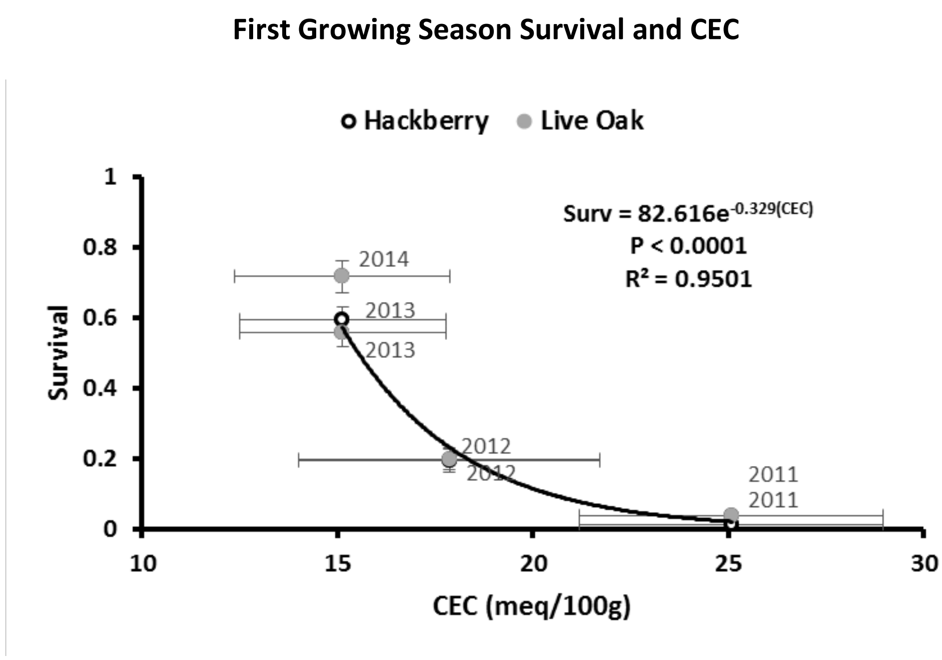

Figure 91 Exponential relationship between first growing season Survival (±SE) and CEC (±SE) for Hackberry and Live Oak. The year indicates the year of planting.

5.8 Other Vegetative Trial Plantings

5.8.1 Herbaceous: Survival & Spread Comparisons Among Planting Positions

The herbaceous vegetative trial planted November 11, 2009, compared three species: *Panicum amarum* (bitter panicum), *Paspalum vaginatum* (seashore paspalum), and *Spartina patens* (marshhay cordgrass) survival and spread on three positions (marsh, ridge slope, and ridge top) of the Far Ridge with the treatment of organic matter (straw) versus no treatment (control) over one growing season.

There was no difference in survival of *Panicum* between the control and straw for the marsh and ridge slope positions (Figure 92). This was due to no survival of any plants at the marsh position and low survival for both the control (6%) and straw (21%) on the ridge slope position. However, survival of *Panicum* was significantly greater on the ridge top for the straw treatment (41%) than for the control (20%). No difference was seen for spread at any position on the ridge (Figure 93).

There was no difference in survival of *Paspalum* between the control and straw for the marsh (17% and 20% respectively) and ridge slope positions (33% and 39% respectively) (Figure 94). However, survival of *Paspalum* was significantly greater on the ridge top for the straw treatment (95%) versus the control (67%). No difference was seen for spread at any position on the ridge (Figure 95).

There was no difference in survival or spread of *S. patens* between the control and straw for any position on the ridge (Figures 96 and 97). Survival at the marsh, slope and ridge top position for the control was 17%, 22%, and 44% respectively. Survival at the marsh, slope, and ridge top positions for the straw treatment was 20%, 35%, and 65% respectively.

The low survival for all species in this trial at the marsh position may be due to sediment deposition due to the extensive erosion of the ridge in the area of study. This high marsh zone also is an area that still has not vegetated with either planted or volunteer vegetation 7 years post construction. These bare areas probably result from complicated soil conditions related to the saline-sodic nature of these soils. The ridge slope had low survival for all 3 species and may be due to the heavy erosion of the slope during the study period. All 3 species benefited from the addition of organic matter (straw) versus no additive (control). The addition of organic matter increased survival through the absorption of available precipitation and then releasing it slowly back to the plant roots over time as needed.

***Panicum* Treatment Survival Comparison Among Planting Positions**

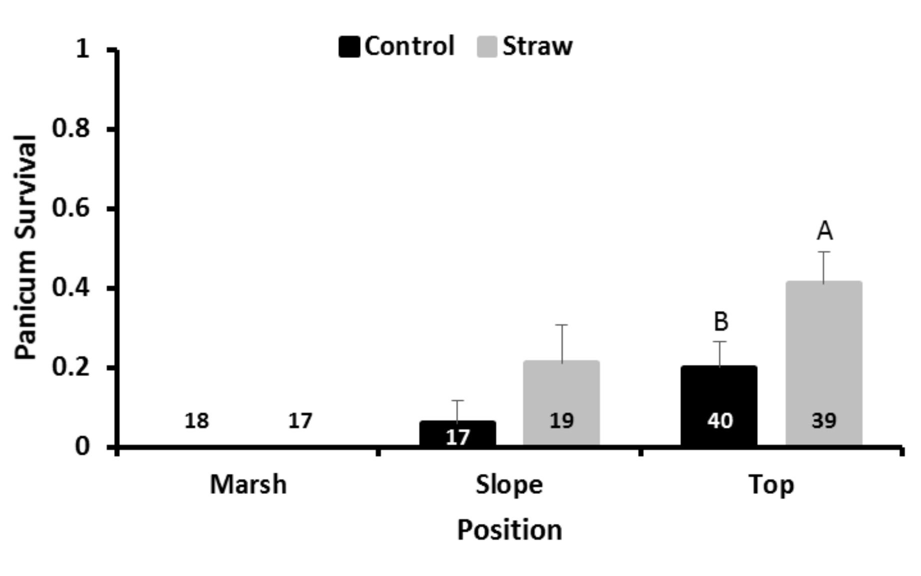

Figure 92 Mean (±SE) survival for *Panicum* planted among three positions on the ridge with or without straw as an additive. Means with different letters are not similar. The numbers inside the base of each column represent the sample size.

***Panicum* Treatment Spread Comparison Among Planting Positions**

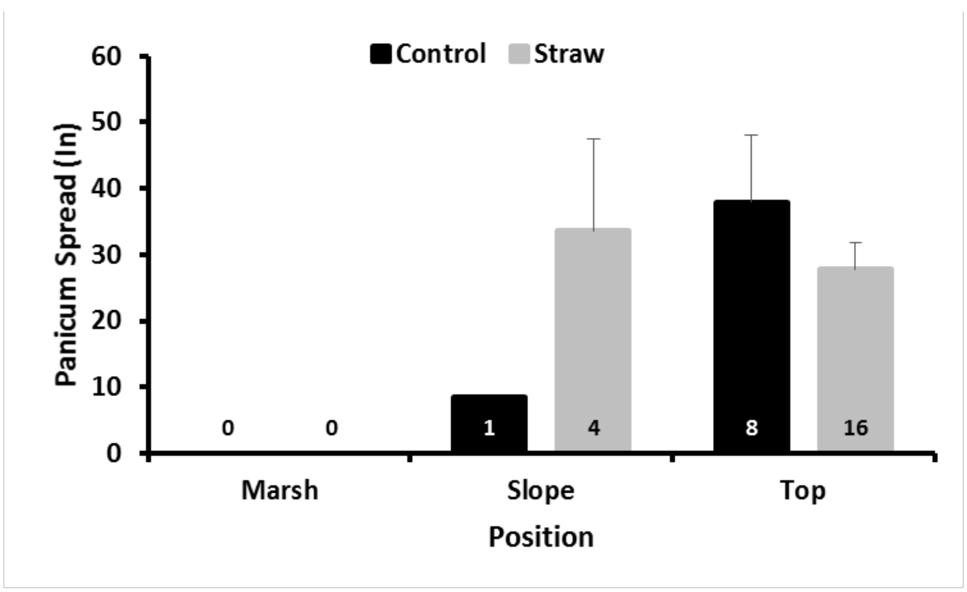

Figure 93 Mean (±SE) spread for *Panicum* planted among three positions on the ridge with or without straw as an additive. The numbers inside the base of each column represent the sample size.

Paspalum Treatment Survival Comparison Among Planting Positions

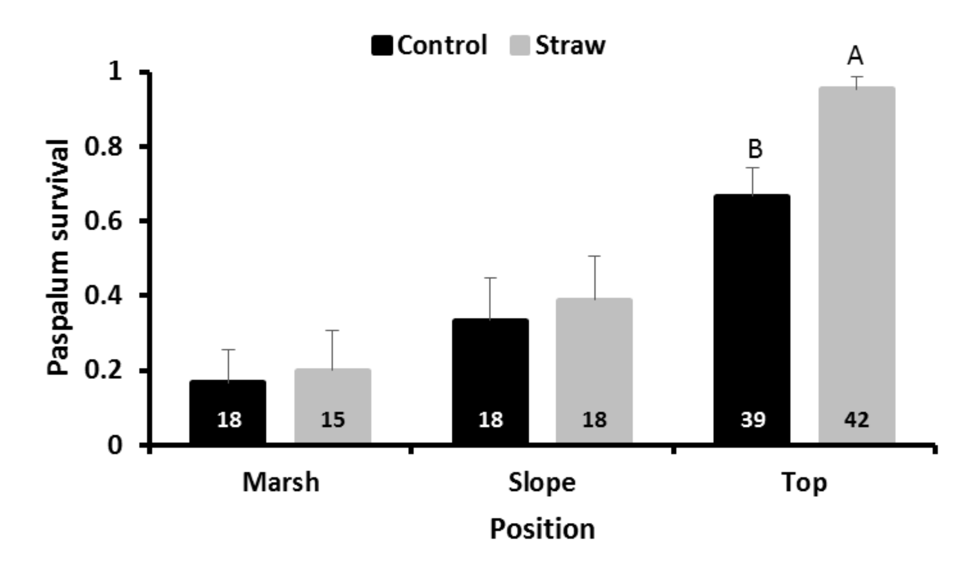

Figure 94 Mean (±SE) survival for *Paspalum* planted among three positions on the ridge with or without straw as an additive. Means with different letters are not similar. The numbers inside the base of each column represent the sample size.

Paspalum Treatment Spread Comparison Among Planting Positions

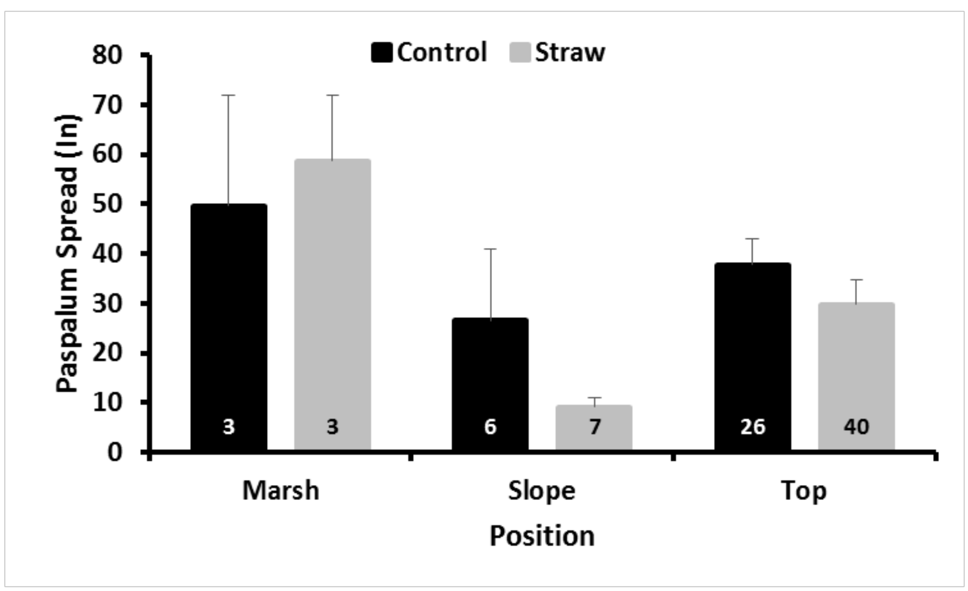

Figure 95 Mean (±SE) spread for *Paspalum* planted among three positions on the ridge with or without straw as an additive. The numbers inside the base of each column represent the sample size.

***S. patens* Treatment Survival Comparison Among Planting Positions**

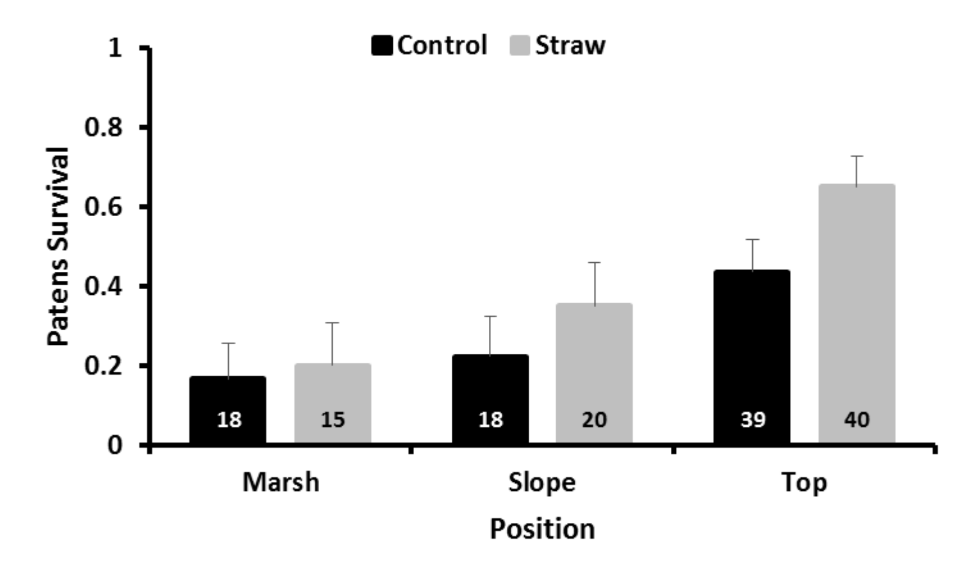

Figure 96 Mean (±SE) survival for *S. patens* planted among three positions on the ridge with or without straw as an additive. The numbers inside the base of each column represent the sample size.

***S. patens* Treatment Spread Comparison Among Planting Positions**

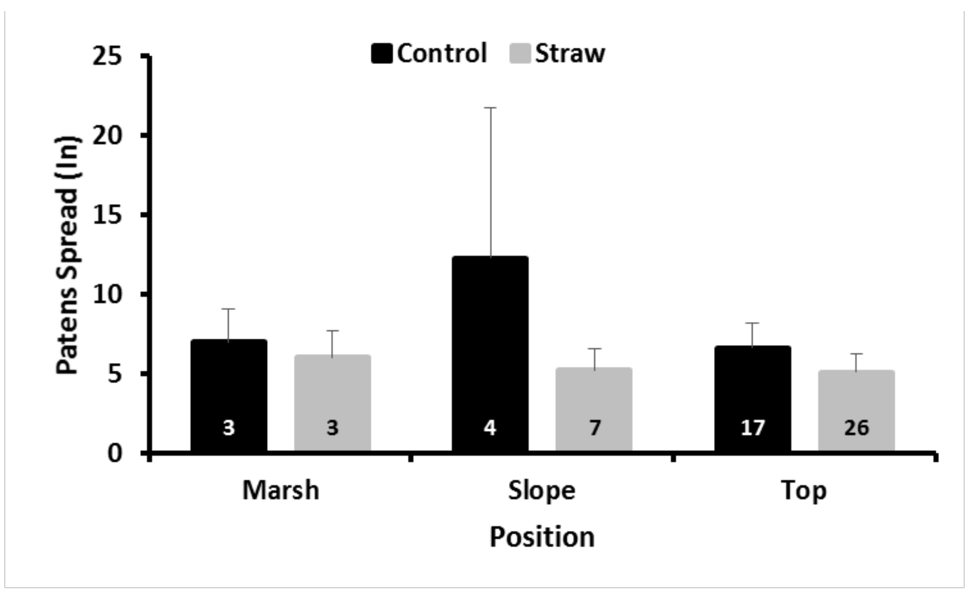

Figure 97 Mean (±SE) spread for *S. patens* planted among three positions on the ridge with or without straw as an additive. The numbers inside the base of each column represent the sample size.

5.8.2 Ring Planting

The Ring planting implemented on March 10, 2009, used trade gallon containers of 4 woody species (American beautyberry, red mulberry, yaupon, and sand live oak) with 3 replicates each on the Middle Ridge and on the Far Ridge. Survival for all 4 species on the Far Ridge was 0% as the plants all died by the time of data collection at the end of the first growing season, September 15, 2009. Mortality for plants on the Far Ridge was probably due to a number of factors. First, the soil conditions were at their highest salinity as this was only about 7 months post construction. Also, the trade gallon plants were 4 year old plants with many ranging from 3 to 5 feet tall and were very top heavy. The root balls were only 5 inches deep and planted in a soil that the top 2 to 3 inches would turn to a sloppy “mud” in rain events. Because of these factors, the top heavy trade gallon plants blew over in rain events exposing part of their root balls and contributing to their mortality.

Overall survival for the Middle Ridge 4 species was 31% at the end of the first growing season. Individual species survival was: American beautyberry, 16%; red mulberry, 47%; yaupon, 24%; and sand live oak, 33%. The better survival of the 4 species on the Middle Ridge was probably due to better soil conditions as this part of the ridge was almost 4 years post construction at the time of planting and had better soil moisture retention due to good herbaceous cover and organic matter deposition. The soil did not become as soft after precipitation like the soil on the Far Ridge and as a consequence of this and better protection from the wind from the surrounding vegetation none of these plants blew over.

5.8.3 Linear Planting

The Linear Block Planting implemented March 28, 2011, using 3 species (honeylocust, persimmon, and Hercules’ club) from conetainers had an overall survival of 1% at the end of the first growing season, October 28, 2011. Only 2 plants out of 180 survived. These 2 plants were both honeylocust, 1 from the control and 1 from the bagasse x fertilizer x gypsum treatment. Individual species survival at the end of the first growing season was honeylocust, 3%; persimmon, 0%; and Hercules’ club, 0%. The high mortality rate is probably due to poor soil conditions and the exceptional drought experienced during this planting year. Both honeylocust plants were dead at the end of the second growing season in October 2013 for an overall survival of 0%.

5.8.4 Mini Block Planting

The Mini Block Planting was a 3 replicate planting of a single treatment (fertilizer) and no control implemented March 20, 2012. Four species were utilized for this planting: American beautyberry, persimmon, live oak, and honeylocust. At the end of the first growing season, October 2012, only 3 plants survived out of 96 for an overall planting survival of 3%. Two of the surviving plants were honeylocust (2%) and one was live oak (1%). American beautyberry and persimmon had 0% survival. The extreme mortality was likely due to poor soil conditions and the extreme drought ongoing at the time of the planting. The 2 honeylocust seedlings and the 1 live oak seedling are still alive with excellent vigor as of the end of the 2015 growing season. Average height, spread and basal stem diameter for the two honeylocusts is 38.75 inches, 42 inches, and 16 mm respectively. The lone live oak height, spread, and basal stem diameter is 59 inches, 51 inches, and 24 mm.

6.0 RECOMMENDATIONS

6.1 Cultural Soil Additives

After analyzing the use of cultural additives (bagasse, fertilizer, and gypsum) for all of the experimental plantings (2010-2014) conducted on the Far Ridge through their first two growing seasons and not finding a difference between their use and that of a control, there is no recommendation to adding these cultural additives to future ridge plantings constructed with saline sediments, at least at the levels used in these woody vegetative trials. Further study is needed to determine if increasing the amount or varying the method of application might increase the benefits of any one of these cultural additives. Increasing application amounts will directly increase plant installation costs. It should be noted, however, that plant installations without the addition of these cultural additives will result in considerable cost savings.

Of course, there are caveats that come with the data for cultural treatments conducted as part of this project. We did not test the effects on the soil or on the plants of using broadcast application of gypsum on the soil surface. In other research using broadcast application of gypsum on saline/sodic soils, this technique was found to be a method for accelerating the leaching process of sodium out of the rooting zone. Due to the initial imperviousness of these soils, however, attention should be paid to gypsum retention in the application area with the expectation that the broadcast gysum on the soil surface can quickly be lost due to surface runoff after rainfall.

The addition of organic matter (straw) to herbaceous plants, however, led to significantly greater survival versus the control (no treatment) for plants planted upon the ridge top. While there was no significant difference between the addition of an organic matter and without for either the slope or marsh section in this experiment, it is likely that the extensive erosion during this first year after contruction led to the high mortality making these comparative results not very meaningful. Their collective high mortality is meaningful in that it shows that adjustments need to be looked at in future ridge slope design to reduce heavy erosion during the early stages of implementing herbaceous plant establishment.

6.2 Woody Seedling Size

Woody seedling size, in addition to herbaceous cover, should be taken into account when planning woody species plantings in dredged saline soils used to construct ridges. Herbaceous plants should be established prior to the planting of woody seedlings for a number of reasons. First, herbaceous plant establishment will create a porous root zone that will help in speeding up the leaching of salts in the highly dispersed soil. Second, litterfall of dead plant material from the herbaceous plants over time will help in the reduction of soil erosion and the increase of soil moisture retention. Detritus on the soil surface slows surface runoff. Detritus covering the soil surface reduces soil moisture loss to wind and solar energy and protects soil aggregates from clay and silt particles that can fill pores when raindrops disturb barren soil. Finally, the roots of the herbaceous plants help bind the soil and will create a matrix for the woody seedling roots to anchor in, reducing erosion and decreasing the chance the woody seedlings will blow down in storm events. Our experience in planting one year old tree seedlings in conetainers (2" x 7") found this to be a sufficient root to crown ratio and we never saw any of these seedlings blown down. Two year (or older) woody seedlings grown out in trade gallons should be staked as the unstaked 4 year old trade gallon woody plants in the Ring planting implemented on March 10, 2009, (approximately 7 months post construction) were too top heavy and blew down in a storm event. Rainstorms caused the soil to become saturated and "muddy" and the winds from the storm were able to push the plant over. This blow down, as well as the poor soil conditions, resulted in complete mortality of the trade gallon plants.

6.3 Woody Species Selection

Woody species composition for use in ridge creation projects utilizing saline sediments should be tailored to the project site's soil conditions. We found that the shrub salt matrimony vine could be used immediately after project completion in saline sediments as this halophytic species is particularly suited (99% survival in 2010 planting and at end of data collection in October 2015) to these early saline-sodic soil conditions. The other species tested required improved soil conditions in order to obtain better plant survival. After salt matrimony vine, live oak had the highest survival of any of the species planted during the woody vegetative trials with the greatest first year survival (72%) in the last planting year in 2014, six years post Ridge construction. Hackberry had the second to highest first year survival (59%) in the 2013 planting year, besting even (but not significantly higher than) live oak (56%). Because there was no statistical difference in survival between the two at the end of the first year's growing season for the 2013 planting, hackberry and live oak are equally suited to be planted for the same low salinity soil conditions. However, as evidenced by this same 2013 planting, hackberry doesn't seem to persist in the environment as well over time as does live oak (overall plant survival at end of 2015 growing season: hackberry, 25%; live oak, 48%) and may benefit in a delay in planting. That being said, from a planting logistics perspective, it probably makes more sense to delay all woody species establishment until conditions are more conducive for all species being utilized. Sand live oak had the poorest survival of the three species (hackberry, live oak, and sand live oak) that were utilized in three or more of the experimental block plantings. In the 2013 planting year, when all three species were assessed and hackberry and live oak had over 50% survival at the end of the first growing season, sand live oak's survival was significantly lower at 31%. It too, like hackberry, doesn't persist over time as well as live oak does and only ended up with an overall survival of 15% at the end of the 2015 growing season. Because it generally occupies the same function as live oak, is considerably harder to collect (out of state), and had less than a third the overall survival of live oak at the end of the growing season in 2015 for the 2013 planting, sand live oak is not recommended for use in woody species composition makeup for maritime forest ridge projects in Louisiana utilizing in situ saline marsh sediments. However, because it grows well in the sand dunes along the panhandle of Florida where the seed was collected, further study is warranted for its inclusion in sandy dune sediments along Louisiana's barrier islands and headlands.

As to further woody species recommendations, because of the vagaries of early soil conditions and the drought of 2011, only the latest planting year in 2014 provides results to base conclusions upon. Due to the poor survival at the end of the first growing season and at the end of data collection in 2015, yaupon and roughleaf dogwood should not be included as candidates for early inclusion for woody plant establishment on ridge projects utilizing in situ saline sediments. Yaupon and roughleaf dogwood survival at the end of the growing season of 2015 at 8 and 2 percent respectively were considerably lower than was live oak's at 58%. Other species utilized in the experimental trials that are inconclusive due to planting during the 2011 drought were American beautyberry, honeylocust, persimmon, and Hercules' club. Additionally, the Mini Block Planting in March of 2012, utilizing live oak, persimmon, American beautyberry, and honeylocust almost all died probably due to soil conditions and a severe drought at the time of planting.

6.4 Runoff Management and Moisture Retention

Runoff management should be designed into every ridge creation and operation and maintenance. Herbaceous vegetation should be planted or seeded with the goal of covering the ridge surface as soon as possible after construction. By covering the ridge surface with vegetation, detrimental effects due to erosion from rain and wind will be reduced. The ability of rainfall to leach out salts will increase, as will organic matter deposition, leading to greater soil moisture retention.

Because of the relatively long time inherent in establishing woody species beneficial to Neotropical migratory birds on the highly altered soils from a man-made created ridge using in situ saline marsh sediments, halophytic herbaceous vegetative plantings should precede the woody species plantings, especially if future projects are targeting 80% vegetative coverage within 3 years. Even if woody species can be established reasonably early, their growth rate is not rapid enough to fill in the ridge top area in that short amount of time.

In order to keep the site as uniform as possible and to better be able to find the experimental woody seedlings planted, it was decided not to vegetate inside the woody vegetative field trial blocks with anything except the woody seedlings used in the experimental trials. Of course, these areas began naturally vegetating with *Salicornia* and other pioneer species almost immediately following construction, eventually progressing to all manner of forbs, grasses and shrubs to the point where finding the stunted trees from the vegetative trials within the volunteer vegetation became difficult. For future (non-experimental) plantings, however, when creating ridges with dredged in situ saline marsh soils and trying to establish woody seedlings, herbaceous plantings should be implemented over the entirety of the ridge as soon as possible post construction in order to accelerate soil conditions acceptable for the establishment of non-halophytic woody species.

Designing swales or depression areas into the top of the ridge that can retain precipitation for longer periods of time can also be beneficial in hastening the establishment of herbaceous and woody vegetation (Figure 98). They can also provide longer periods of available fresh water for birds and animals following rainfall. Care must be given to placement of the swales on the ridge top so that it doesn't "blowout" and lead to a quick erosive feature. Monitoring of rill formation and placement of hay bales and/or silt-fences to catch or slow sediment runoff can help stabilize these areas. Concentration of herbaceous vegetation in areas prone or shown to be forming rills can help in sediment runoff reduction as well.

Although our analysis showed no benefit to the addition of bagasse (organic matter) to the seedling holes, it is probably due to the quantities added being too small. The addition of bagasse to this project was limited to only the 7 inch diameter hole the seedlings were planted in. Precipitation would be captured in the immediate area surrounding the plant, but once this soil moisture was taken up by the plant, it had no other surrounding moisture to draw upon. If in situ organic matter can be incorporated into the entire surface area or even worked into the top foot or more of the project site, precipitation would be captured in vastly greater quantities and allow for the plants to capture much more of the surrounding moisture in the soil. The

Figure 98 Standing water on top of the far eastern end of Middle Ridge, February 25, 2014.

addition of organic matter to the entire surface of the project site would also help reduce soil erosion as more of the precipitation would be absorbed into the soil reducing erosion due to surface runoff. Through herbaceous plant establishment, as well as the creation of swales, promotion of water infiltration through the soil horizon will speed up leaching of salts from the soil and lead to a healthier soil better suited to establishing non-halophytic woody species.

According to the as-built schematics provided by the contractor of the ridge, the slopes of the ridge were graded to 35% for both phases of the ridge. Although efforts were made to immediately try to stabilize the ridge slopes through the planting of a variety of halophytic herbaceous species, extensive and heavy erosion occurred post construction. In fact, even to this day, there are extensive stretches of the north side of the Far Ridge where plant establishment has still not occurred. Mostly this has occurred on the narrower 900 foot long western end of the Far Ridge. Repeated attempts to plant these areas have not been very successful due to what appears to be continued rapid erosion. Even plants once established, if not in sufficient quantities to benefit one another through collectively reducing erosion, can eventually succumb to erosion of soil surrounding their roots (Figure 99). Rapid erosion of the soil in this area may also lead to deeper soils being exposed that have not had the benefit of leaching from precipitation and therefore may have higher salinities for the plants to deal with. Follow up plantings, too, won't benefit from the leaching out of the salts over time, but will be planted in these newly exposed higher saline soils. As mentioned in an earlier section of this report, one area that did not experience heavy erosion post construction is the south slope of the Far Ridge (Phase Two), because of a heavy deposition of wrack from Hurricane Gustav mere weeks post construction. The wrack was deposited along the slope and up to the top edge of the ridge. The wrack deposition helped in reducing erosion from rain runoff and provided organic matter for soil moisture retention which assisted in plant survival and establishment. The wrack deposition also acted as a wind break and collected windborne seed of plants that then established themselves in these areas.

Figure 99 Exposed roots (8+ inches) due to soil erosion of a salt matrimony vine plant on the north slope of the Far Ridge located along the narrower 900 foot long western end, December 2, 2015.

6.5 Soil Quality & Predictions Based on a Fifty Percent Survival Scenario

Soil quality is directly related to woody species establishment. Saline-sodic soils are not conducive to establishment and survival of non-halophytic woody species. Decreasing saline-sodic levels across soil parameters is significantly related to the increase in first growing season survival for these species. Survival through the first growing season has the greatest effect on the successful establishment of non-halophytic woody species on ridges created with saline-sodic soils. Once established through this first critical year, surviving plants tend to persist over time with ever decreasing mortality. Therefore, soil quality should be assessed through sampling prior to planting to ensure soil conditions are hospitable to the survival of the seedlings.

Based on the exponential relationship between each soil parameter and survival for the multiple planting years for hackberry and live oak we are able to make estimates (see Table 3) for soil parameter levels to achieve 50% survival at the end of the first growing season. These predictions are based on our findings for hackberry and live oak combined. For all 5 soil parameters, decreased levels resulted in increased survival. Fifty percent survival was chosen as point for vegetative survival because above this point there is an exponential increase in survival and appears to mark a dramatic inflection point in the data for survival of these species. As soon as the soil conditions reach this critical threshold, plant survival dramatically increases over a narrow window of time. EC and/or Salts (interchangeable) had the highest correlation to survival and are then the best use as an indicator for prediction of a successful planting on ridges created with saline-sodic soils. The results from this report support planting when EC levels decrease to 13.3 dS/m or lower for 50% survival or greater.

Table 3 Calculated levels of each soil quality parameter that results in 50% survival based on the exponential relationship between each variable and survival for multiple years of plantings for Hackberry and Live Oak.

Soil Parameter	Exponential Regression Equation	Estimated 50% Survival Level
EC (dS/m)	$Surv = 137.31e^{-0.422(EC)}$	13.3
Salts (ppm)	$Surv = 137.32e^{-0.0007(Salts)}$	8,022.1
Na (mg/kg)	$Surv = 97.117e^{-0.002(Na)}$	2634.5
SAR	$Surv = 2903.7e^{-0.388(SAR)}$	22.3
CEC (meq/100g)	$Surv = 82.616e^{-0.329(CEC)}$	15.5

APPENDIX 1

Woody Species Seed Collections and Locations

Woody Species Seed Collections and Locations

Date	Species Collected	Parish
12/2/2008	Persimmon	Lafourche
12/12/2008	Sand live oak	Escambia County, FL
12/17/2008	Honeylocust	Terrebonne
12/18/2008	Live oak	Jefferson
1/8/2009	Salt matrimony vine	Lafourche
1/20/2009	Hackberry & yaupon	Jefferson
2/4/2009	wax myrtle	Jefferson
4/14/2009	Red mulberry	Jefferson
7/17/2009	Hercules club	Calcasieu
8/4/2010	Sweet acacia	Lafourche
8/28/2009	American beautyberry	Lafourche
9/15/2009	American beautyberry	Lafourche
9/18/2009	Roughleaf dogwood	Lafourche
10/7/2009	Honeylocust	Terrebonne
10/13/2009	Honeylocust	Terrebonne
10/16/2009	American beautyberry	Lafourche
10/19/2009	American beautyberry & persimmon	Assumption
10/20/2009	Live oak	Cameron
11/1/2009	Sand live oak	Escambia County, FL
11/13/2009	Live oak	Cameron
11/19/2009	Live oak	Jefferson
12/2/2009	Sand live oak	Escambia County, FL
1/5/2010	Live oak	Jefferson
1/22/2010	Salt matrimony vine	Lafourche
1/28/2010	Live oak & salt matrimony vine	Cameron
2/2/2010	Hackberry, salt matrimony vine, yaupon & wax-myrtle	Jefferson
6/1/2010	Red mulberry	Lafourche
8/13/2010	Hercules club	Calcasieu
10/1/2010	American beautyberry & persimmon	Assumption
10/13/2010	Roughleaf dogwood	Lafourche
11/3/2010	Persimmon	Lafourche
11/22/2010	Live oak	Jefferson
11/25/2010	Sand live oak	Escambia County, Florida
12/15/2010	Live oak	Jefferson
11/30/2010	Wax-myrtle	Jefferson
1/21/2011	Live oak, yaupon, hackberry & wax-myrtle	Jefferson
1/25/2011	Salt matrimony vine	Lafourche
10/24/2011	American beautyberry	Assumption

10/27/2011	Persimmon	Lafourche
10/31/2011	Honeylocust	Terrebonne
11/11/2011	Sand live oak	Escambia County, Florida
11/16/2011	Live oak	Jefferson
11/29/2011	Persimmon	Lafourche
12/4/2011	Live oak	Cameron
12/15/2011	Live oak	Lafourche
2/6/2012	Salt matrimony vine	Lafourche
2/13/2012	Yaupon, hackberry & wax-myrtle	Jefferson
2/22/2012	Hackberry & salt matrimony vine	Jefferson
9/13/2012	Persimmon	Lafourche
10/17/2012	Sand live oak	Escambia County, Florida
12/9/2012	Live oak	Jefferson
12/11/2012	Live oak	Jefferson
2/19/2013	Yaupon, hackberry	Jefferson
2/20/2013	Wax myrtle	Jefferson
5/3/2013	Red mulberry	Jefferson
8/11/2013	Hercules-club	Calcasieu
8/20/2013	Hercules-club	Jefferson
8/30/2013	Hercules-club	Calcasieu
9/25/2013	Roughleaf dogwood	Lafourche
10/17/2013	American beautyberry	Assumption
10/21/2013	Persimmon	Lafourche
10/25/2013	Sand live oak	Escambia County, Florida
12/10/2013	Live oak	Jefferson
12/12/2013	Salt matrimony vine	Lafourche
1/17/2014	Yaupon, hackberry	Jefferson
1/18/2014	Hackberry, wax myrtle	Jefferson
7/11/2014	Hercules-club	Calcasieu
7/14/2014	Hercules-club	Jefferson
8/1/2014	Hercules-club	Jefferson
8/12/2014	Hercules-club	Jefferson
10/7/2014	Roughleaf dogwood	Lafourche
10/8/2014	American beautyberry	Lafourche
10/13/2014	Persimmon	Lafourche
10/24/2014	Sand live oak	Escambia County, Florida
11/7/2014	Live oak, wax myrtle & mangrove	Jefferson
11/10/2014	Honeylocust	Terrebonne

12/12/2014	Live oak	Jefferson
2/24/2015	Wax-myrtle, hackberry & yaupon	Jefferson
4/8/2015	Red mulberry	Jefferson
7/21/2015	Hercules' Club	Jefferson
9/18/2015	American beautyberry	Assumption
9/30/2015	Salt matrimony vine	Lafourche
10/9/2015	Persimmon	Lafourche
11/20/2015	Sand live oak	Escambia County, Florida
11/24/2015	Live oak	Jefferson

The following figures show a number of the woody species fruit and acorns we collected in the field over the course of the grant. All species were collected within Louisiana except sand live oak acorns collected in Escambia County, Florida.

Figure 1. American beautyberry, Bayou Sherman, Assumption Parish, October 19, 2009.

Figure 2. Persimmon fruits, Bayou Sherman, Assumption Parish, Louisiana, October 19, 2009.

Figure 3. Hackberry seeds, Cameron Parish, November 28, 2008.

Figure 4. Sand live oak acorns, Escambia County, Florida, November 11, 2011.

Figure 5. Yaupon fruits, Grand Isle, Louisiana, January 5, 2010.

Figure 6. Wax myrtle seeds, Grand Isle, Louisiana, January 5, 2010.

Figure 7. Honeylocust seed pods, Terrebonne Parish, Louisiana, October 13, 2009.

APPENDIX 2

Assessment and Evaluation of Soil Physical and Chemical Properties of Dredged Material in Constructed Wetland

FOURCHON MARITIME FOREST RIDGE AND MARSH RESTORATION
BTNEP

PREFACE

BTNEP caveats with the following report: Assessment and Evaluation of Soil Physical and Chemical Properties of Dredged Material in Constructed Wetland by Manoch Kongchum, October 2015.

BTNEP contracted with Manoch Kongchum, Lousiana State University Agricultural Center, School of Plant, Environmental and Soil Sciences, to analyze and interpret soil samples collected from the Fourchon Maritime Forest Ridge and Marsh Restoration project for soil samples collected and sent to LSU Agricultural Center's Soil Testing and Wetland Soil Characterization Laboratories between October 2011 and October 2014. Manoch Kongchum also assessed and evaluated soil samples previously collected from the Fourchon Maritime Forest Ridge and Marsh Restoration project between May 2008 and February 2011 that were analyzed by A&L Analytical Laboratories, Inc.

For his report, Kongchum used a different Electrical Conductivity (EC) meter than the one used by the LSU Agricultural Center's Soil Testing and Wetland Soil Characterization Laboratories as he stated he did not find the readings reliable. Kongchum's EC meter reading results were from 1.1 to 4.3 times (with an average of 2.7 times) less than the EC meter results reported by LSU Agricultural Center's Soil Testing and Wetland Soil Characterization Laboratories. His EC meter results are used in his paper and are closer in alignment with the earlier readings from A&L Analytical Laboratories, Inc. in that A&L's results, even from 2008 and 2009, were lower than those produced by LSU in 2011. BTNEP, however, used LSU Agricultural Center's Soil Testing and Wetland Soil Characterization Laboratories' results in our Vegetative Efforts report as we considered these easier for comparison to anyone wanting to compare our findings with their own if using LSU Agricultural Center's Soil Testing and Wetland Soil Characterization Laboratories which are easily accessible.

Also, for his report, Kongchum's Sodium Adsorption Ratio (SAR) results averaged 3.167 times (low of 3.161 to high of 3.168) lower than the results from by LSU Agricultural Center's Soil Testing and Wetland Soil Characterization Laboratories. Kongchum states that he uses the same formula found in "Methods of Soil Analysis" or in "Soil Survey Laboratory Manual". He also stated that "To convert ppm to meq: ppm Na/230, Ca/200, Mg/121, and K/391. This conversion is also used for CEC calculation." Although those element values are used in the CEC calculation, we could find no reference to their use in the SAR formula. In fact, they are 10 times higher than the values in every reference we found used in calculating the formula (e.g. Na/23, Ca/20, Mg/12.1, and K/39.1). BTNEP, therefore, used LSU Agricultural Center's Soil Testing and Wetland Soil Characterization Laboratories' results for SAR in our Vegetative Efforts report as we considered their results in line with the protocols we could find.

ASSESSMENT AND EVALUATION OF SOIL PHYSICAL AND CHEMICAL PROPERTIES OF DREDGED MATERIAL IN CONSTRUCTED WETLAND

SUBMITTED TO:

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IN FULFILLMENT OF:
LUMCON AGREEMENT NO. BTNEP14-07

OCTOBER 2015

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ASSESSMENT AND EVALUATION OF SOIL PHYSICAL AND CHEMICAL PROPERTIES OF DREDGED MATERIAL IN CONSTRUCTED WETLAND

INTRODUCTION

The use of dredge materials for marsh creation has proven to be a sound and economical approach for coastal restoration capable of restoring large areas of deteriorated marsh. In the absence of any soil contamination, the success of created marshes to meet or exceed their targeted objectives is primarily a function of project design, physical and chemical properties of dredged material and the restored marsh surface elevations. The rapidity of vegetative establishment following restoration is generally governed by availability of in-situ foundation plant materials that serve as nursery plants and also whether introduced planting of foundation materials is included in the restoration effort.

Coastal restoration using sediment mined from relic soil-banks, sediment landfills, or near-shore dredged sediments have become increasingly more common in marsh restoration construction. However, there is inadequate information on the physical and chemical properties and vegetative performance of dredged sediments, particularly as related to plant recruitment, productivity, and near-term sustainability. A limited understanding of how sediment depth and elevation can affect the hydrologic and edaphic environments is a major constraint to successful plant establishment and natural plant recruitment. Too little sediment may have no beneficial effect, while too much sediment may detrimentally modify the hydrology-soil-vegetative dynamics essential for maintenance, self-regulation, and sustainability of these systems. Only with a better understanding of the hydrologic and edaphic environments, that control successful wetlands sustainability, will restoration of deteriorating wetlands using dredge sediments be predictable.

Currently, there is an accelerated initiative to restore Louisiana's barrier islands, deltaic and cheniere ridges, as well as bay islands and near-shore interior marshes. Marshes and swamps being the major wetland type in coastal Louisiana. Marshes convert to open water due to many factors, including sea-level rise, sediment starvation, subsidence, salinity and change in hydrology and soil chemistry. Conversion of wetlands for agricultural and industrial uses have also played a major role in the wetland loss (Coleman et al., 2008). Fresh water and sediment input are critical factors for use in combating coastal marsh loss (Day et al., 2000). Accumulation of organic matter is also important with maintaining marsh elevation (Nyman et al., 2006; Craft, 2007).

Regional long-term processes, such as down-warping because of sedimentary loading and global sea-level rise, along with regional short-term processes (i.e. the change in location of delta formation, compaction, dewatering, and oxidation of coastal fine-grained and organic-rich sediments) in addition to human modification of the riverine system also contribute to wetland loss. Local short-term processes including those of a catastrophic nature (hurricanes), those of a biologic nature, and human nature also contribute to losses. Many researchers have noted the complex physical and biogeochemical processes governing wetland loss (Turner and Cahoon, 1987). Increasing salinity associated with salt water intrusion is one major cause for wetland loss. Salt water extending into the brackish and fresh marshes impacts vegetation resulting in collapse of the organic peat layer (DeLaune et al., 1994) creating more open water (Craig et al., 1979; Van Sickle et al., 1976, Gagliano et al., 1970).

Management of salt-affected soils

The table below provides information that is helpful in evaluating problems with salt-affected soils and in identifying appropriate management practices. Having long-term data on how the soil has changed over time is essential to making well-informed decisions about irrigation water management, rates and types of soil amendments, and the probability of positive economic returns from managing salt-affected soils. Once the necessary soil test and field history has been collected and assessed, the next step is to identify economical options for reclamation. Salt-affected soils will need management and careful monitoring to achieve reclamation.

Table 1. Typical characteristics of saline, sodic and saline-sodic soils

Classification	Electrical Conductivity (millimhos/cm or mS/cm)	Soil pH	Exchangeable Sodium percentage (%)	Sodium Absorption Ratio	Soil Physical Condition
Saline	>4.0	<8.5	<15	<13	Normal
Sodic	<4.0	>8.5	>15	>13	Poor
Saline-Sodic	>4.0	<8.5	>15	>13	Normal

Source: NDSU Extension Service; Managing Saline Soils in North Dakota, Revised, David Franzen, 2007.

In soils suspected as being saline or affected by sodium, the extent of the problem and its management are difficult to determine unless the soil is analyzed using laboratory procedures. Soil salinity can be diagnosed by measuring the salt concentration in soil water (solution) by analyzing it for Electrical Conductivity (EC). EC is the ability of a material to transmit electrical current, which in the case of a soil is the result of salt concentration.

The extent of soil sodicity is measured either through its Exchangeable Sodium Percentage (ESP) or Sodium Adsorption Ratio (SAR). Both measure the sodium content of the soils in relation to calcium and magnesium using specific mathematical formulas. Sodic soils are low in total soluble salts but high in exchangeable sodium, which tends to disperse soil particles and destroys soil structure (Management of Saline and Sodic Soils, Kansas State University, 1992). A soil will be interpreted as sodic if it has an Exchangeable Sodium Percentage of 15 or more or have Sodium Adsorption Ratio of 13 or more. Sodic soils often have a pH level of 8.5 or more in carbonate-rich soils, such as in northeastern North Dakota, but may also have very low pH, perhaps as low as 4.0 in southeastern North Dakota in soils with no carbonates. Soils having both salinity and sodicity problems are considered as saline-sodic soils and will have the characteristics of both.

In order to better understand the relationship of plant establishment, growth and development under specific environmental conditions, the physical and chemical properties of dredge material used in marsh restoration must be examined.

OBJECTIVES

The objectives of this research were to: 1) assay and interpret the physical and chemical analyses of all soil samples previously completed by A&L laboratory in 2011; and 2) assist BTNEP project managers in the implementation and analysis of the incomplete 2012, 2013, and 2014 soil sample series. Assessments for both Objectives 1 and 2 included interpreting the physical and chemical property of dredged materials as they relate to plant species selection, establishment, and near-term sustainability.

Study objectives were to complete the two primary tasks conducted over a 12-month period. The LSU AgCenter completed all soil testing using the Soils Testing and Wetland Soil Characterization Laboratories. The Barataria-Terrebonne National Estuary Program (BTNEP) was responsible for collecting soil samples and costs associated with the laboratory analyses.

METHODOLOGY

The total of 264 soil samples that were collected in 2011-2014 were analyzed at the LSU Agricultural Center's Soils Testing and Wetland Soil Characterization Laboratories. The samples were collected from different locations i.e. MA (Mitigation Area), OR (Old Ridge), MR (Middle Ridge) and FR (Far Ridge) (Appendix Table 2-13). The analyses included pH, electrical conductivity (EC), salinity, macro- and micronutrients. Salinity, conductivity, soluble salts, and pH were analyzed using a ratio of 1:2 for dry soil and distilled water. Electrical conductivity measures the ability of soluble salts to conduct electricity in water. The macro and micro nutrients including phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), sodium (Na), iron (Fe), copper (Cu), and zinc (Zn) were analyzed from the water soluble extract of the 1:2 soil and water ratio, and the element concentration was determined using ICP (Inductively Couple Plasma spectrophotometer). Cation Exchange Capacity (CEC) and Sodium Absorption Ratio (SAR) were calculated based on the element analyses. SAR is defined as the ratio of sodium to calcium plus magnesium. The calculations are based on molecular weight of each of the three elements and their respective valence and expressed as milliequivalent (meq). For example, low sodium content in soil or sediment would yield a low SAR value, with a SAR value of less than 13 being desirable. In addition to soil analysis, the test results from the LSU Lab were also compared to the test results of 212 samples that were tested by the A&L Lab for the samples collected from 2008 to 2011. The soil analysis package from the A&L lab included organic matter, cation exchange capacity, pH, soluble salts, and extractable elements i.e. P, K, Ca, Mg, S, Na Zn, Mn, Fe, Cu, boron (B), and nitrate (NO_3^-). Mehlich III (an acid extractant with the mixture of 0.2N CH_3COOH + 0.25N NH_4NO_3 + 0.013N HNO_3 +0.015N NH_4F + 0.001M EDTA) was used to determine the concentration of extractable elements. The correlation and comparison of the results from both labs were analyzed by averaging the data over 6 different sampling times at the same sampling sites and same parameters. There were only 44 sites that have completed for the analysis in both labs. Graphs were plotted for each important parameter using results from both labs including the correlation coefficient value.

RESULTS

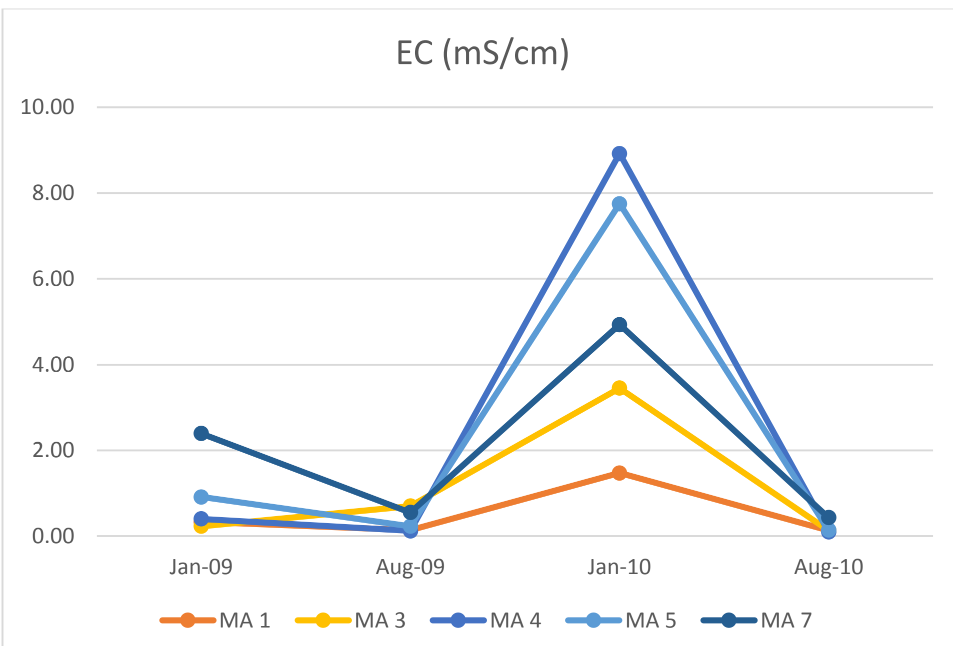
1. **Soil test results from A&L Laboratory for the samples collected from May 2008 to February 2011 (Mehlich III Extraction)**

Soil test package offered from the A&L lab covered most of the important factors for agricultural soil basis i.e. electrical conductivity (EC) organic matter, pH, pH buffer, soluble salts, cation exchange capacity, macronutrient and micronutrient content. Six sampling times were collected from four locations namely; MA, OR, MR, and FR from May 2008 to February 2011. A summary of the soil test results for each sampling date are in Table 2 for the samples collected in May 2008, Table 3 for the samples collected in January in 2009, Table 4 for the samples collected in August 2009, Table 5 for the samples collected in January 2010, Table 6 for the samples collected in August 2010, and Table 7 for samples collected in February 2011. In May 2008 and February 2011, soil samples were collected only from OR and MR locations. In addition to the results in the tables that attached at the end of the report, graphs below show the results of the important elements from Mehlich III extraction. The additional 2 parameter; EC and pH, which were measured in the mixture of soil and water slurry to show the level of salinity in each location.

1.1 Mitigation Area (MA1-MA10), Ten samples were collected from this area. The site is a created marsh initially pumped with sediment in 2001. The samples were collected from 3 landforms: Low ridge (MA1, MA3, MA4, MA5, and MA7); Low Ridge Slope (MA2, MA6, and MA8); and Marsh (MA9 and MA10).

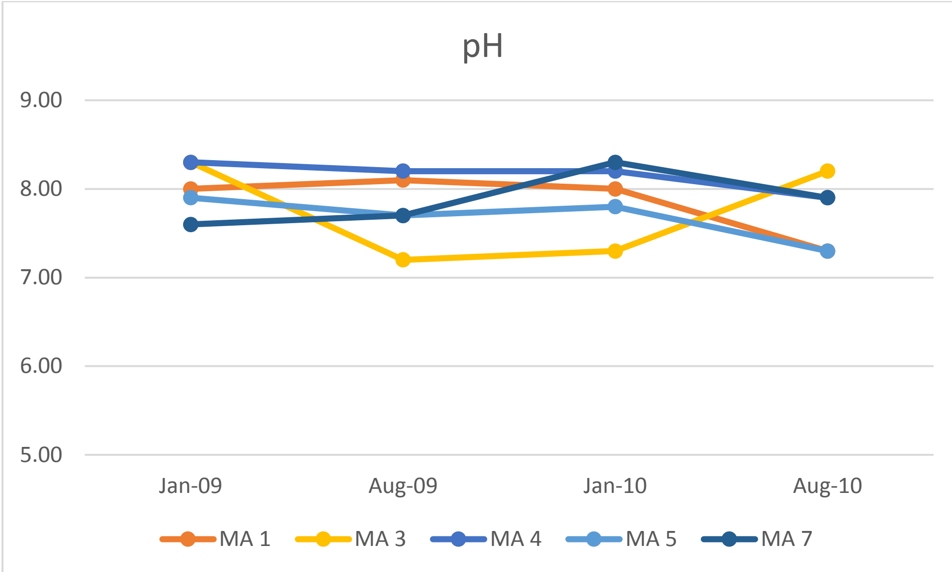
1.1.1 Low Ridge (MA1, MA3, MA4, MA5, and MA7)

1.1.1.1 Electrical conductivity (mS/cm)



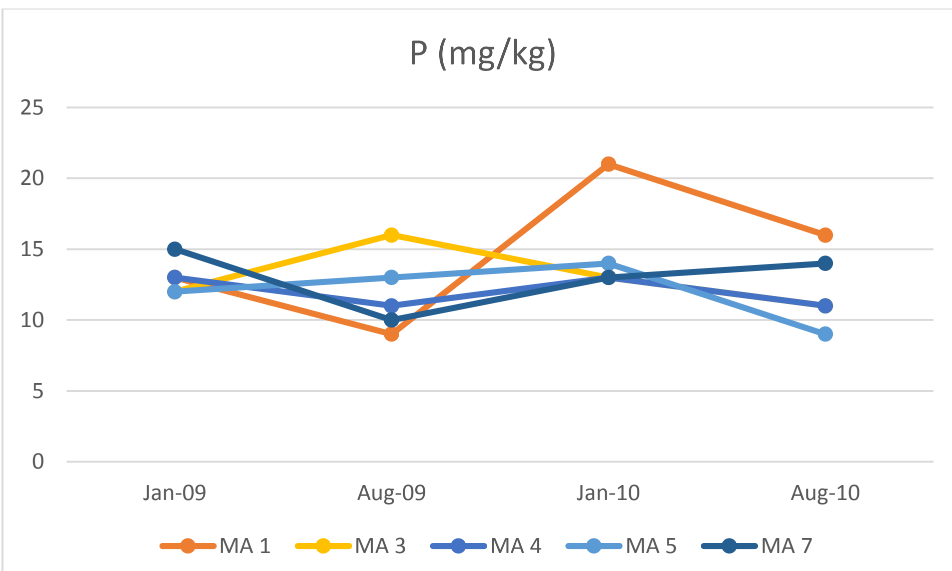
Electrical conductivity for the low ridge ranged from 0.14 to 8.92 milliSiemens/cm (mS/cm). EC for the samples collected in January 2010 were increased significantly as compared to other sampling dates that might be due to weather condition before sampling (such as major hurricanes or long drying period).

1.1.1.2 pH



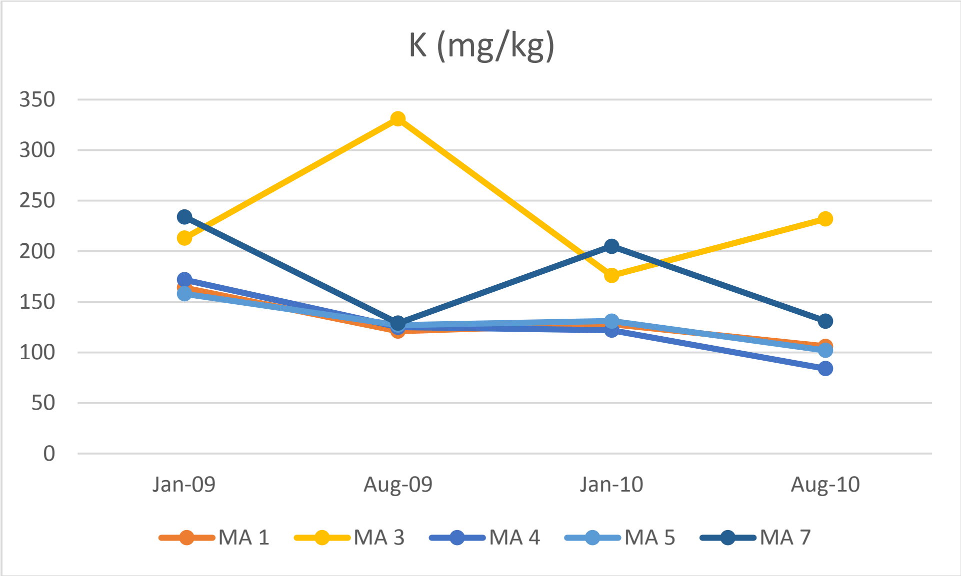
pH was also measured in the soil slurry. It ranged from 7.2 to 8.3, which is common in the saltmarsh area.

1.1.1.3 Extractable P (mg/kg)



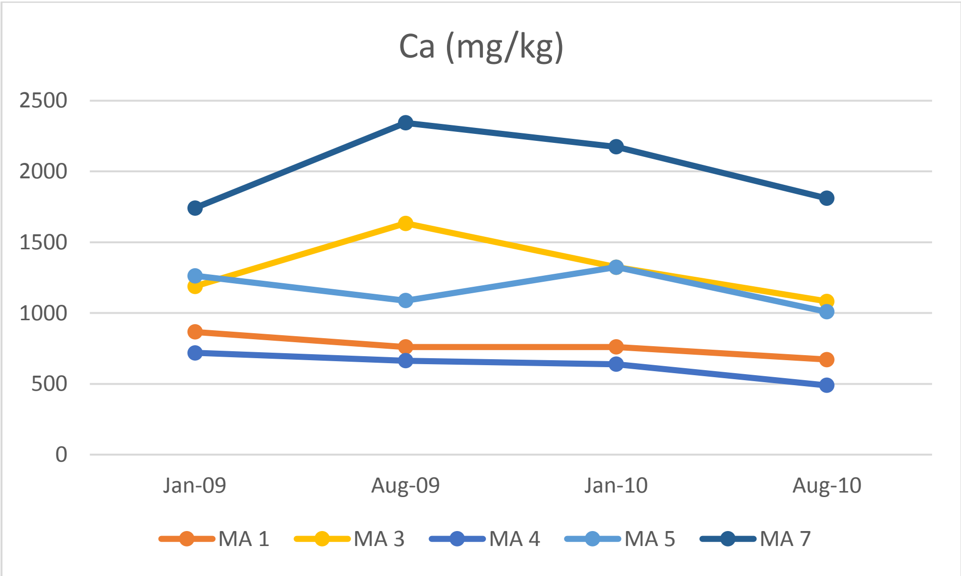
Extractable P was extracted by Mehlich III solution ranged from 9-23 mg/kg.

1.1.1.4 Extractable K (mg/kg)



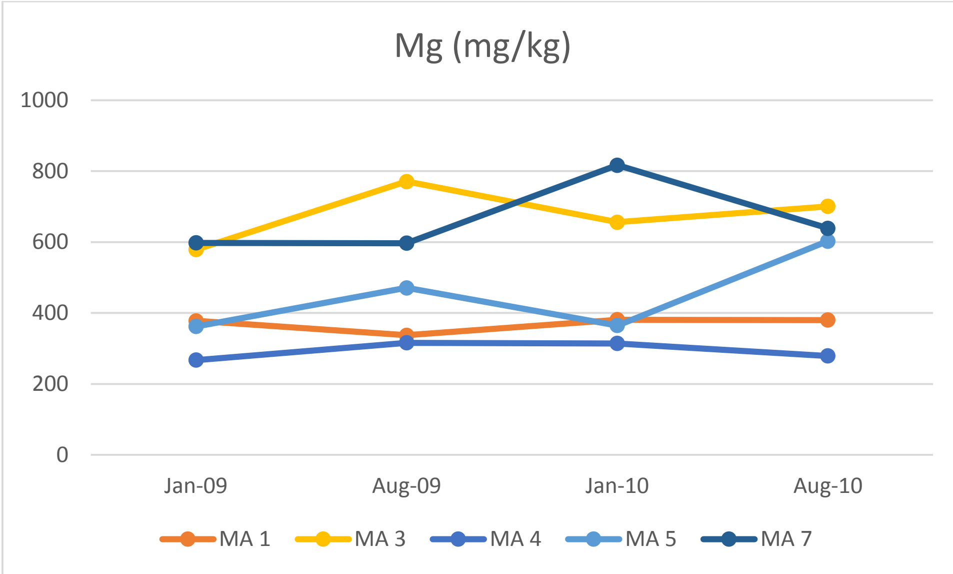
Extractable K ranged from 84 to 331 mg/kg. The lowest was observed in MA4 and the highest was in MA3.

1.1.1.5 Extractable Ca (mg/kg)



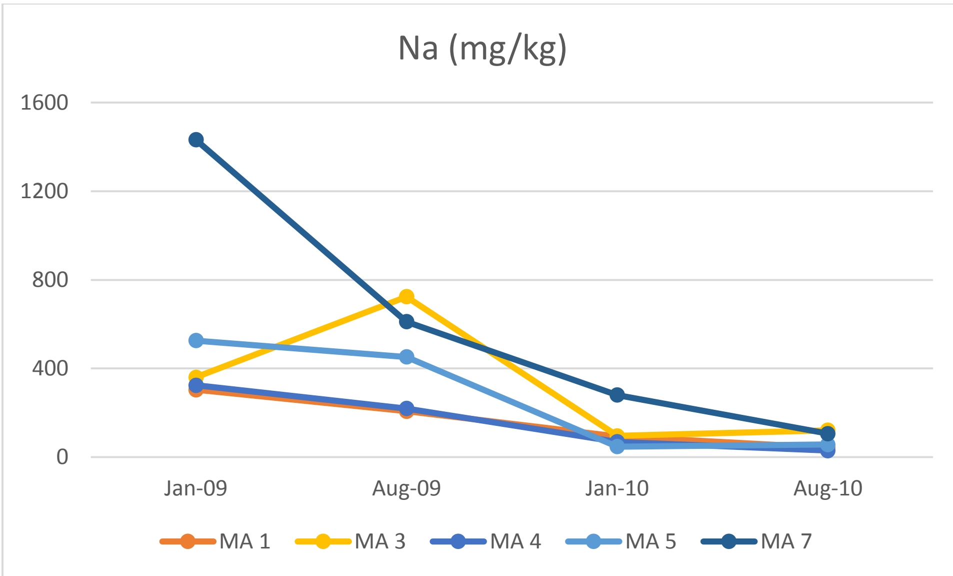
Ca was a dominant cations as compared to K, Mg, and Na for this location. The lowest concentration was found in MA4 and the highest was in MA7. The Ca concentration was influenced by oyster shell at the sites.

1.1.1.6 Extractable Mg (mg/kg)



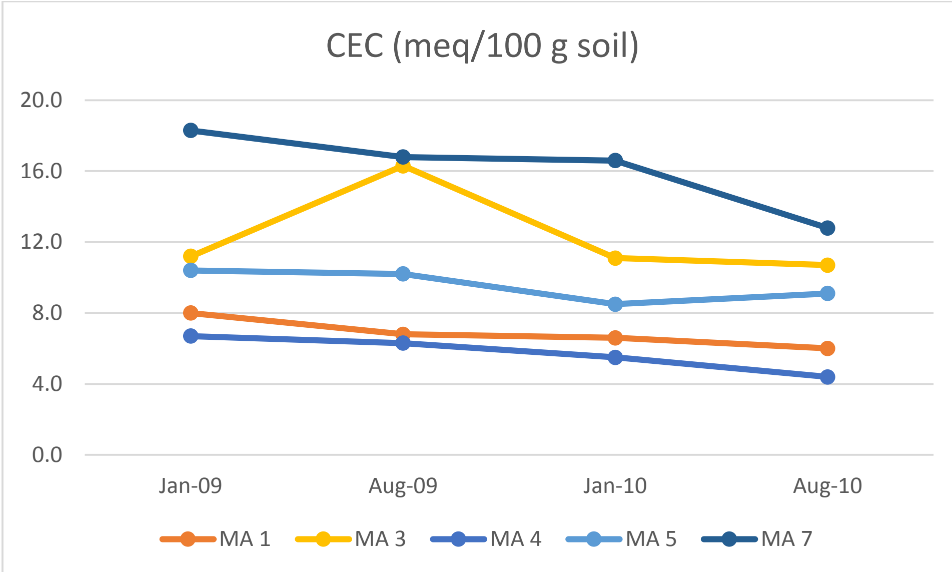
Mg was also similar trend with Ca but in lower level. The lowest was found in MA4 for 267 mg/kg and the highest at MA7 for 817 mg/kg.

1.1.1.7 Extractable Na (mg/kg)



Na usually is a major cation in the soil collected from high salinity environment like saltmarsh. However, at this location the amount of Na was lower than Ca because of the high amount of oyster shell.

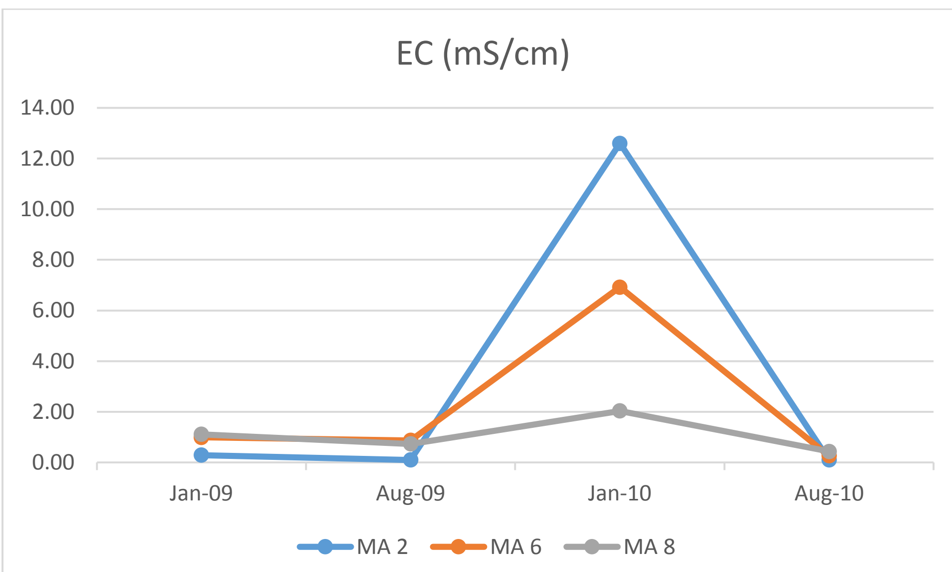
1.1.1.8 Cation exchange capacity (meq /100 g soil)



CEC was highly influenced by the amount of Ca, which was the highest cation concentration in the sites.

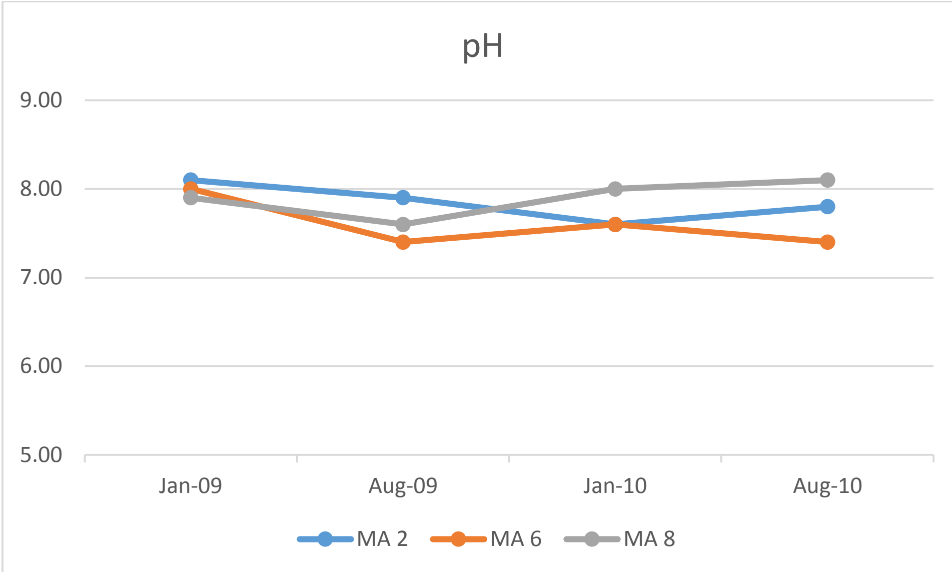
1.1.2 Low Ridge Slope (MA2, MA6, and MA8). The elevation of these three sites were lower than "Ridge Top".

1.1.2.1 Electrical conductivity (mS/cm)



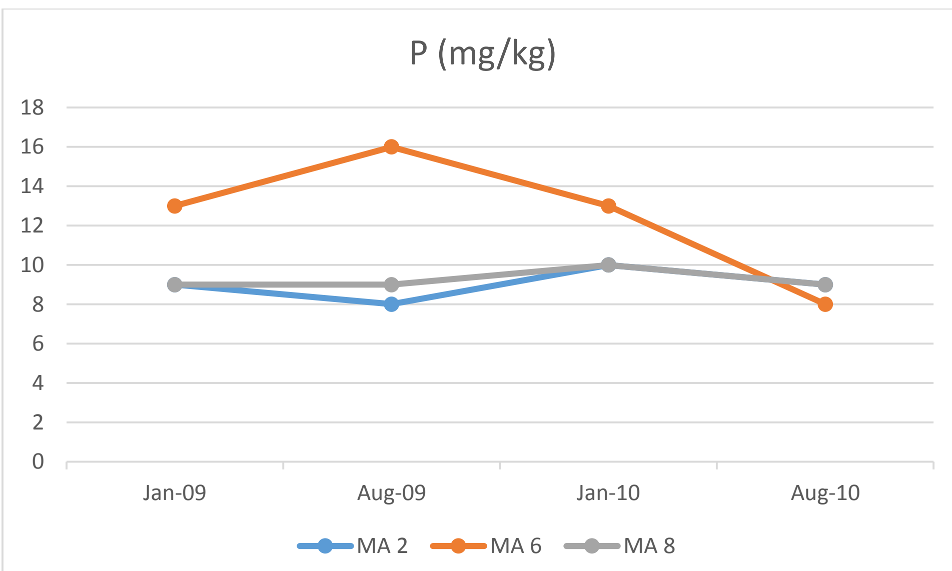
EC for the samples collected in January 2009, August 2009, and August 2010 were lower than 2 mS/cm but it jumped up for the sampling in January 2010 that might be because of weather as described above.

1.1.2.2 pH



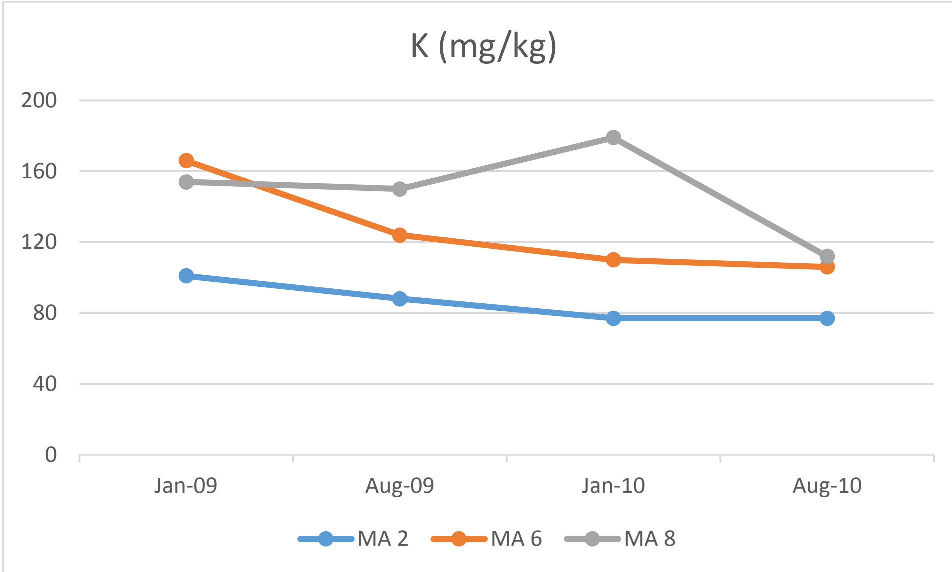
The average pH of these 3 sites was almost same with the Ridge Top. The lowest pH was 7.4 and the highest was 8.1.

1.1.2.3 Extractable P (mg/kg)



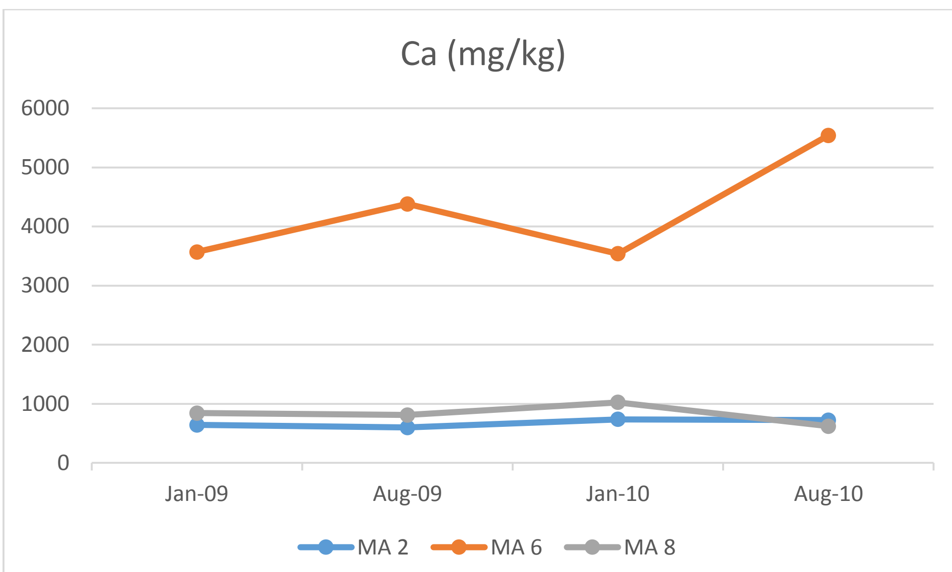
Extractable P ranged from 8 to 16 mg/kg. It was not different between the sampling times for MA2 and MA8 but it was varied by the sampling times in the MA6.

1.1.2.4 Extractable K (mg/kg)



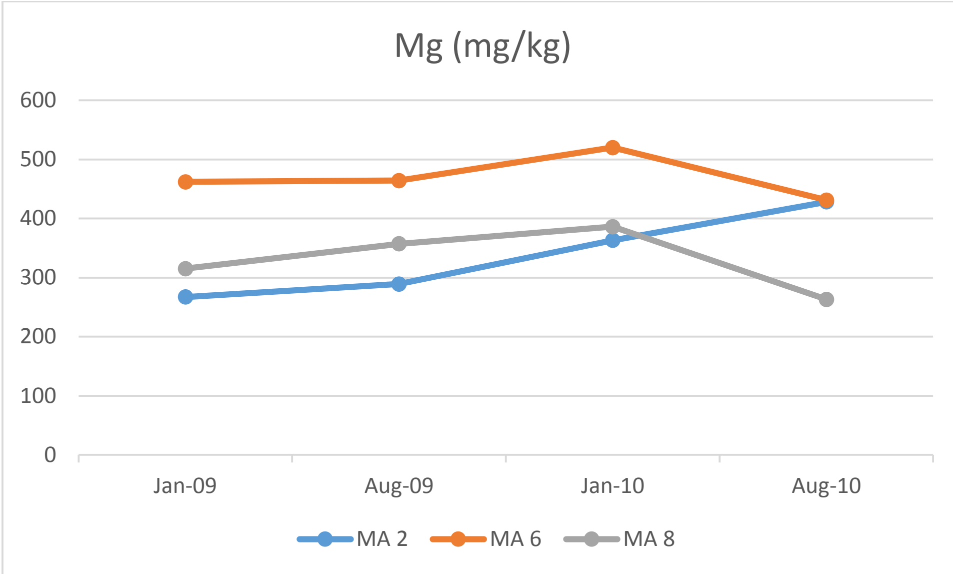
Extractable K ranged from 77 to 179 mg/kg. It was lower than the Ridge Top location.

1.1.2.5 Extractable Ca (mg/kg)



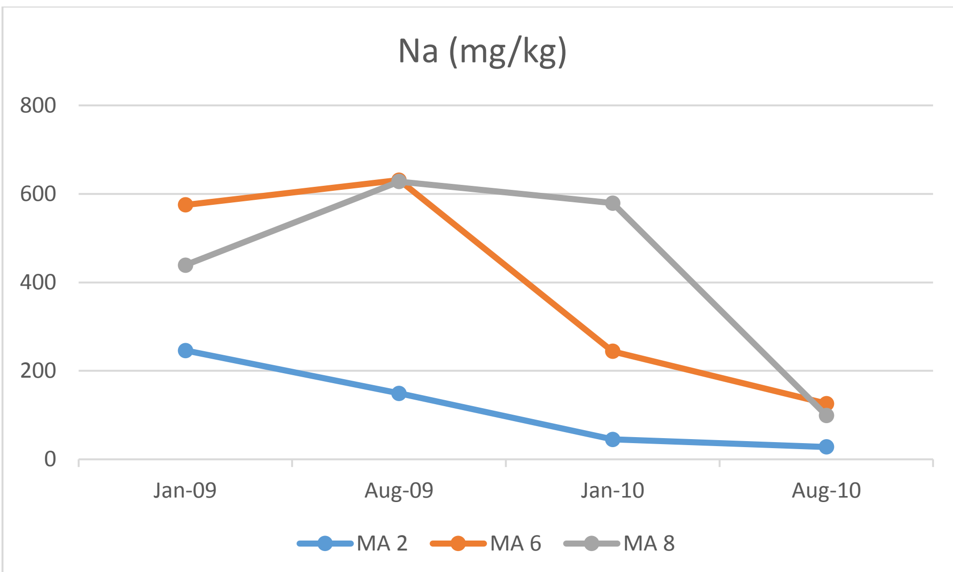
Ca was also high particularly in the MA6 that might be because of the oyster shell in the sample.

1.1.2.6 Extractable Mg (mg/kg)



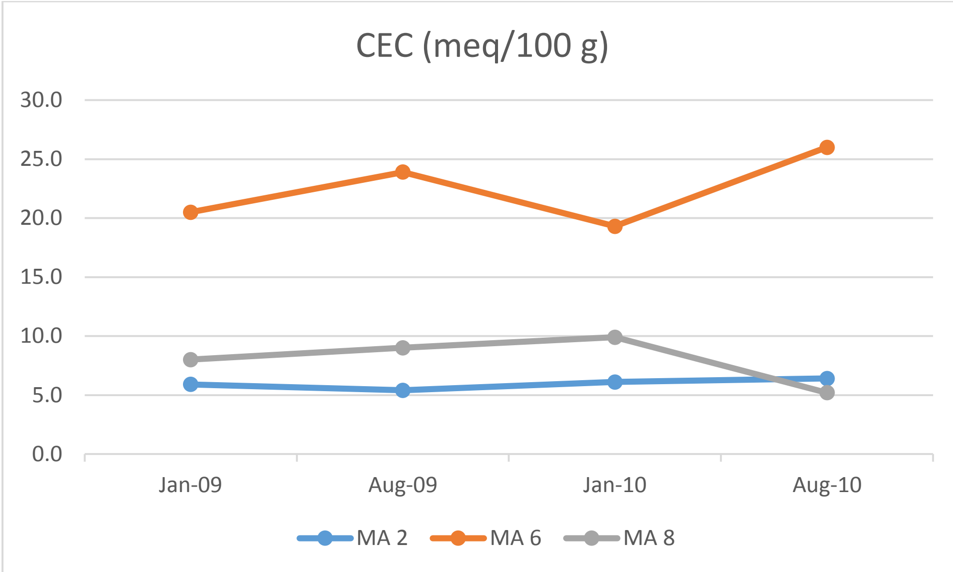
Mg ranged from 263 to 520 mg/kg. The highest concentration was observed in the MA6.

1.1.2.7 Extractable Na (mg/kg)



Na was dropped by time. The lowest was 28 mg/kg in MA2 and the highest was 631 mg/kg in MA6.

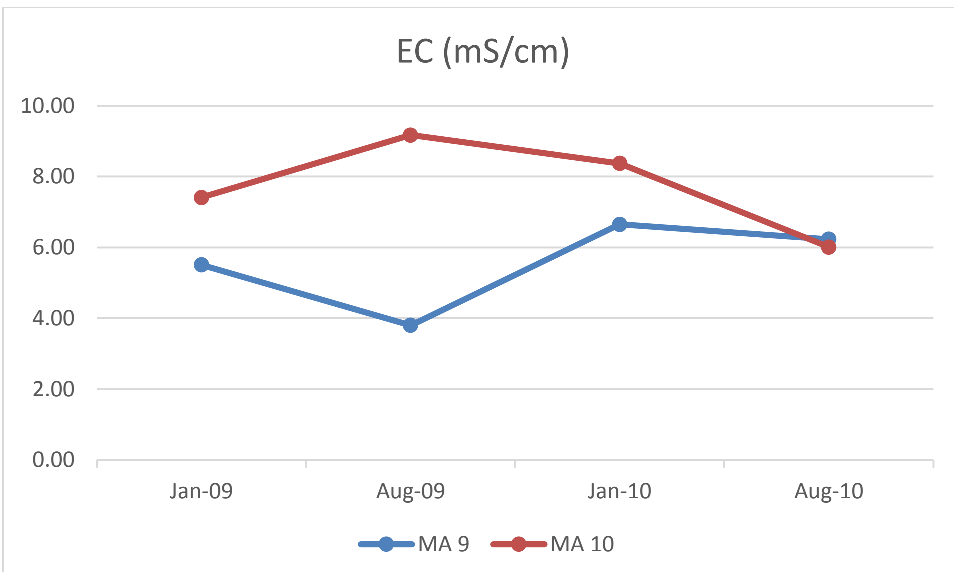
1.1.2.8 Cation exchange capacity (meq/100g soil)



CEC was highly affected by the concentration of Ca which was the highest concentration of the cations in this area.

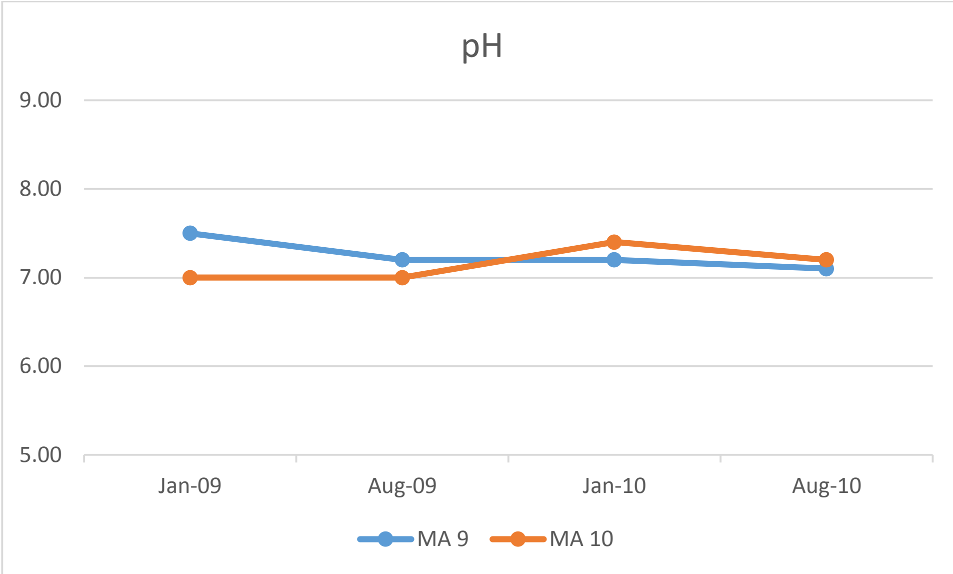
1.1.3 Marsh (MA9 and MA10)

1.1.3.1 Electrical conductivity (mS/cm)



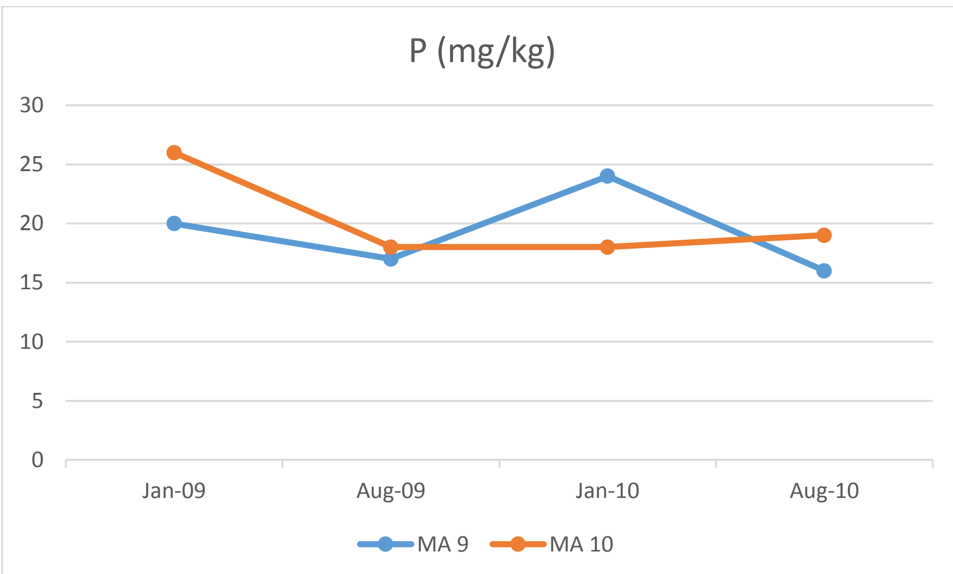
EC in the marsh area were slightly differ from the two sites. The value for MA9 was dropped in August 2009. That might be an error from the measurement. The EC in these two sites should not different.

1.1.3.2 pH



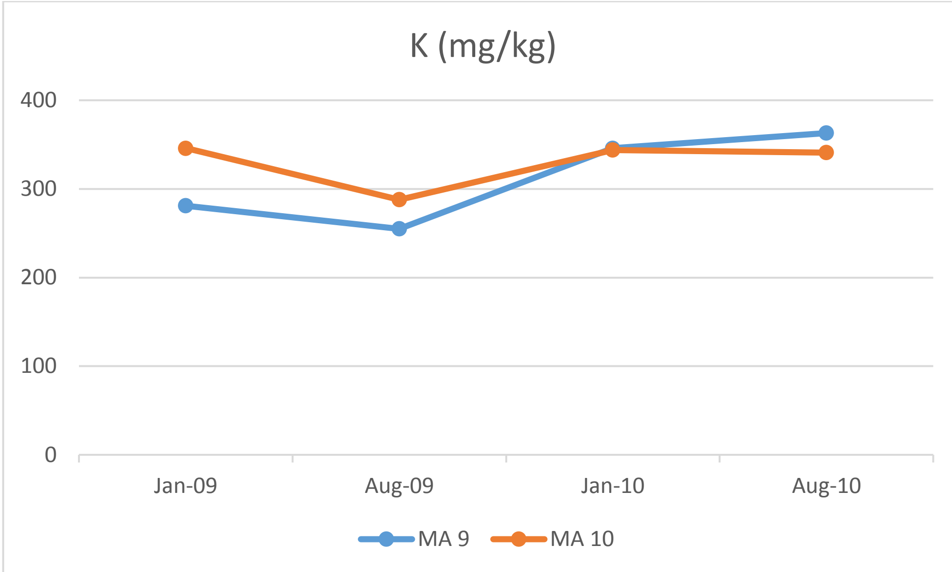
Soil pH of these two sites were not deferent. It ranged from 7.0 – 7.5.

1.1.3.3 Extractable P (mg/kg)



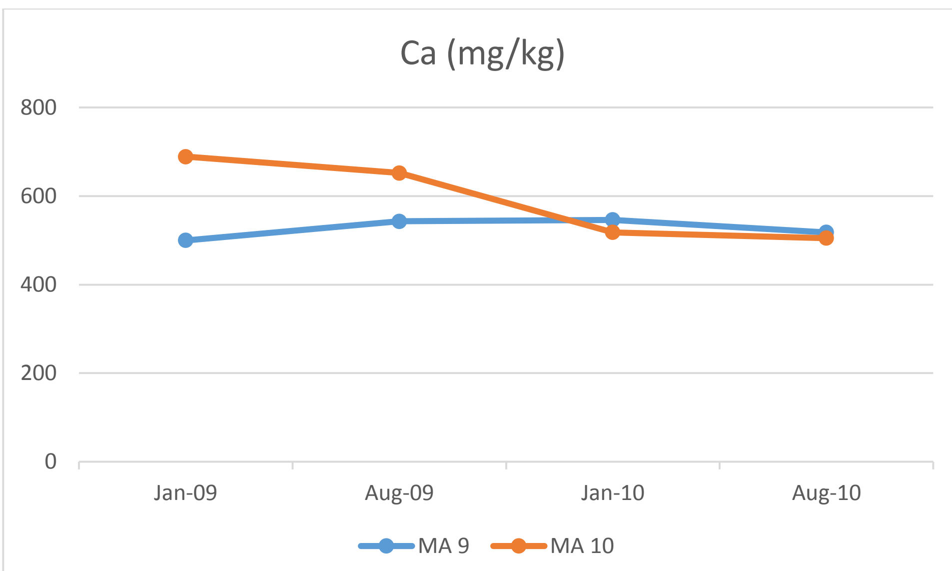
Extractable P from the two sites were not different. It ranged from 16 – 26 mg/kg.

1.1.3.4 Extractable K (mg/kg)



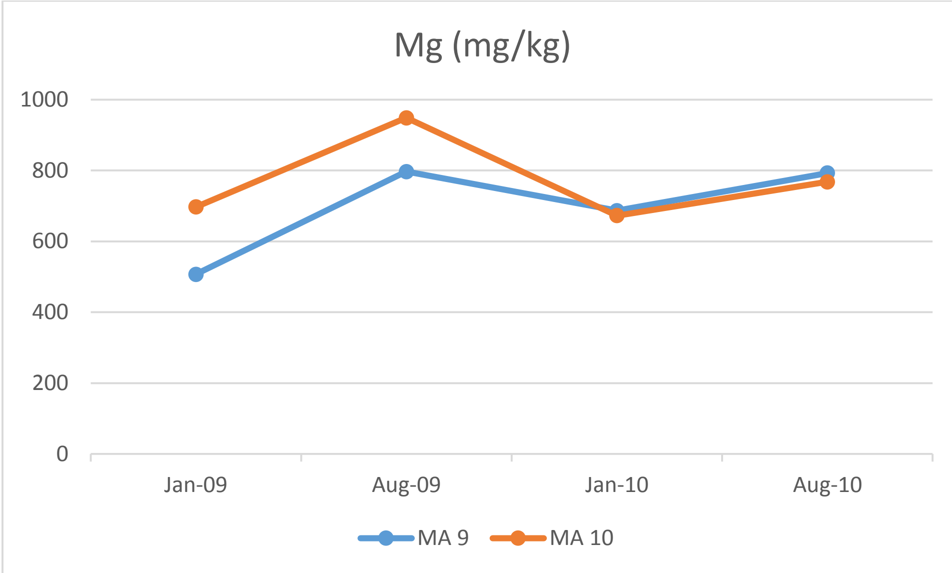
Extractable K ranged from 225 to 263 mg/kg. the values from both sites were not much different.

1.1.3.5 Extractable Ca (mg/kg)



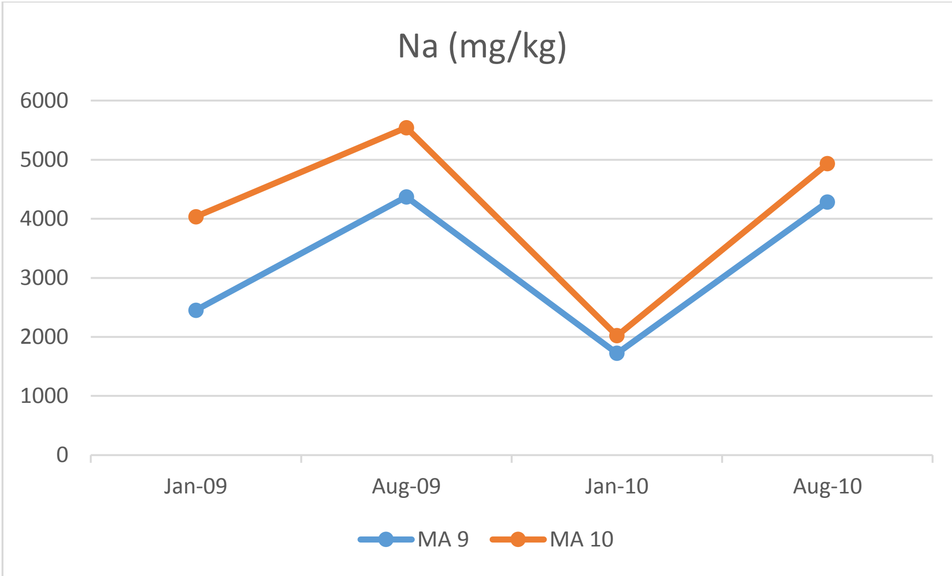
Ca ranged from 500 to 689 mS/cm. By the average, the value of the MA10 was higher than the MA9.

1.1.3.6 Extractable Mg (mg/kg)



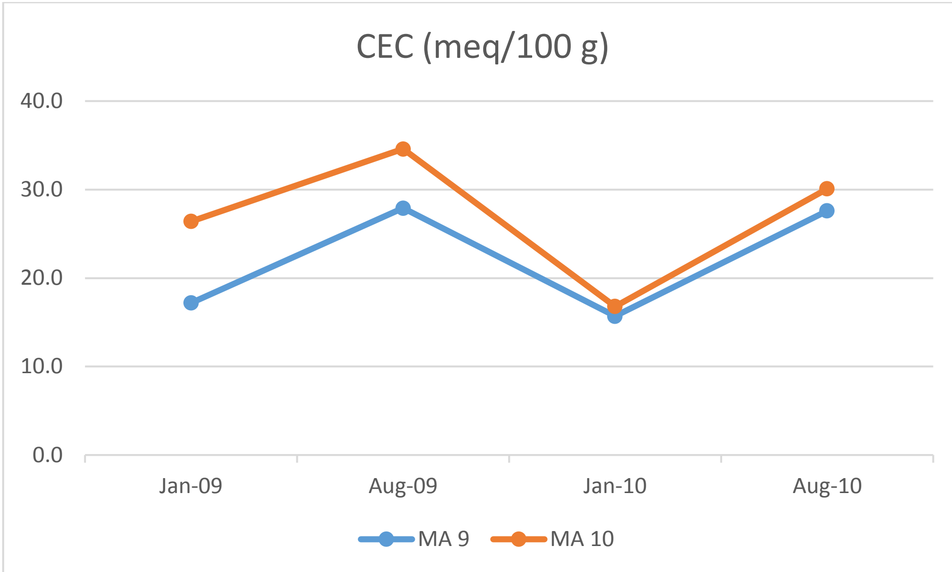
Mg was increased at the August 2009 sampling. The average for MA10 was higher than MA9.

1.1.3.7 Extractable Na (mg/kg)



Extractable Na were fluctuated by time of sampling with the lowest was 1,723 mg/kg of MA9 and the highest was 5,540 mg/kg in MA10.

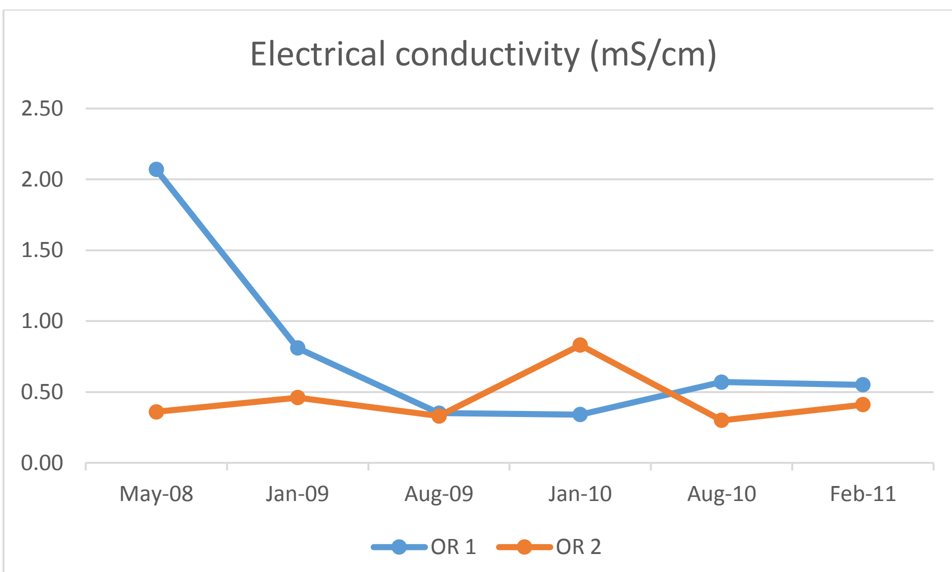
1.1.3.8 Cation exchange capacity (meq/100 g soil)



CEC were highly related to amount of Na content, which was the highest cation concentration as compared to K, Ca, and Mg.

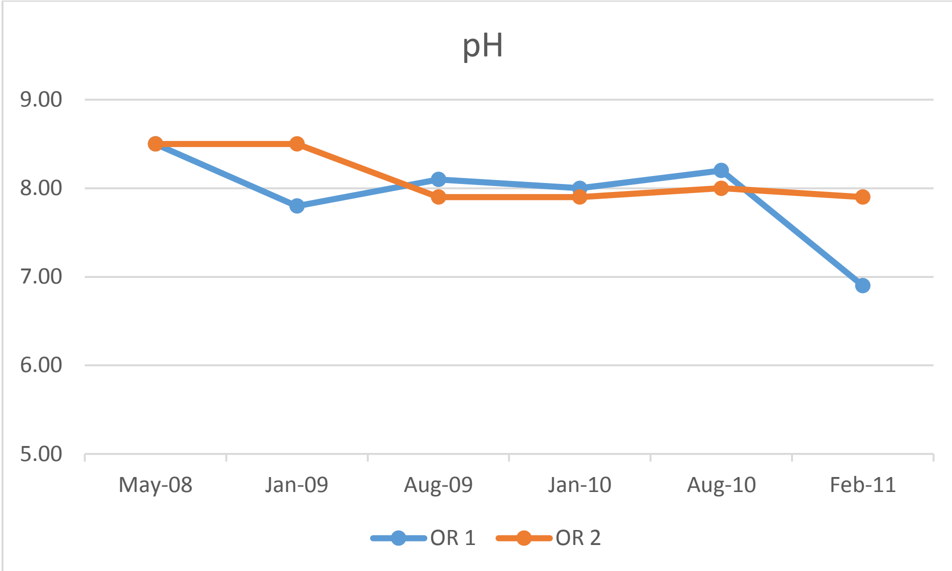
1.2 Old Ridge (OR1 and OR2), this site was created in 2003. Only two samples were collected from the Old Ridge site. The samples were collected 6 different times (May 2008, January 2009, August 2009, January 2010, and February 2011). Electrical conductivity appeared to be the lowest as compared to other locations and would likely not impact plant growth.

1.2.1 Electrical conductivity (mS/cm)



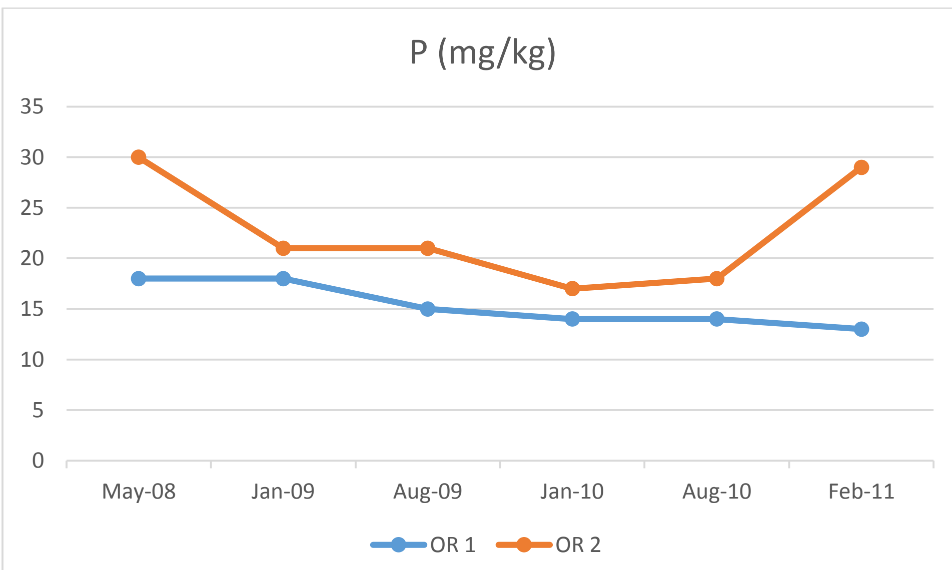
Electrical conductivity was lower than the samples collected from MA area. The highest was 2.07 mS/cm at the first sampling in May 2008 for the OR1. Most of the results were lower than 1.0 mS/cm.

1.2.2 pH



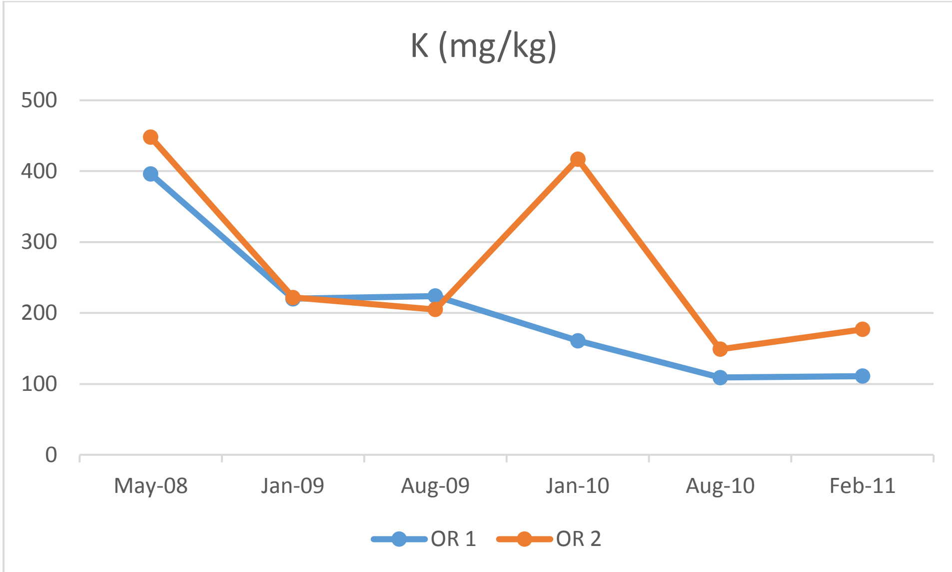
Soil pH ranged from 6.9 to 8.5 and it was slightly higher than the MA samples, except the sample collected in February 2011 that significantly dropped to below 7.

1.2.3 Extractable P (mg/kg)



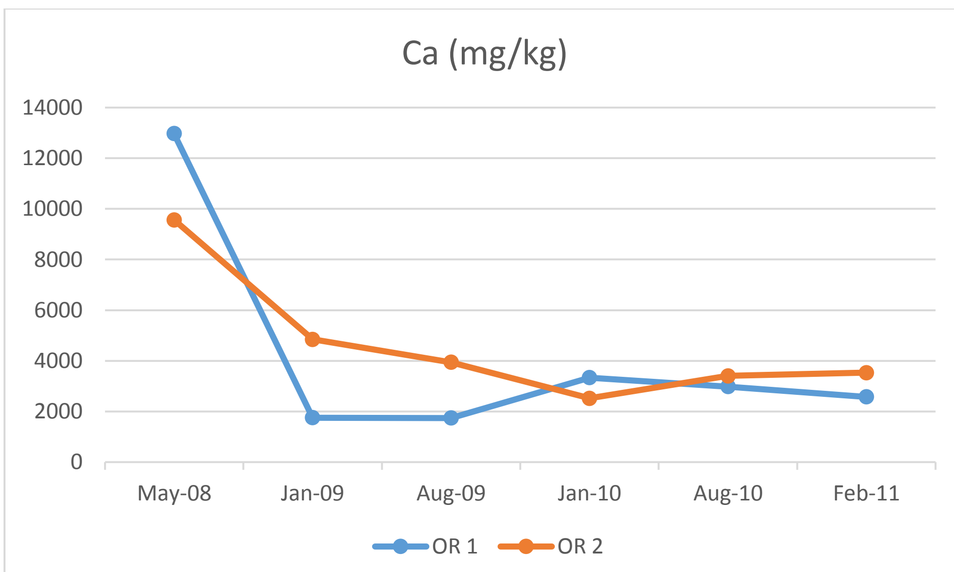
Extractable P ranged from 13 to 30 mg/kg. The highest concentration was observed in OR 2 for the sampled in February 2011.

1.2.4 Extractable K (mg/kg)



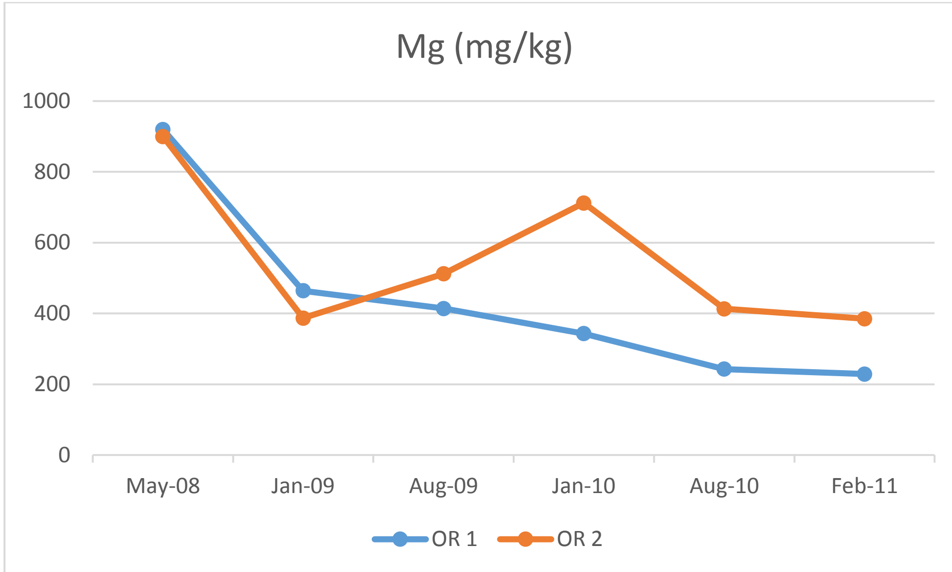
Extractable K were higher at the first sampled in May 2008 (396-448 mg/kg) and dropped afterward to the lowest at 111 mg/kg for the OR1. However, fluctuation P concentration was observed in the OR2.

1.2.5 Extractable Ca (mg/kg)



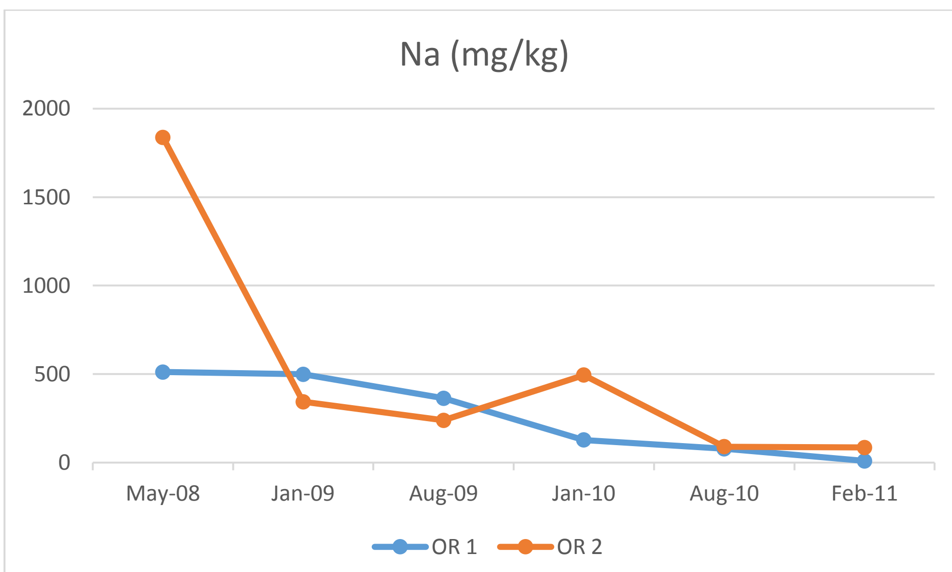
Extractable Ca were extremely high (12,970 mg/kg for OR1 and 9,562 mg/kg for OR2) at the first sampling date (May 2008) and subsequently were significantly decreased to 2,579 mg/kg for OR1 and 3,531 mg/kg for OR2 in February 2011.

1.2.6 Extractable Mg (mg/kg)



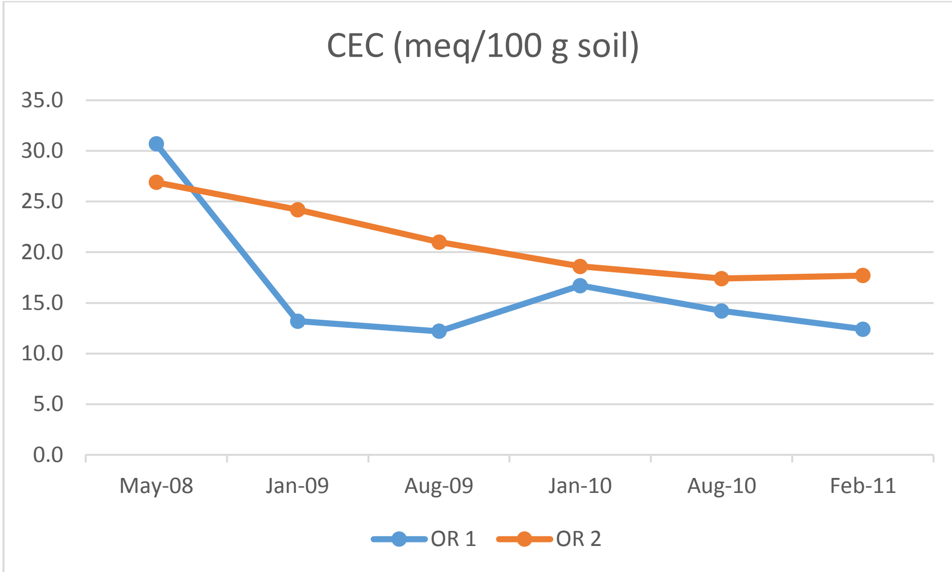
Extractable Mg ranged from 229-920 mg/kg. Effect of sampled dates on the concentration of extractable Mg was observed. The latest sampling date in February 2011 has the lowest concentration as compared to the other sampling dates.

1.2.7 Extractable Na (mg/kg)



Extractable Na has similar trend with Na. For the OR1, the concentration dropped from 1,838 mg/kg (May 2008) to 85 mg/kg (February 2011).

1.2.8 Cation exchange capacity (meq/100 g soil)

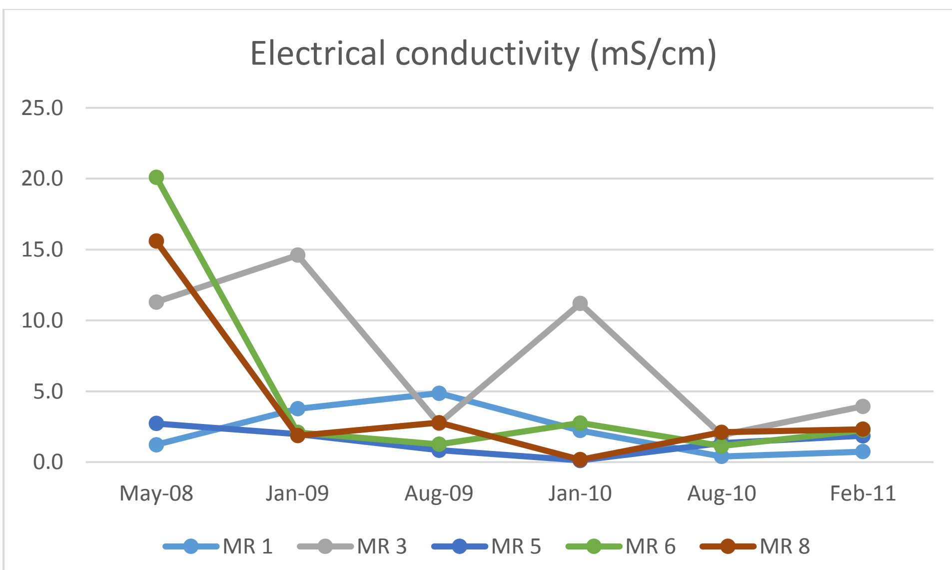


CEC for this site was relatively low as compared to other sites and the values were decreased by time. That might be because of the leaching of cations from the upper soil layers.

1.3 Middle Ridge (MR1-MR10) was formed in summer of 2005. The 10 samples were collected from 6 different times (May 2008, January 2009, August 2009, January 2010, August 2010, and February 2011) and are broken down into 3 landforms: Ridge top (MR1, MR3, MR5, MR6, and MR8), Ridge slope (MR10), and Marsh (MR2, MR4, MR7, and MR9).

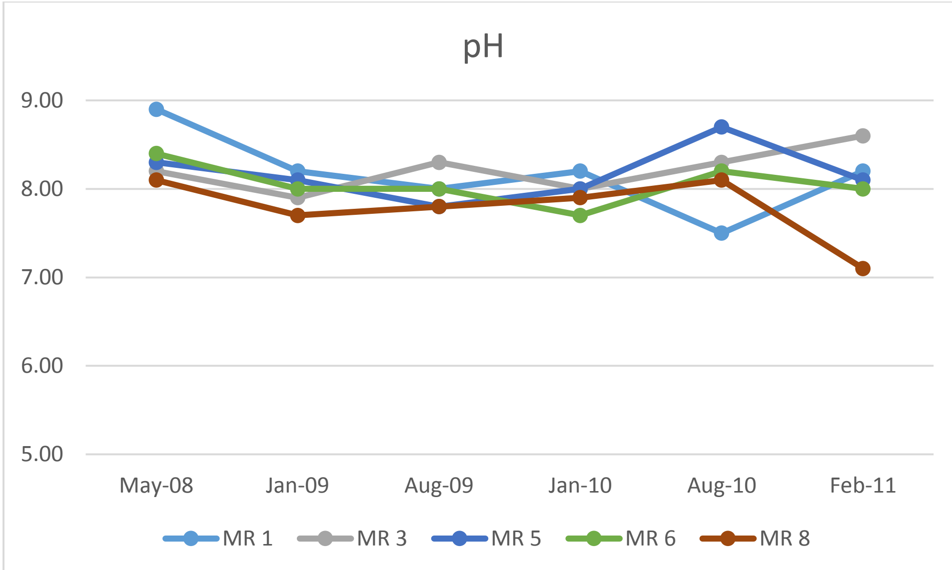
1.3.1 Ridge Top (MR1, MR3, MR5, MR6, and MR8)

1.3.1.1 Electrical conductivity (mS/cm)

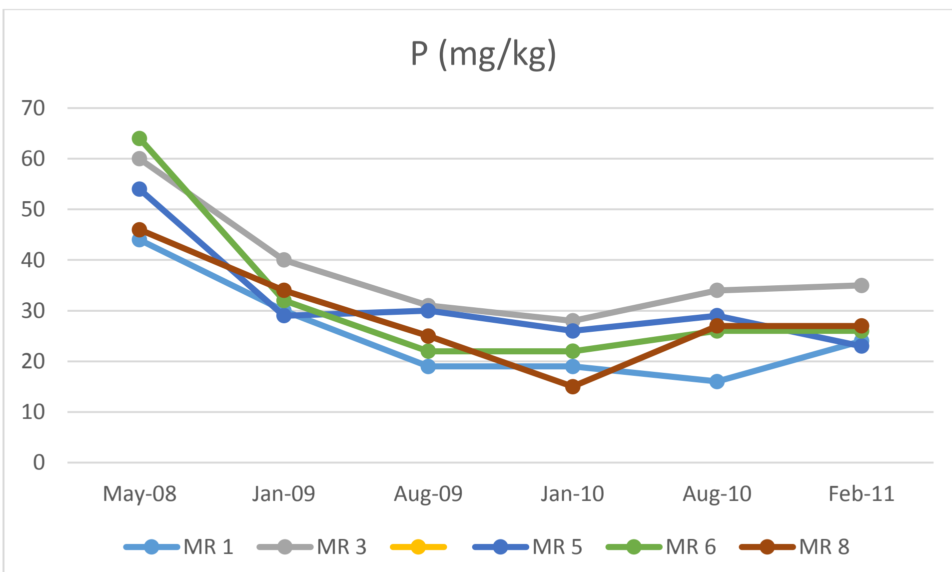


EC and pH were analyzed based on soil slurry. High variation of EC at the first sampling in May 2008 (1.22-20.10 mS/cm). However, the last sampling in February 2011, EC were dropped between 1.86-3.93 mS/cm.

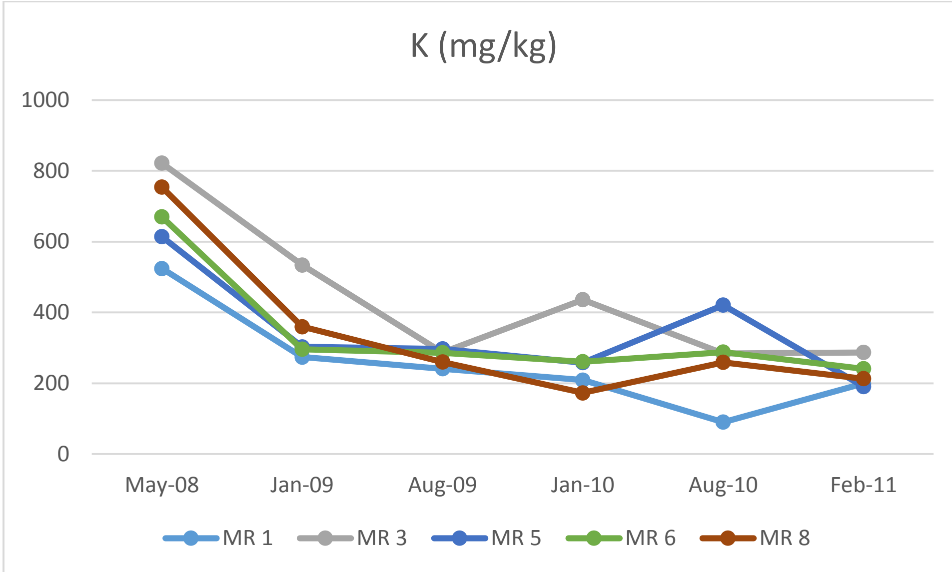
1.3.1.2 pH



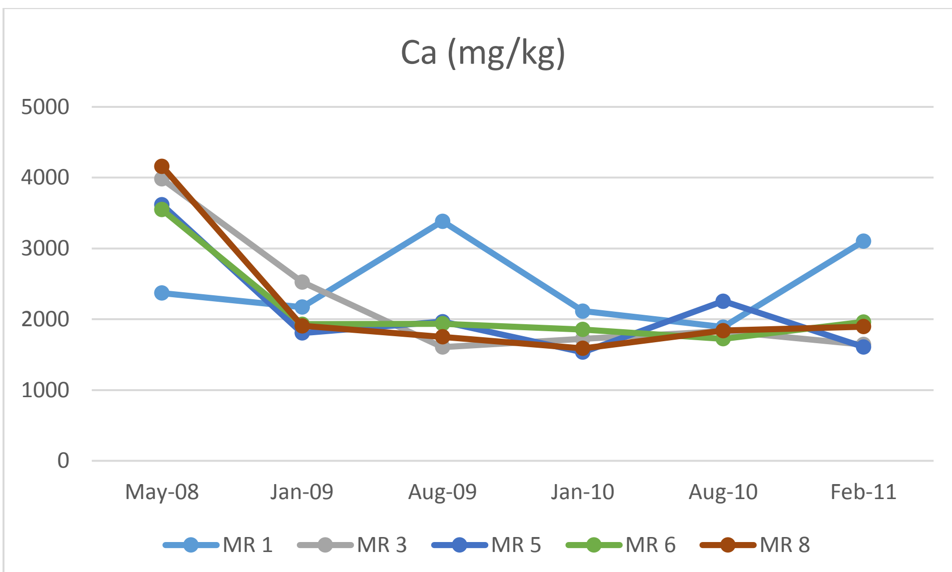
1.3.1.3 Extractable P (mg/kg)



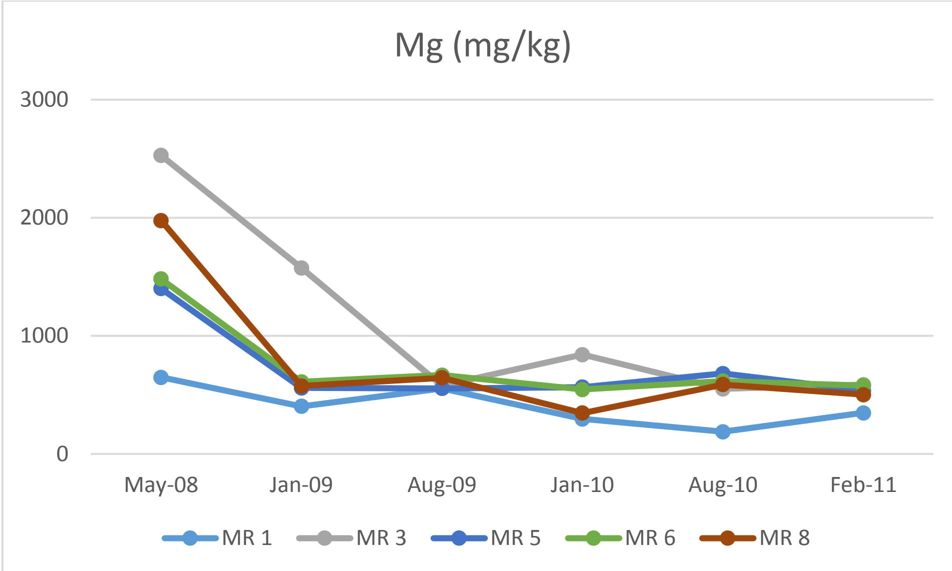
1.3.1.4 Extractable K (mg/kg)



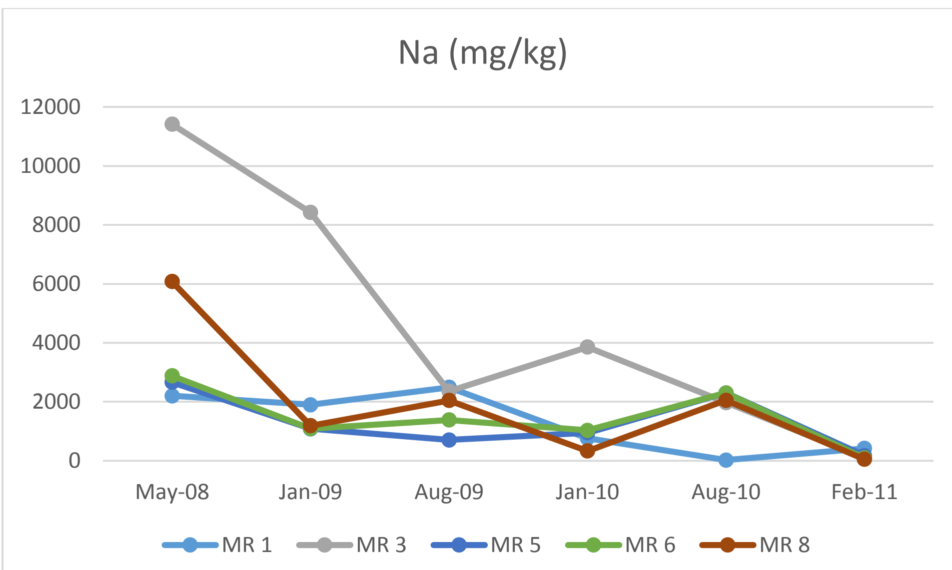
1.3.1.5 Extractable Ca (mg/kg)



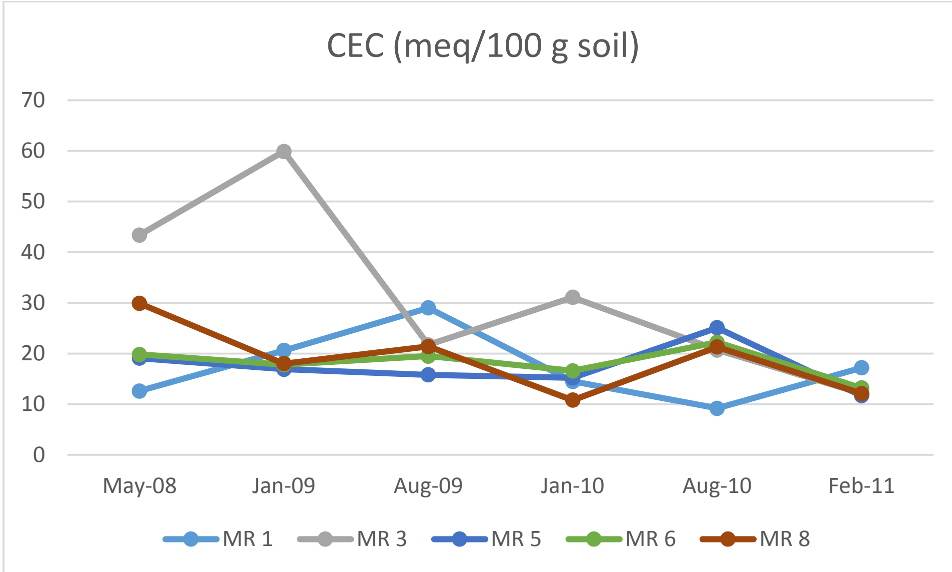
1.3.1.6 Extractable Mg (mg/kg)



1.3.1.7 Extractable Na (mg/kg)



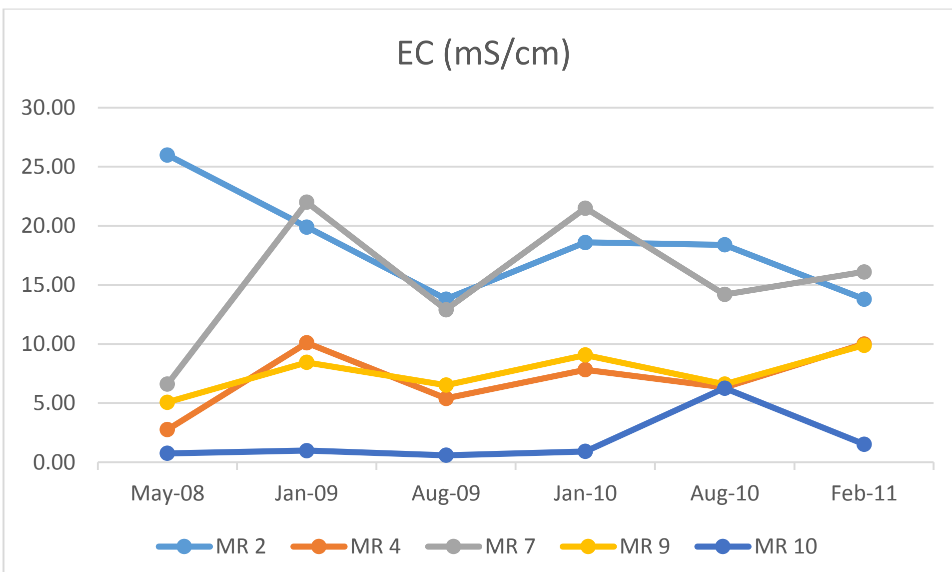
1.3.1.8 Cation exchange capacity (meq/ 100 g soil)



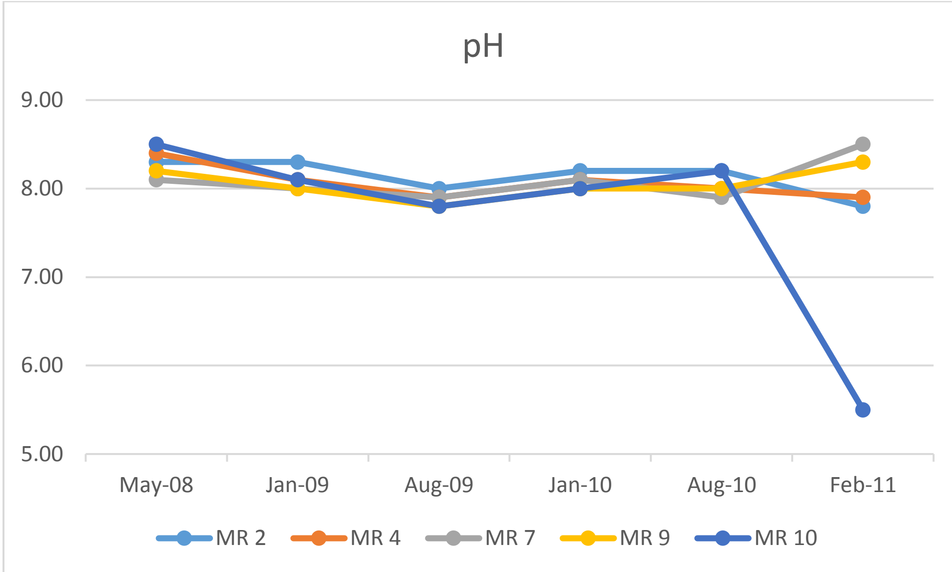
The average extractable P, K, Ca, Mg, Na, including CEC were slightly decreased by time.

1.3.2 Ridge slope (MR10), and Marsh (MR2, MR4, MR7, and MR9). The following 8 charts in this section were included 2 landforms; Ridge slope and Marsh location.

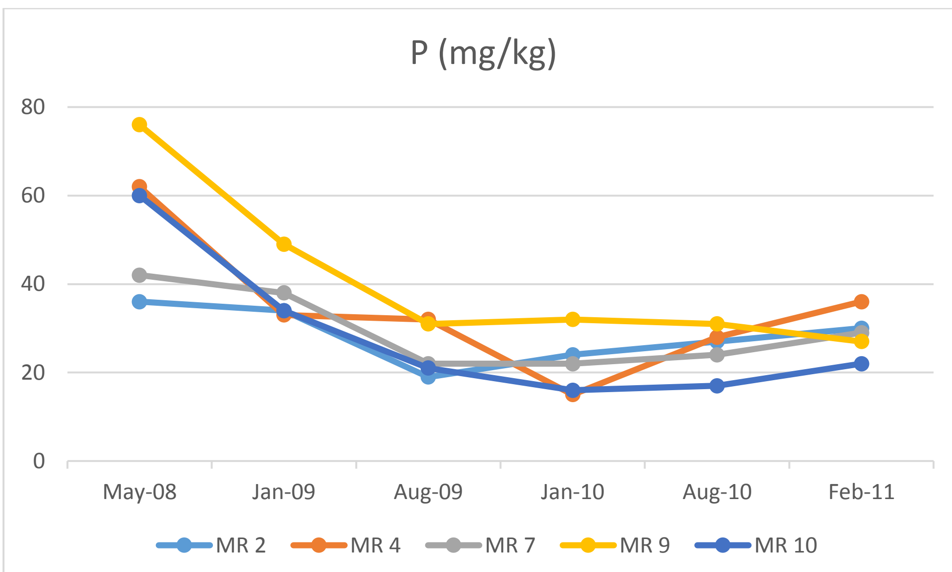
1.3.2.1 Electrical conductivity (mS/cm)



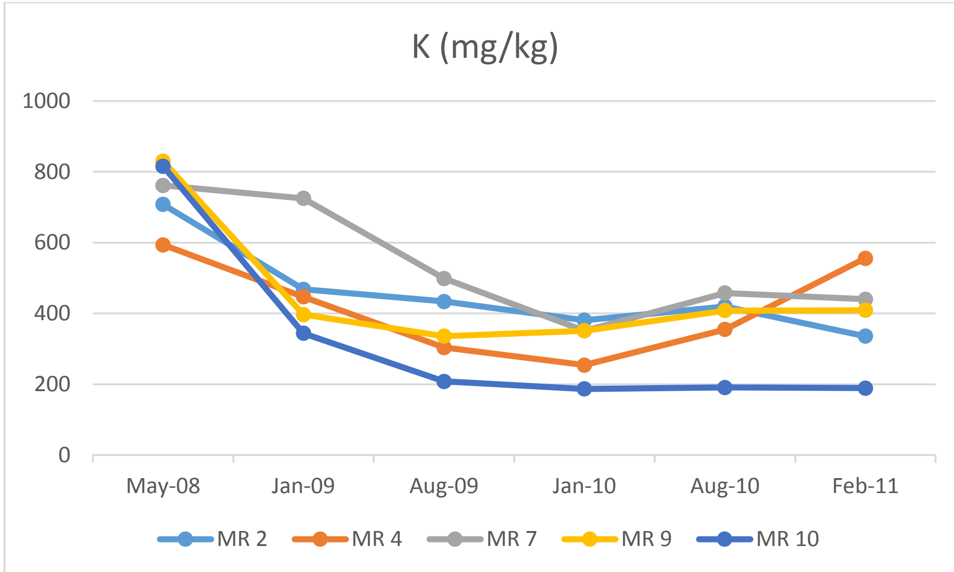
1.3.2.2 pH



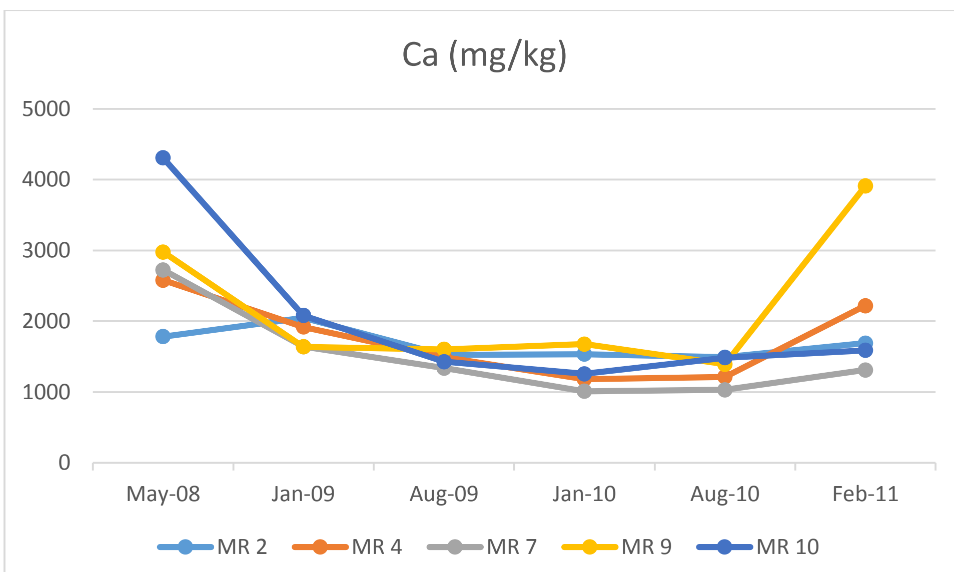
1.3.2.3 Extractable P (mg/kg)



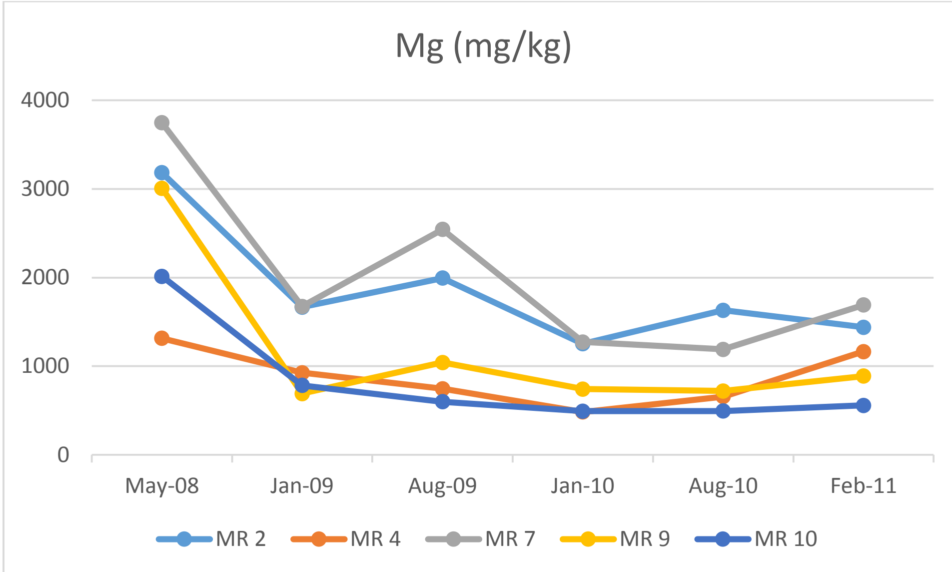
1.3.2.4 Extractable K (mg/kg)



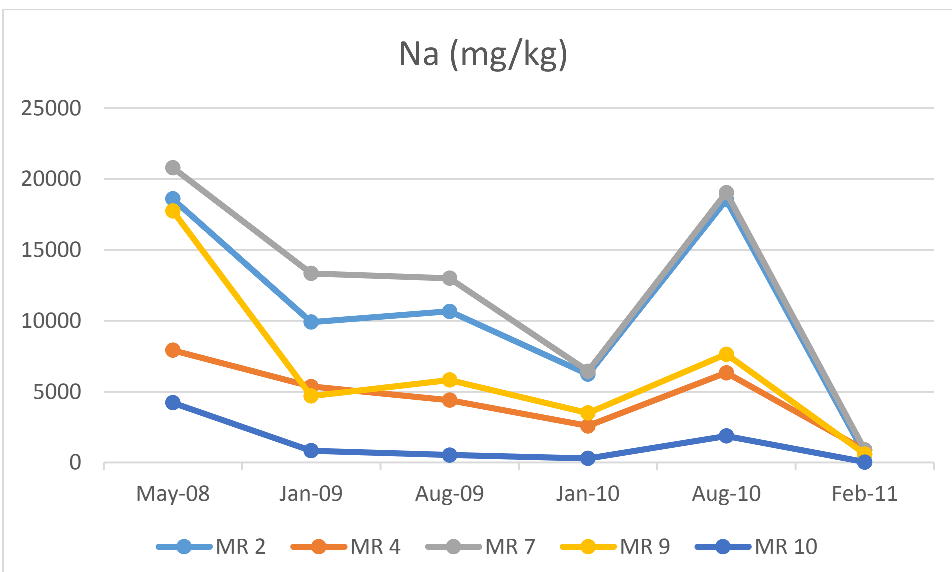
1.3.2.5 Extractable Ca (mg/kg)



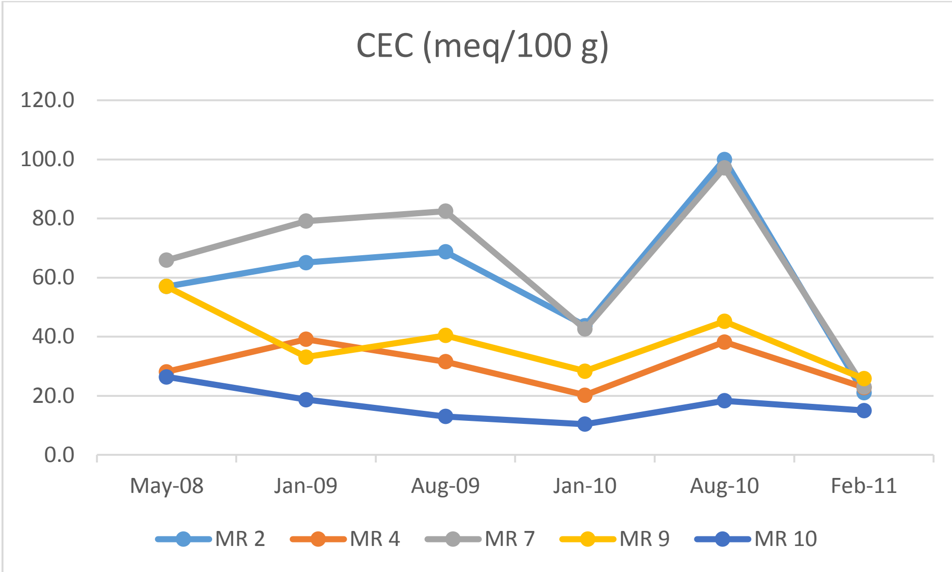
1.3.2.6 Extractable Mg (mg/kg)



1.3.2.7 Extractable Na (mg/kg)



1.3.2.8 Cation exchange capacity (meq/ 100 g soil)

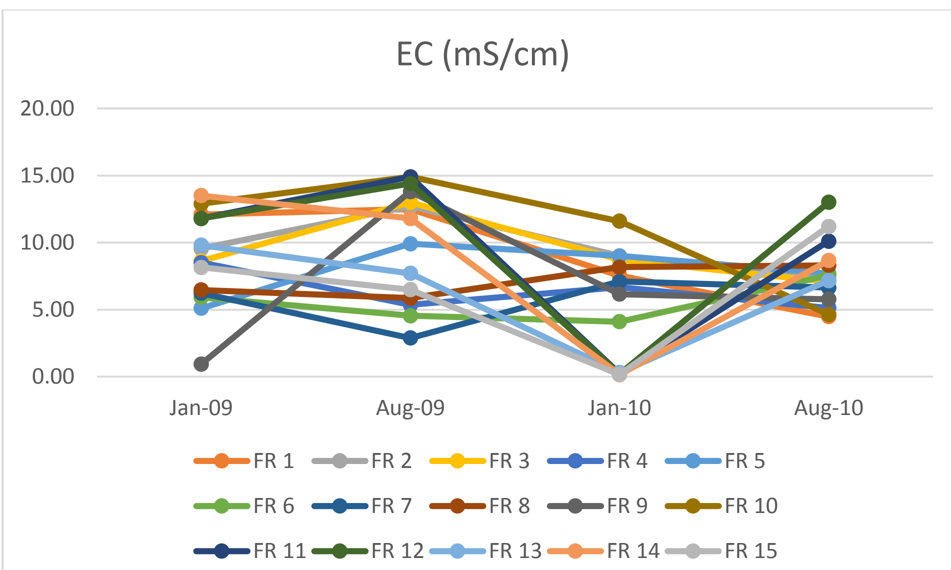


EC from these sites were highly variation while pH were not different except for the last sampling of the Ridge slope (MR10), the pH was dropped from 8.2 to 5.5 that might be due to measurement error. Extractable P, K, Ca, and Mg were significantly lower by time. For extractable Na and CEC were showed similar trend. The Na content for MR2 and MR7 were bumped up. This might be because of MR2 and MR7 were located on the open marsh which could be affected by sea water.

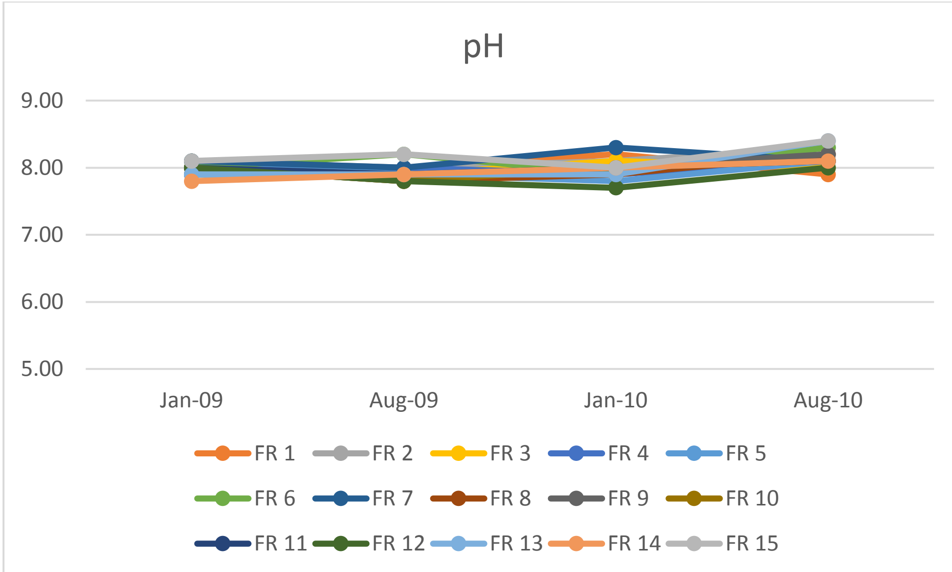
1.4 Far Ridge was formed in the fall of 2008. The samples are broken down into three landforms: Ridge Top (FR1-15), North Marsh (FRN1-5), and South Marsh (FRS1-5)

1.4.1 Ridge Top (FR1-FR15)

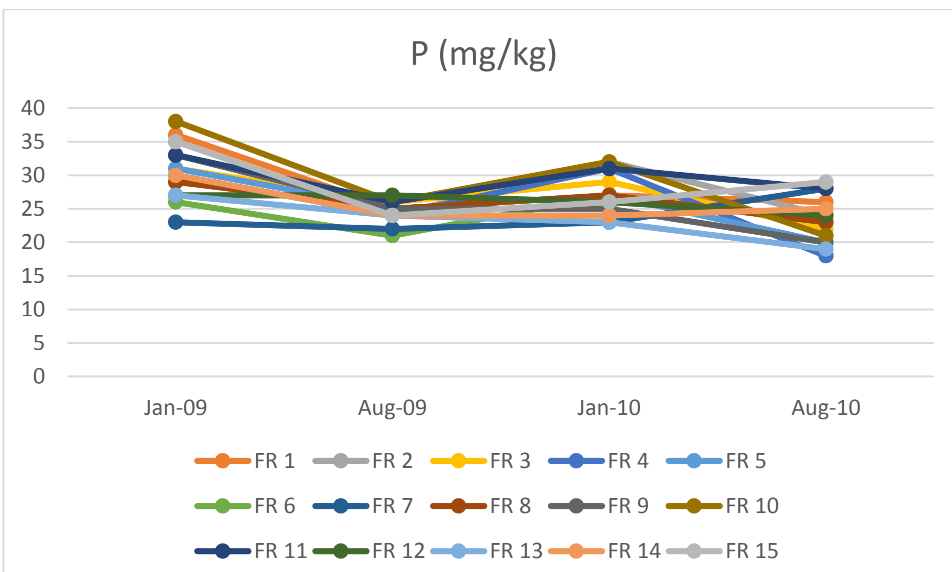
1.4.1.1 Electrical conductivity (mS/cm)



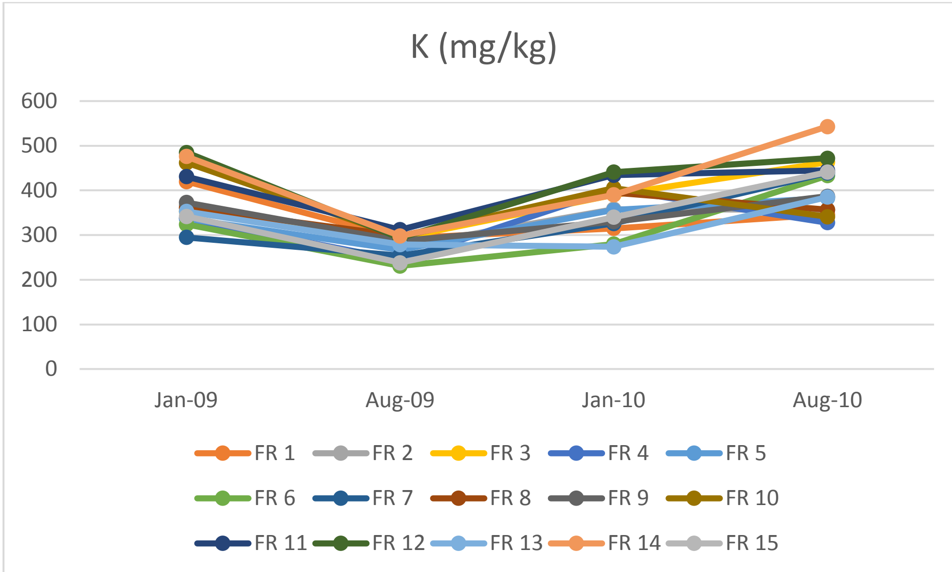
1.4.1.2 pH



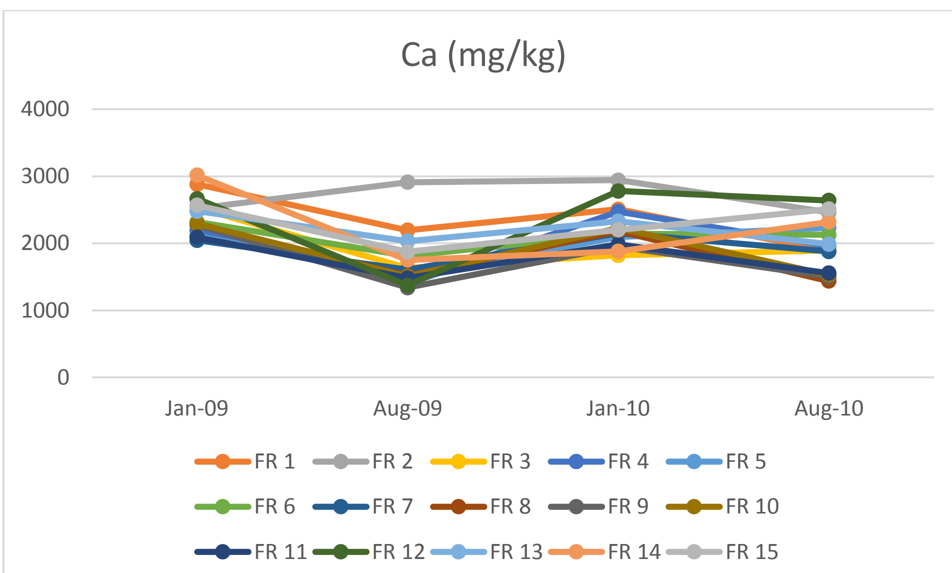
1.4.1.3 Extractable P (mg/kg)



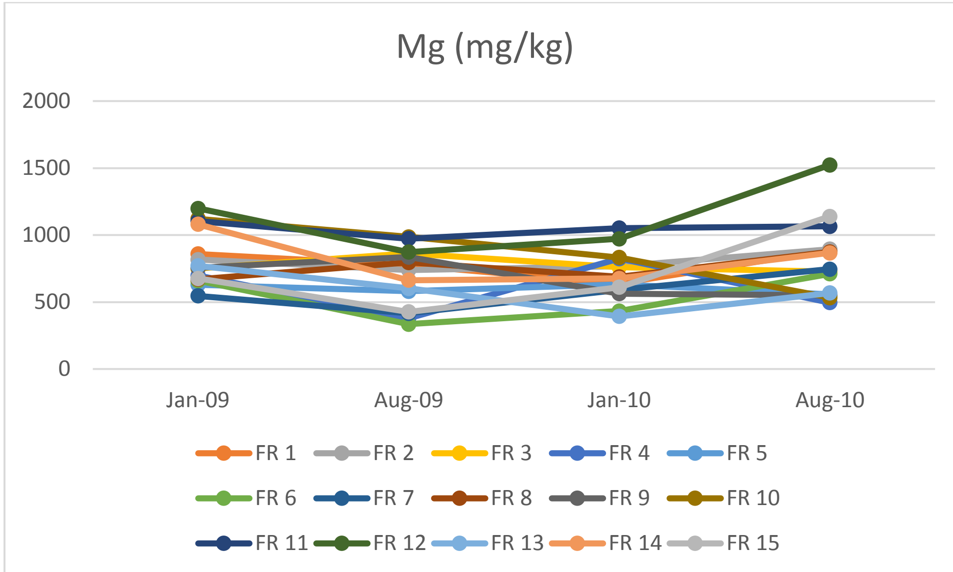
1.4.1.4 Extractable K (mg/kg)



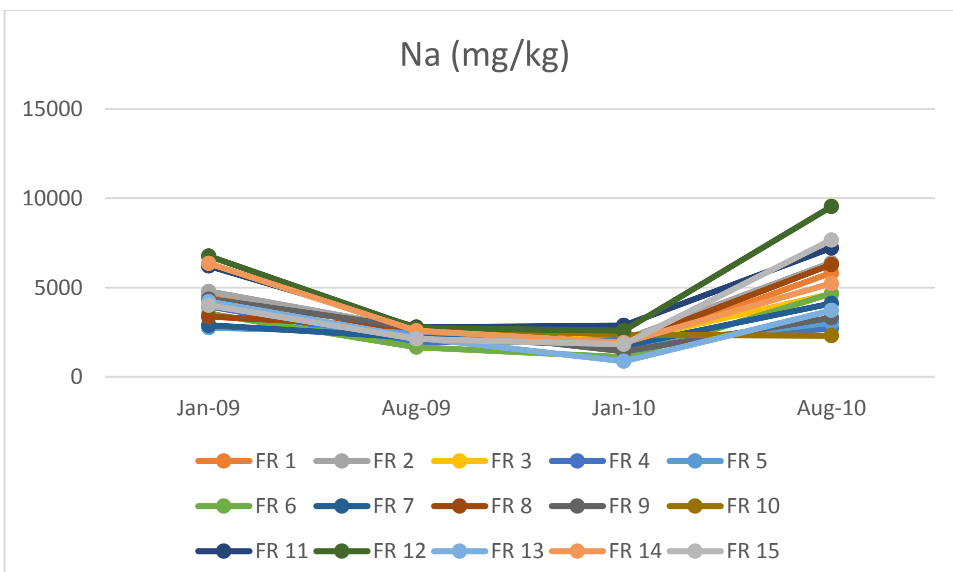
1.4.1.5 Extractable Ca (mg/kg)



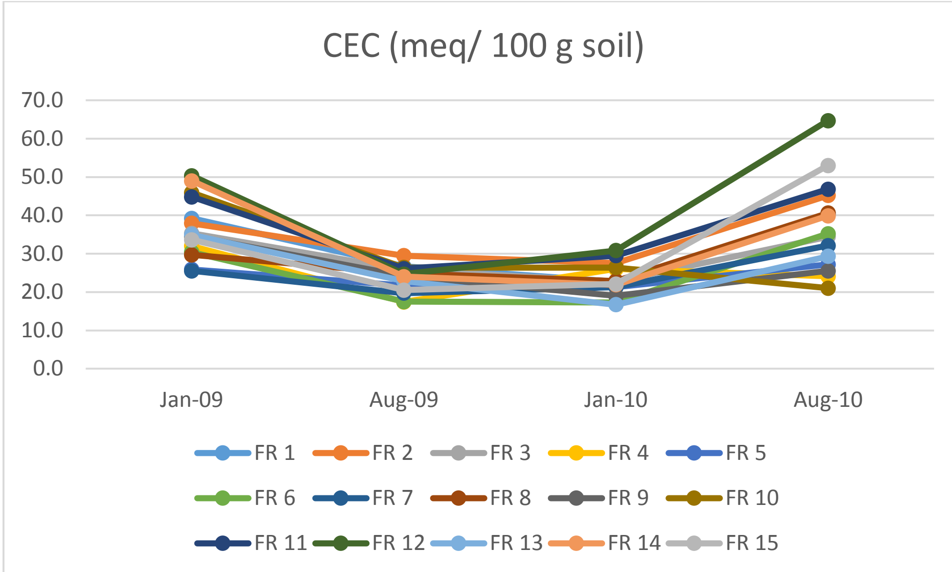
1.4.1.6 Extractable Mg (mg/kg)



1.4.1.7 Extractable Na (mg/kg)



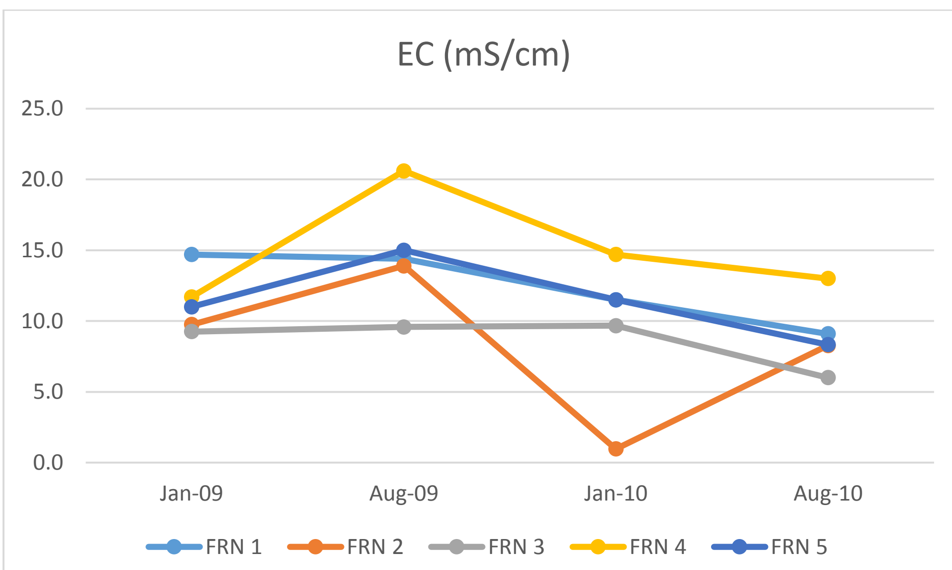
1.4.1.8 Cation exchange capacity (meq/100 g soil)



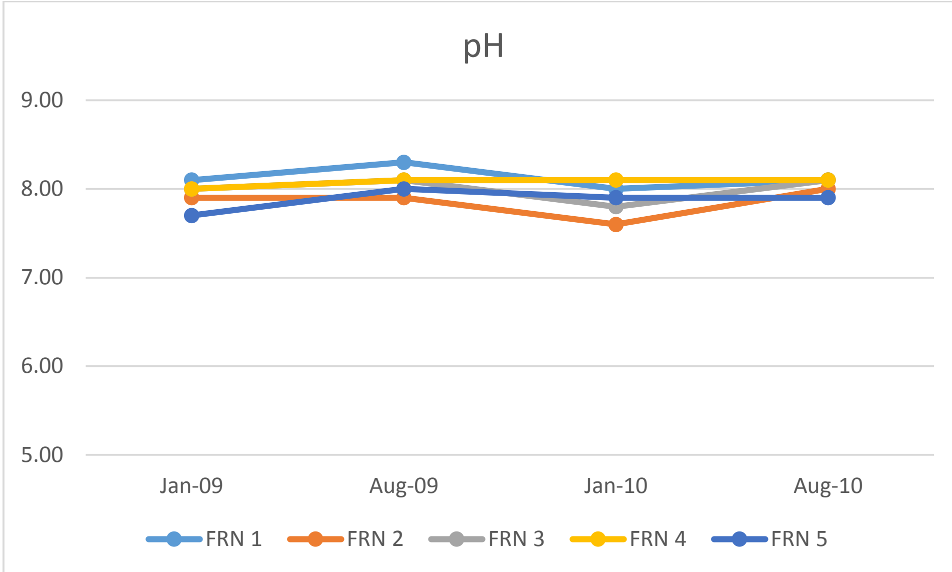
EC highly varied between the sites (0.16-14.90mS/cm). Soil pH were not different from the sites and sampling times (7.7-8.3). Extractable P, K, and Ca were not influenced by time but extractable Mg and Na varied by sites, particularly at the last sampling in August 2010.

1.4.2 Marsh on the north side (FRN1-5).

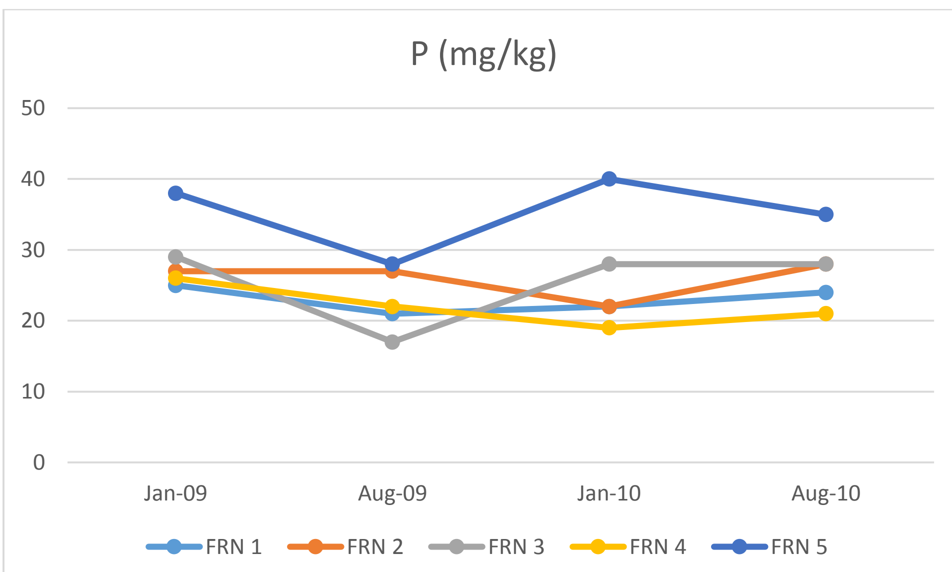
1.4.2.1 Electrical conductivity (mS/cm)



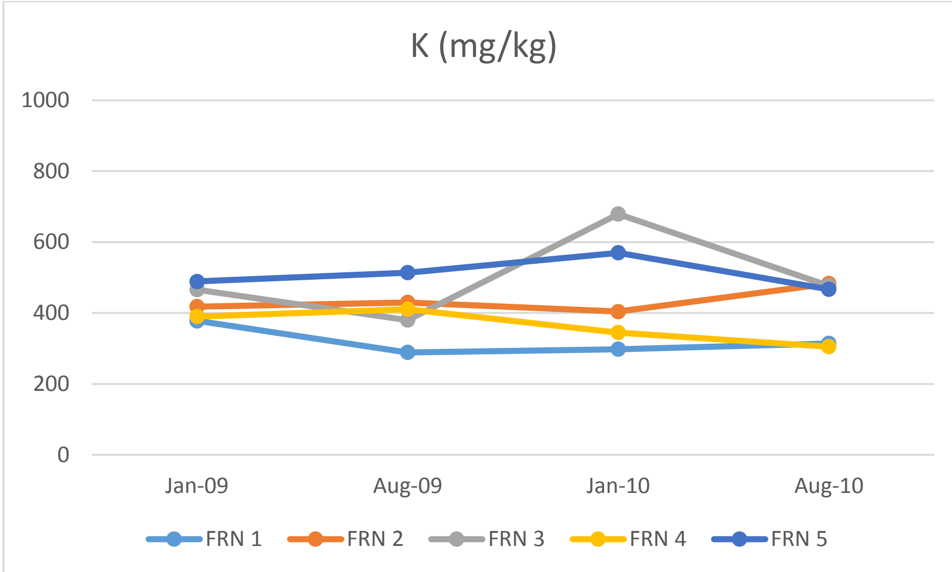
1.4.2.2 pH



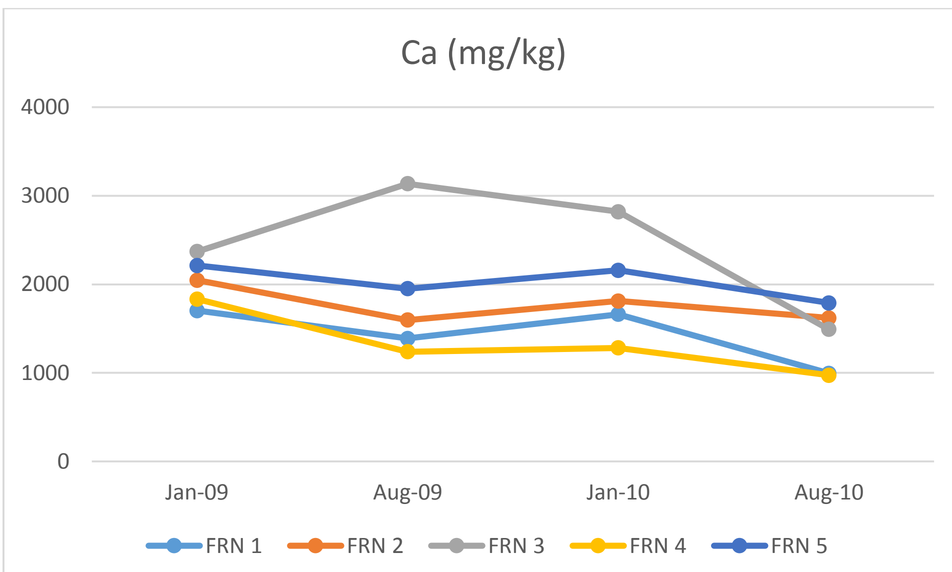
1.4.2.3 Extractable P (mg/kg)



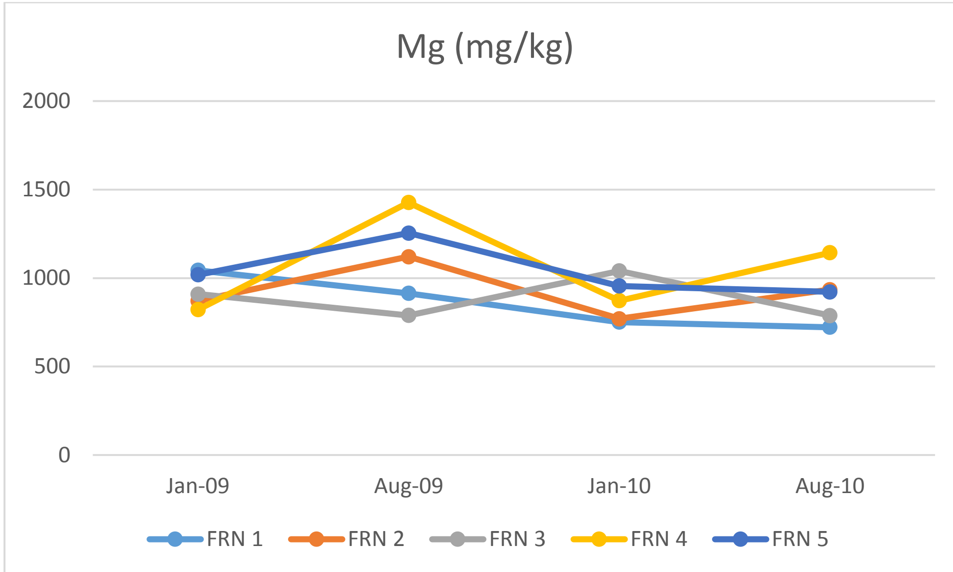
1.4.2.4 Extractable K (mg/kg)



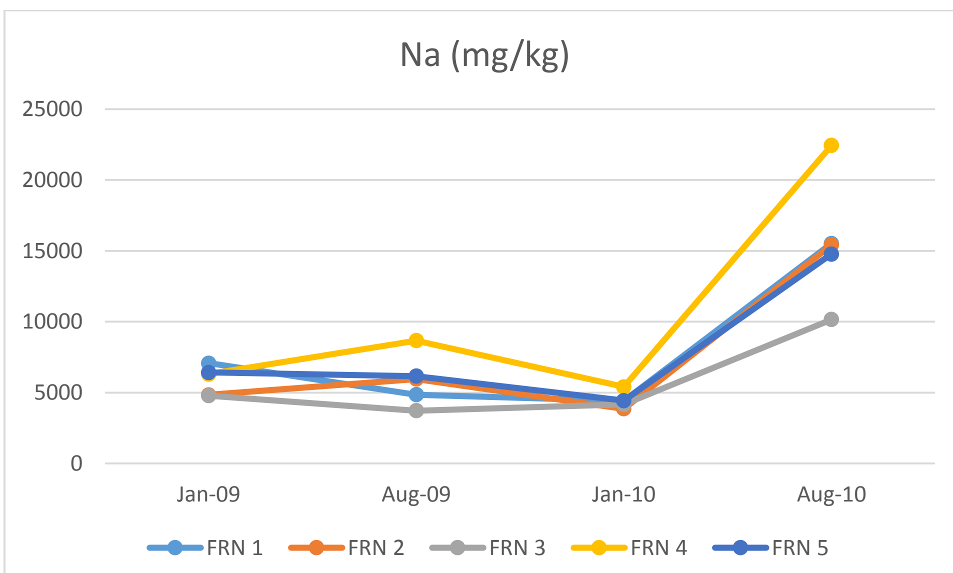
1.4.2.5 Extractable Ca (mg/kg)



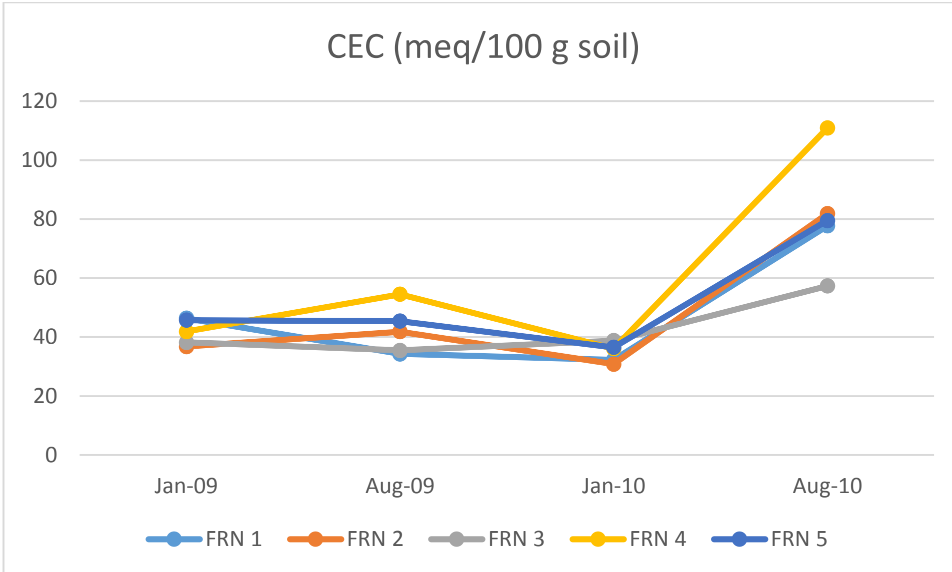
1.4.2.6 Extractable Mg (mg/kg)



1.4.2.7 Extractable Na (mg/kg)



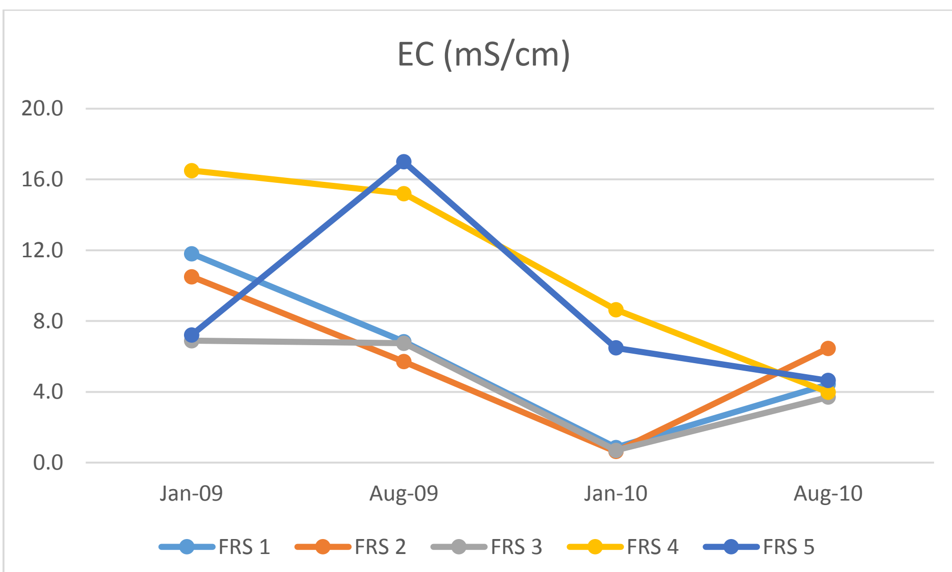
1.4.2.8 Cation exchange capacity (meq/100 g soil)



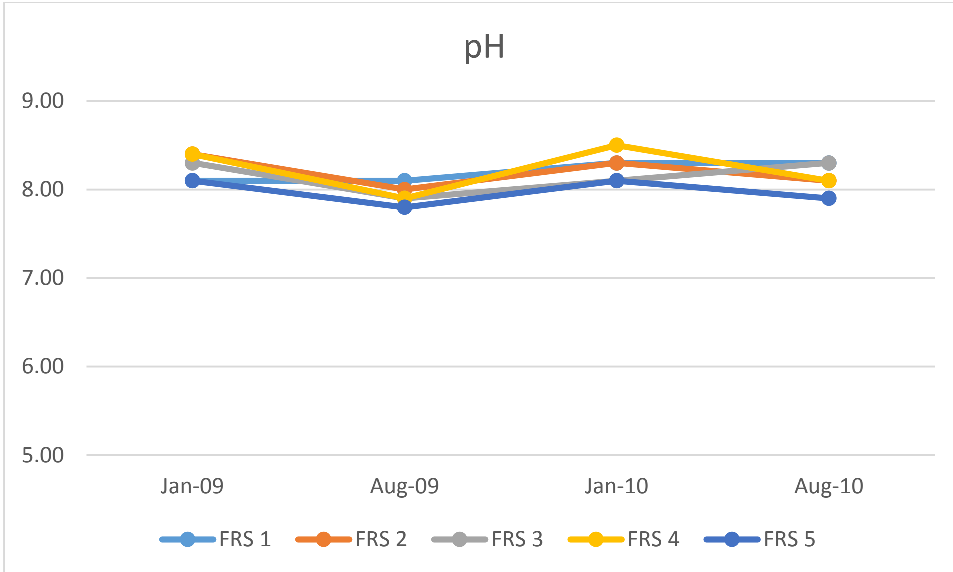
EC for this area (marsh) were higher than 4.0 mS/cm. Soil pH were below 8.5. High sodium concentration ranged from 3725 to 22440 mg/kg. These properties are common for saltmarsh environment.

1.4.3 Marsh on the south side (FRS1-5)

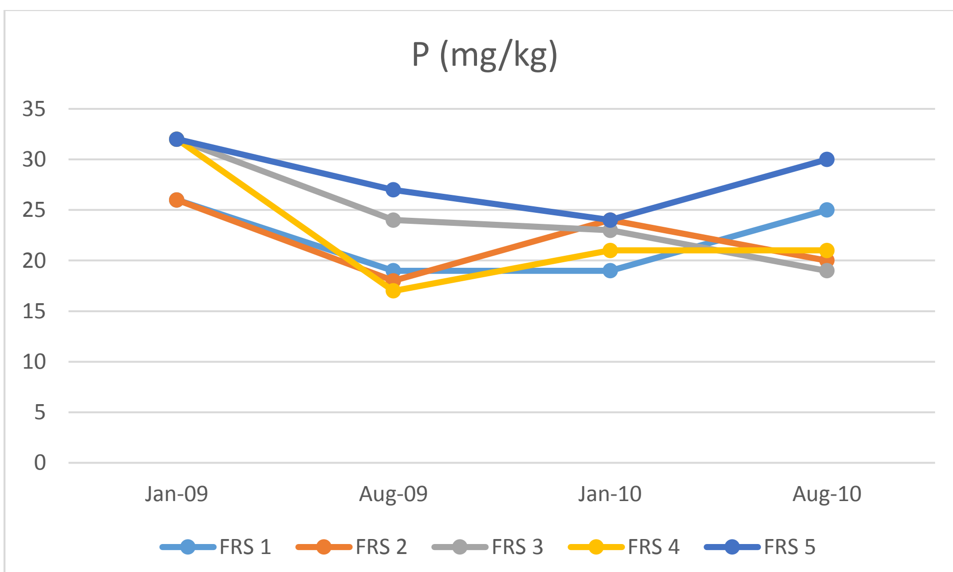
1.4.3.1 Electrical conductivity (mS/cm)



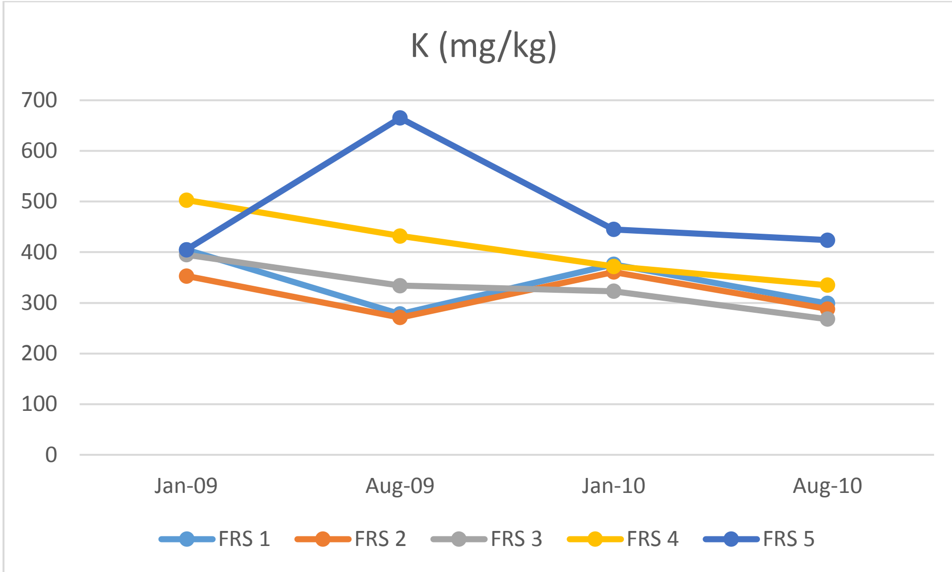
1.4.3.2 pH



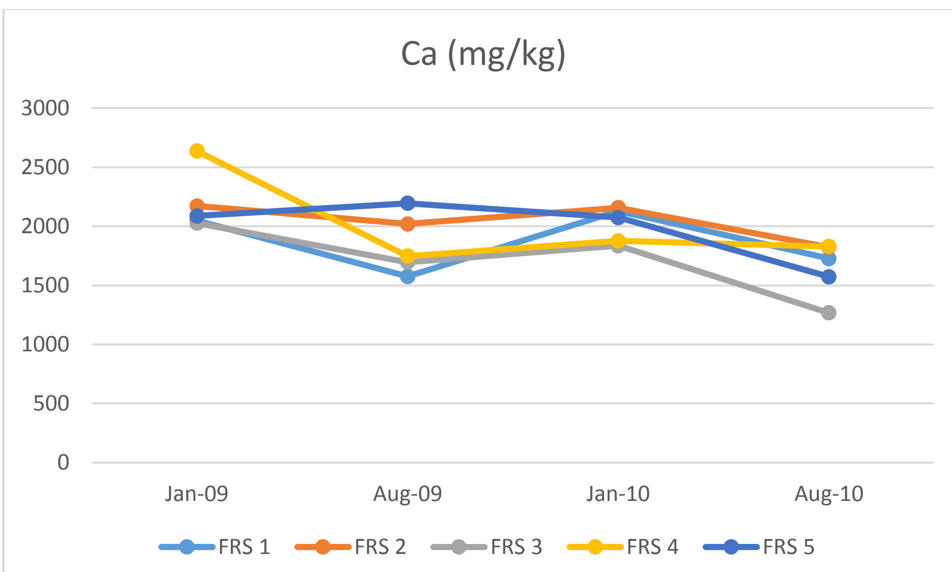
1.4.3.3 Extractable P (mg/kg)



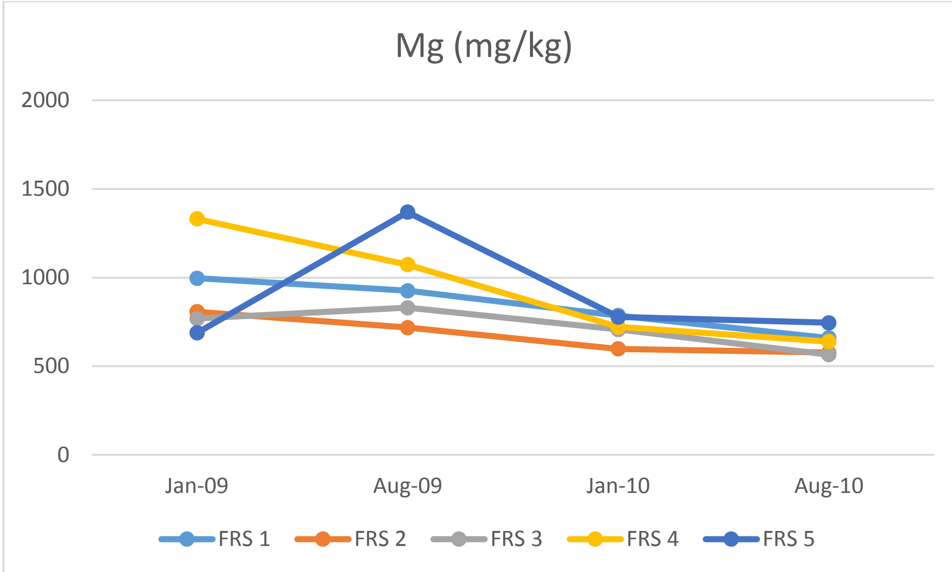
1.4.3.4 Extractable K (mg/kg)



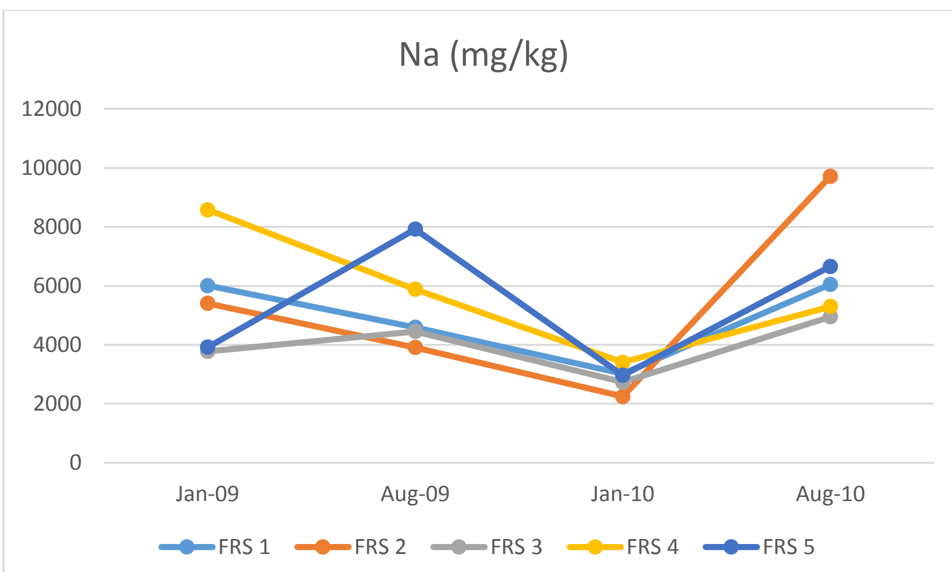
1.4.3.5 Extractable Ca (mg/kg)



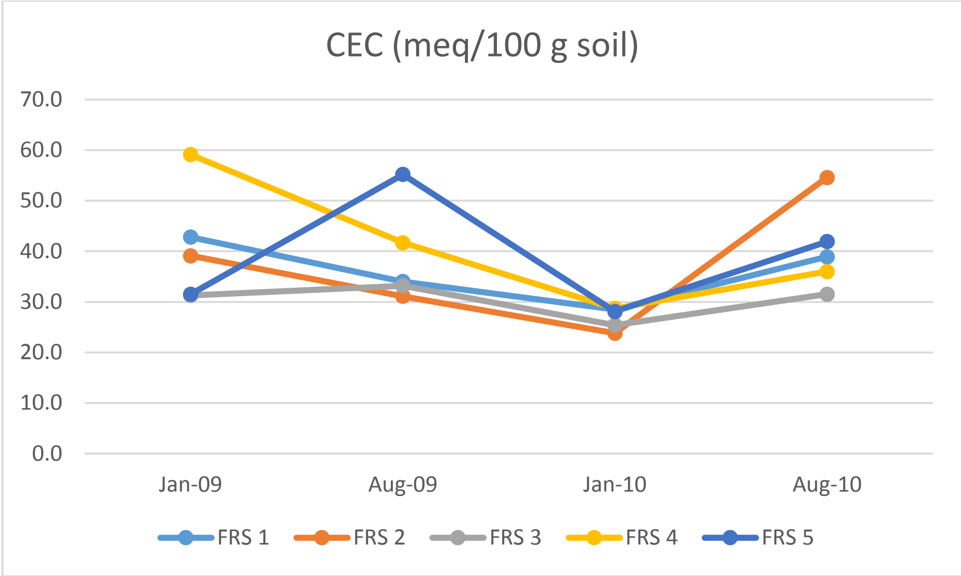
1.4.3.6 Extractable Mg (mg/kg)



1.4.3.7 Extractable Na (mg/kg)



1.4.3.8 Cation exchange capacity (meq/100 g soil)



EC for this area (marsh) were higher than 4.0 mS/cm. Soil pH were below 8.5. High sodium concentration ranged from 3725 to 22440 mg/kg. The high EC and Na concentrations are common for saltmarsh environment.

2 Soil test results from Soil Testing Laboratory, Louisiana State University Agricultural Center (1:2 water extraction method)

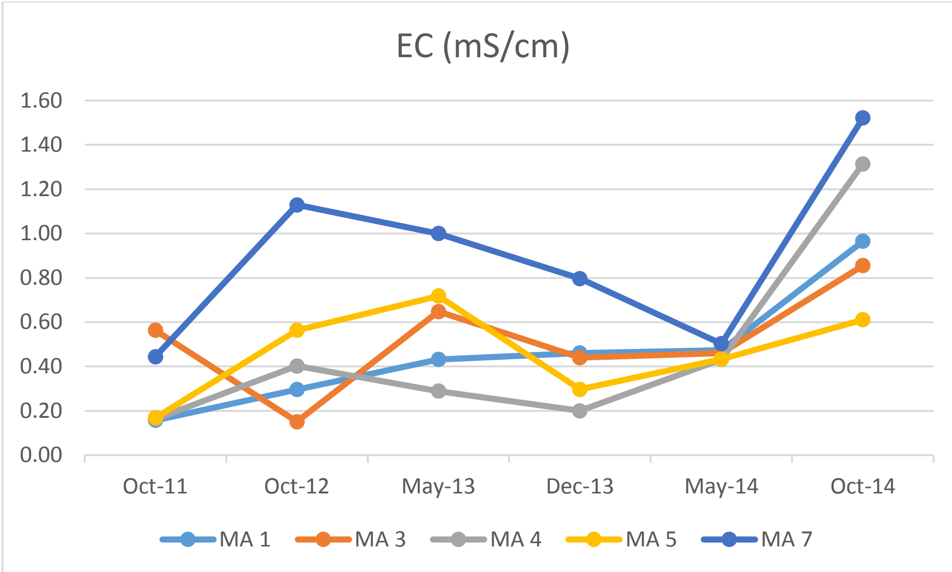
The samples were collected at 6 different times from 2011-2014: October 2011, October 2012, May 2013, December 2013, May 2014, and October 2014. The analysis package included electrical conductivity (EC), salinity, pH, soluble salts, cation exchange capacity, sodium absorption ratio (SAR), macro and micronutrients (P, K, Ca, Mg, Na, S, Cl, Fe, and Mn). In addition, SAR and CEC were calculated from sum of cations. The full test results are summarized by the sampling dates in Table 8 - Table 13. Besides summary tables, graphs that related to salinity and other important cations are showed below by the locations.

2.1 Mitigation Area (MA1-MA10). Ten samples were collected from this area. The site is a created marsh initially pumped with sediment in 2001. The samples were collected from 3 landforms: Low ridge (MA1, MA3, MA4, MA5, and MA7); Low Ridge Slope (MA2, MA6, andMA8); and Marsh (MA9 and MA10). All salinity factors i.e. electrical conductivity, soluble salt, sodium content, and SAR were higher in the marsh area as compared to the ridge area. This was likely associated with the influence of tidal water which floods the marsh. Figures below show details for each variable from different sampling times.

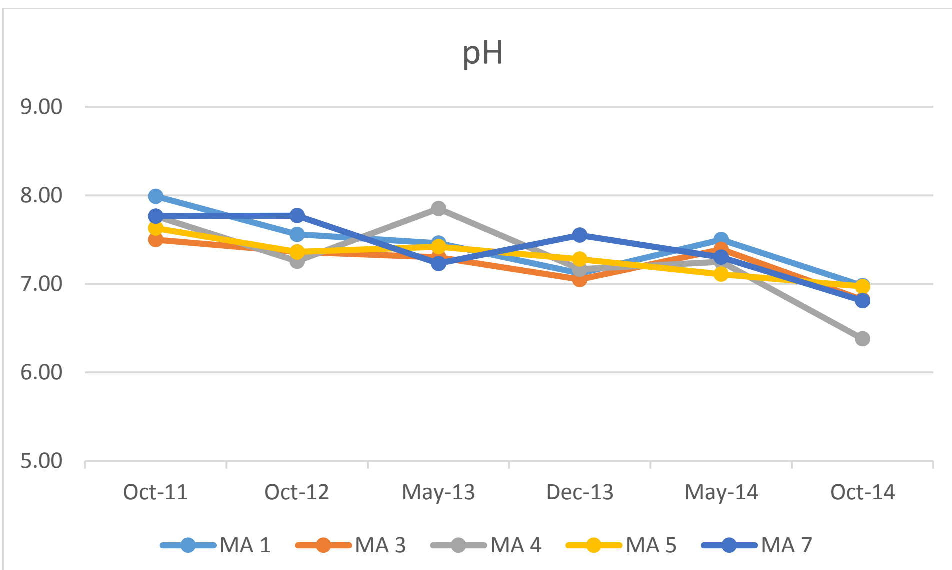
Test results showed that marsh sites (MA9 and MA10) have significantly greater salinity-related factors than the others, which is common for a saltmarsh. However, the variation of these factors from sampling times are the result of the influence of seasonal tidal water.

2.1.1 Low Ridge (MA1, MA3, MA4, MA5, and MA7)

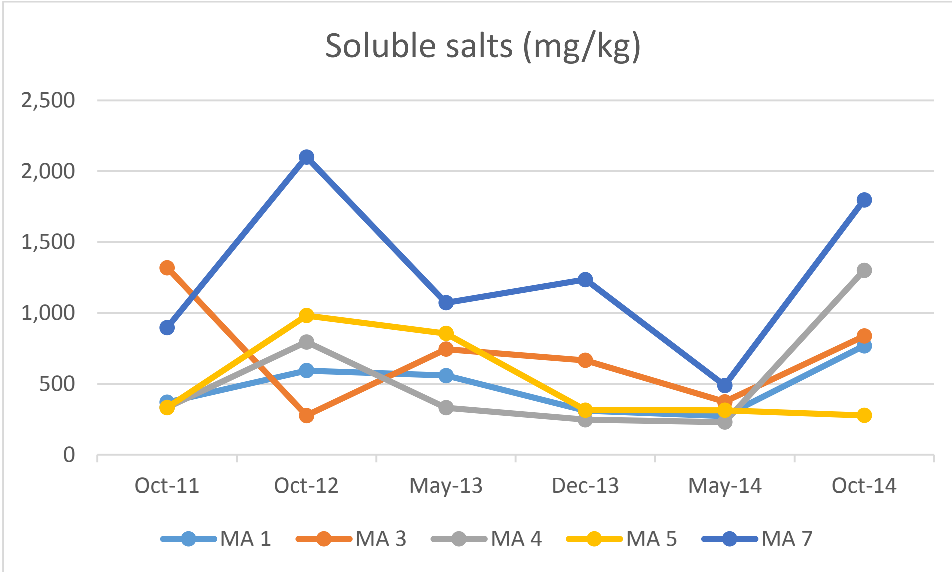
2.1.1.1 Electrical conductivity (mS/cm)



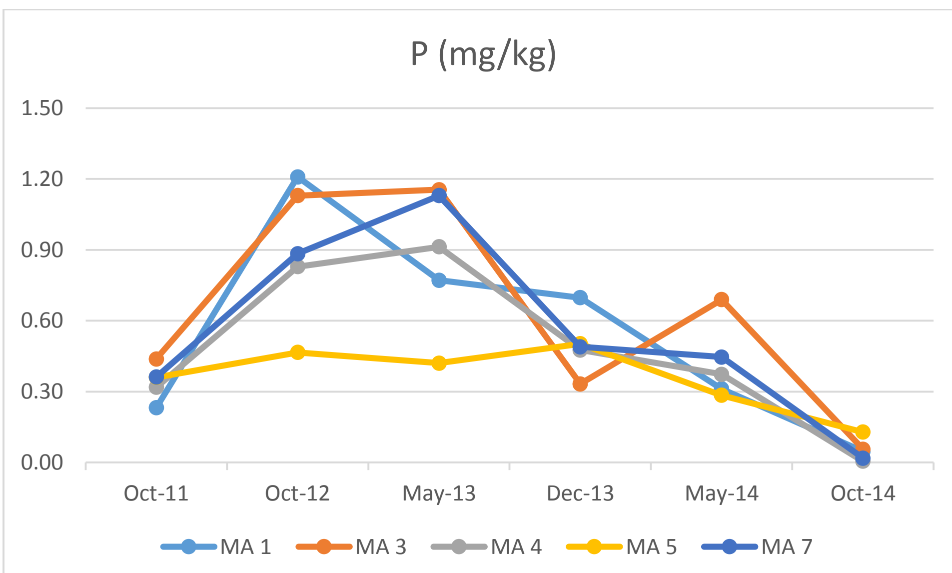
2.1.1.2 pH



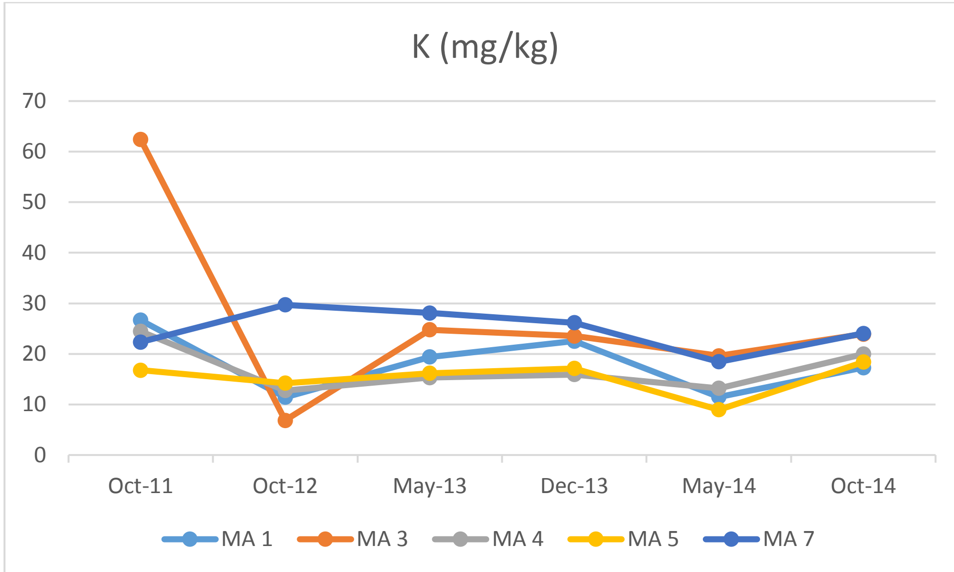
2.1.1.3 Soluble salts (mg/kg)



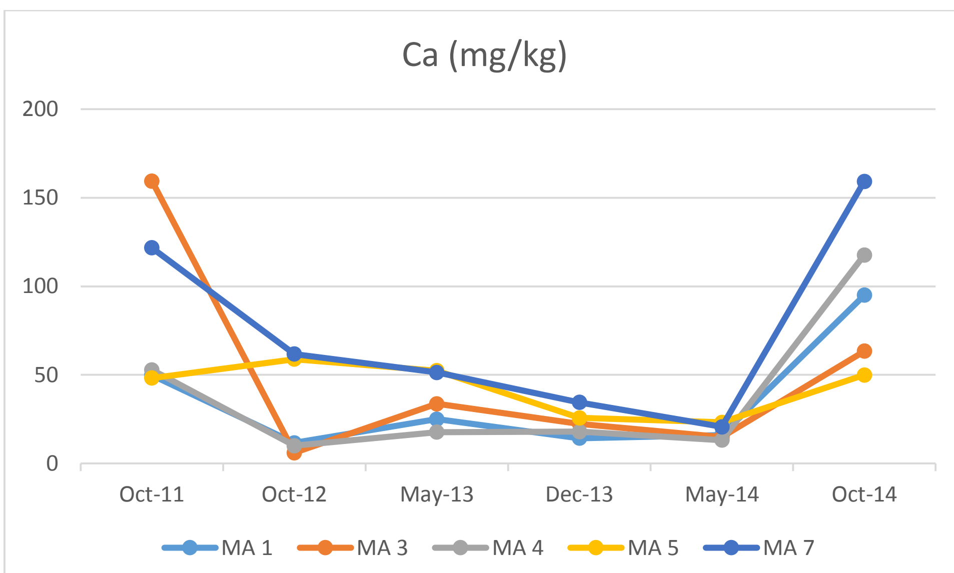
2.1.1.4 Soluble P (mg/kg)



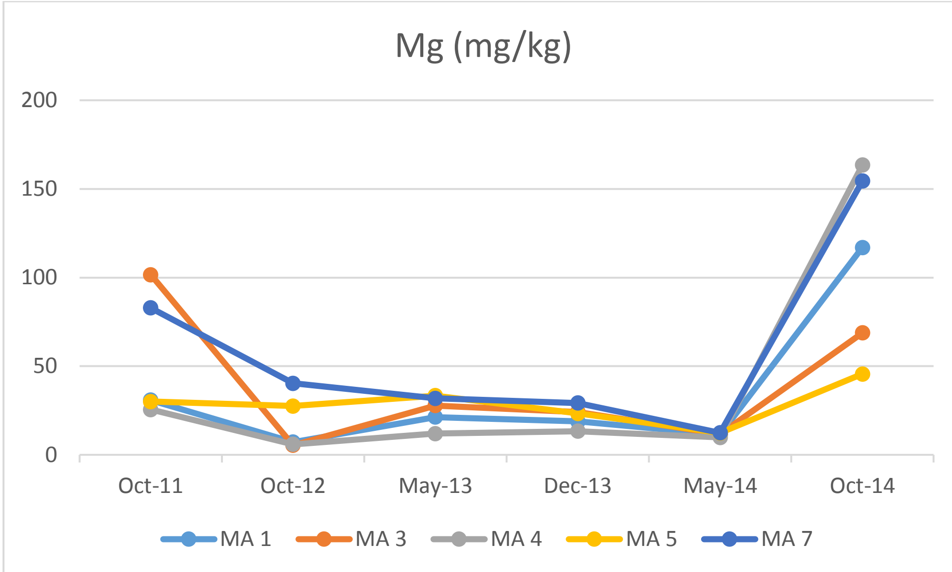
2.1.1.5 Soluble K (mg/kg)



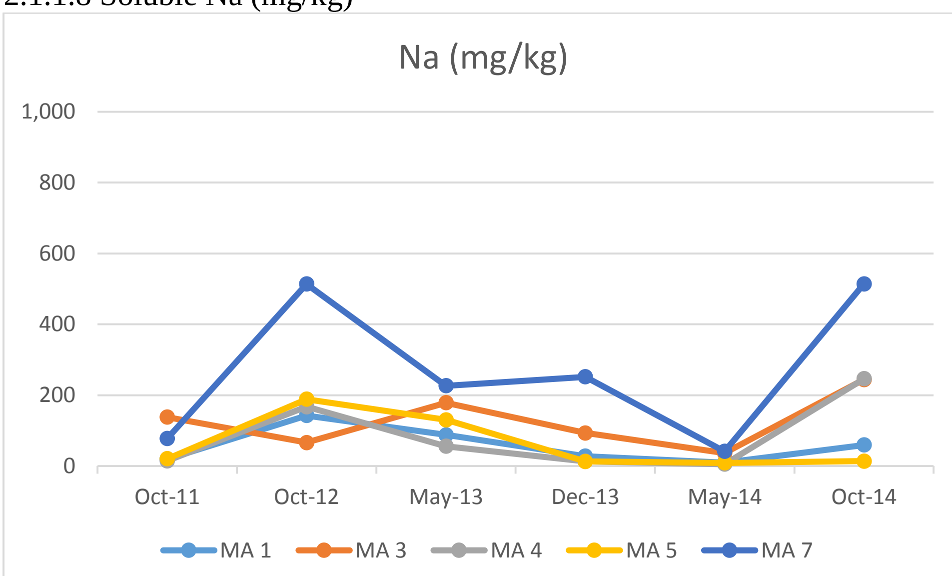
2.1.1.6 Soluble Ca (mg/kg)



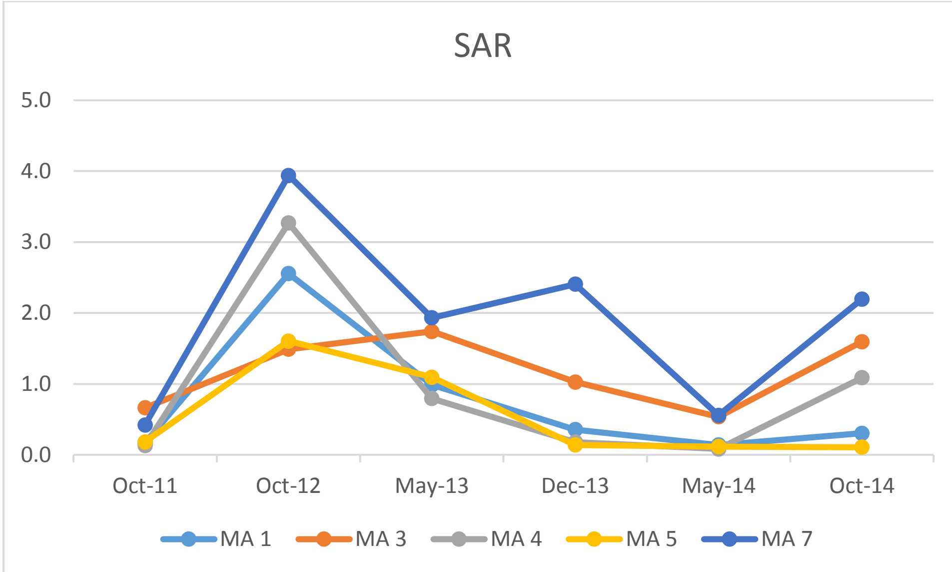
2.1.1.7 Soluble Mg (mg/kg)



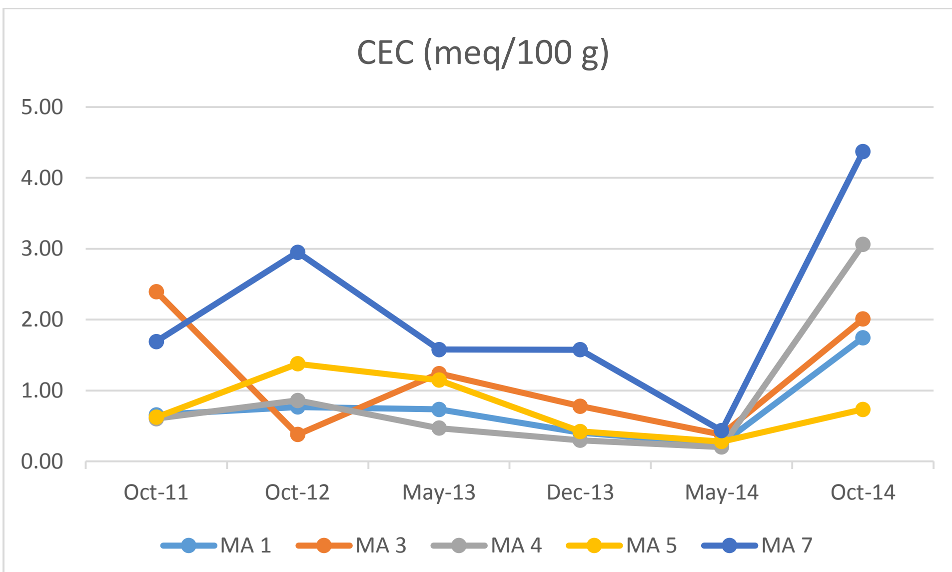
2.1.1.8 Soluble Na (mg/kg)



2.1.1.9 Sodium absorption ratio



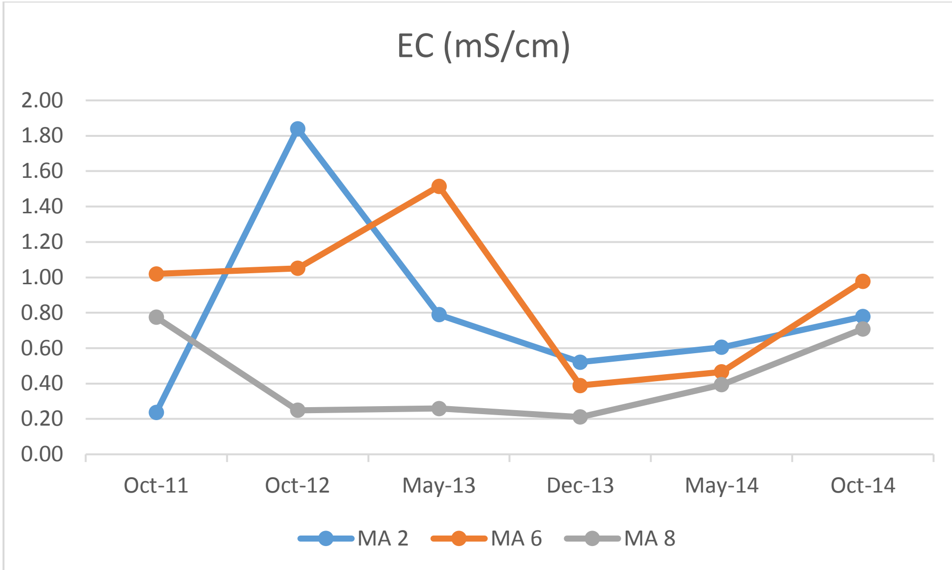
2.1.1.10 Cation exchange capacity (meq/100g soil)



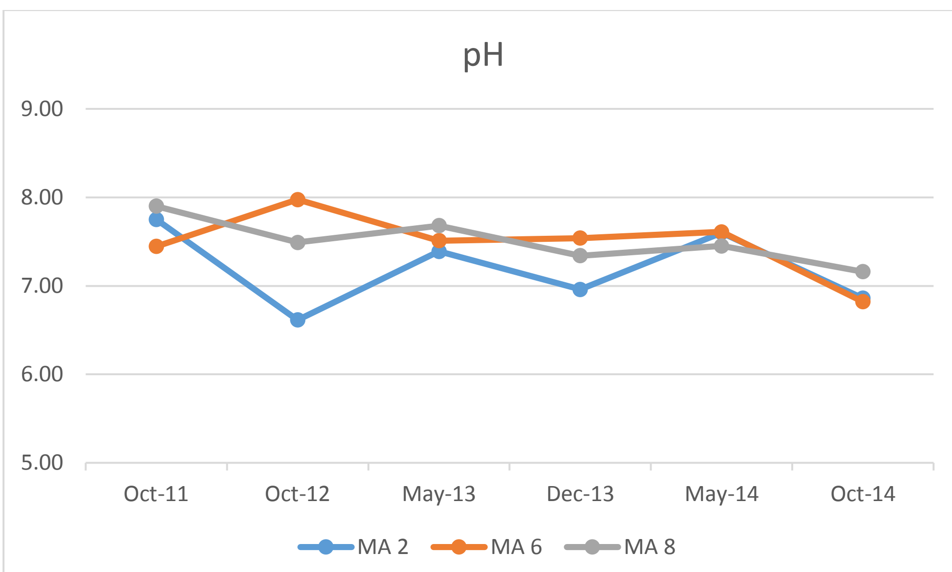
Electrical conductivity of all sites for this area were below 4.0 mS/cm. Soil pH were below 8.0 and sodium absorption ratio were below 13. The results indicated that these soil did not meet any categories for saline, sodic or saline-sodic soil. However, soluble sodium were still high for non-halophytic species. In addition, soil nutrients concertation such as P were also low. To increase productivity, fertilization for the plants in these sites would be a good practice.

2.1.2 Low Ridge Slope (MA2, MA6, and MA8).

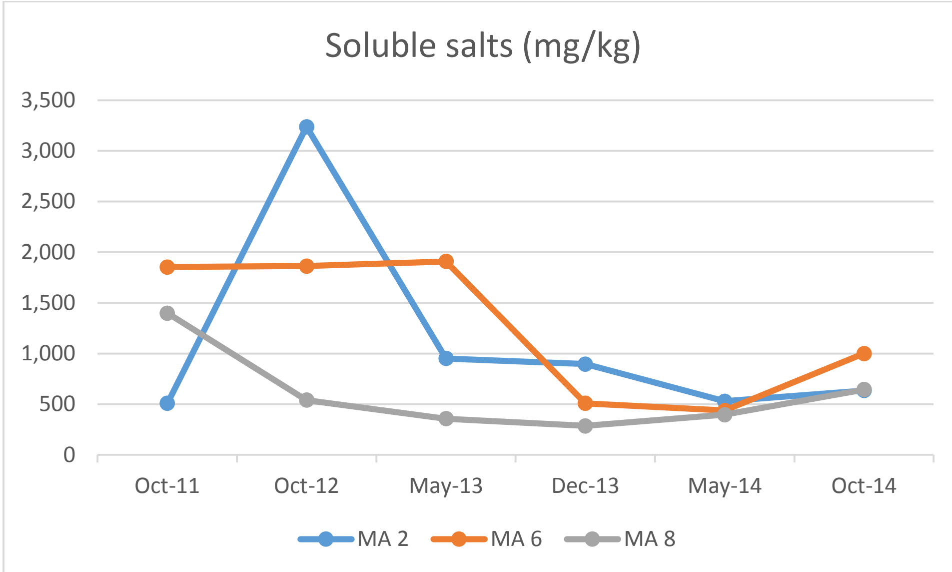
2.1.2.1 Electrical conductivity (mS/cm)



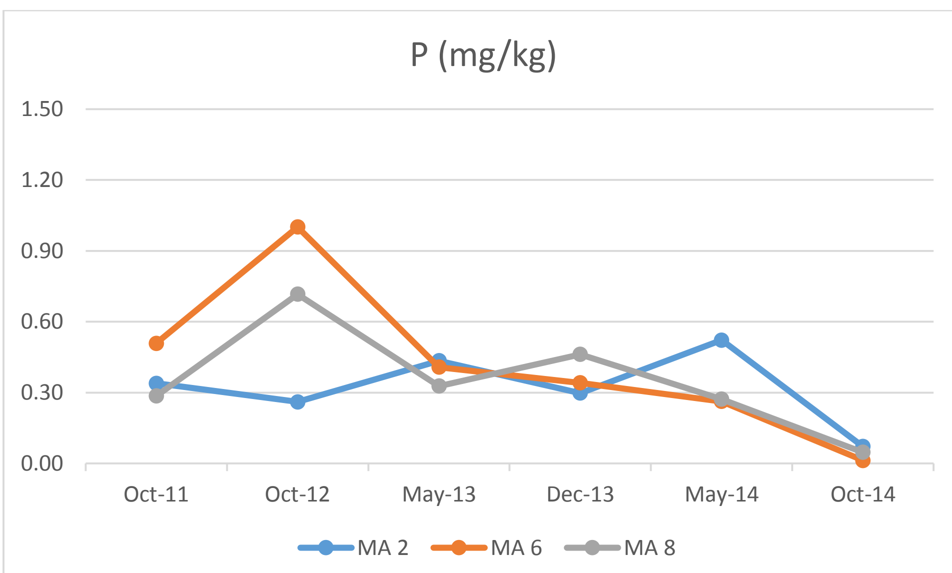
2.1.2.2 pH



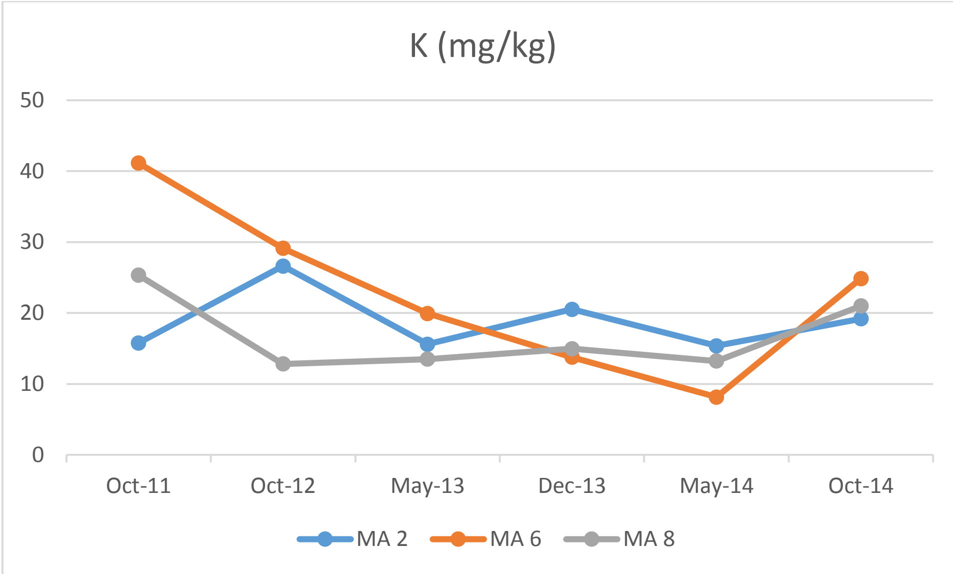
2.1.2.3 Soluble salts (mg/kg)



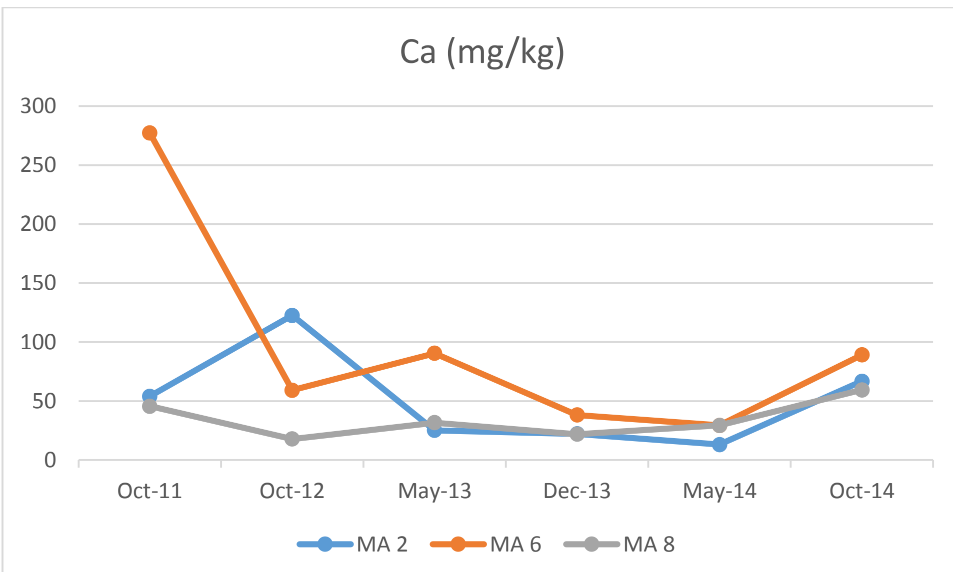
2.1.2.4 Soluble P (mg/kg)



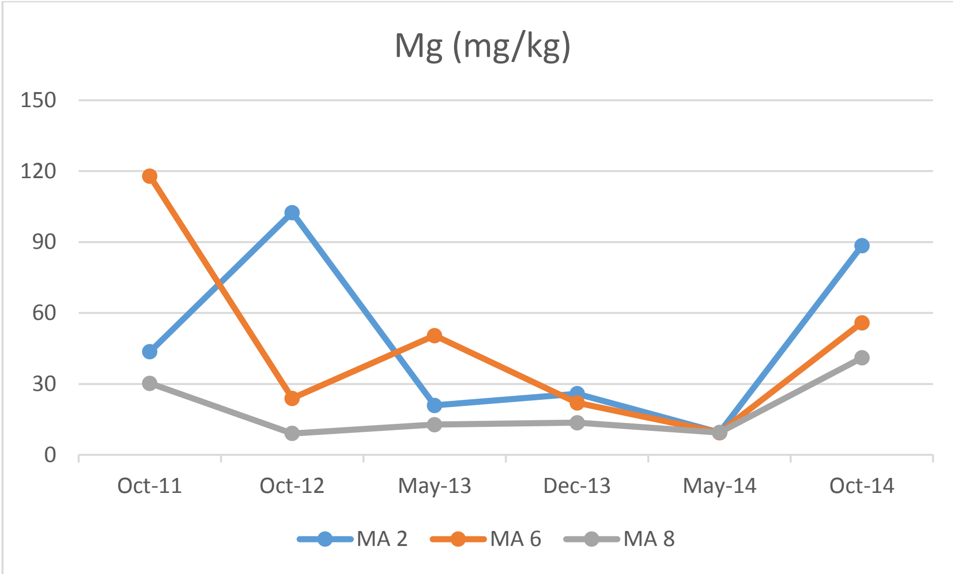
2.1.2.5 Soluble K (mg/kg)



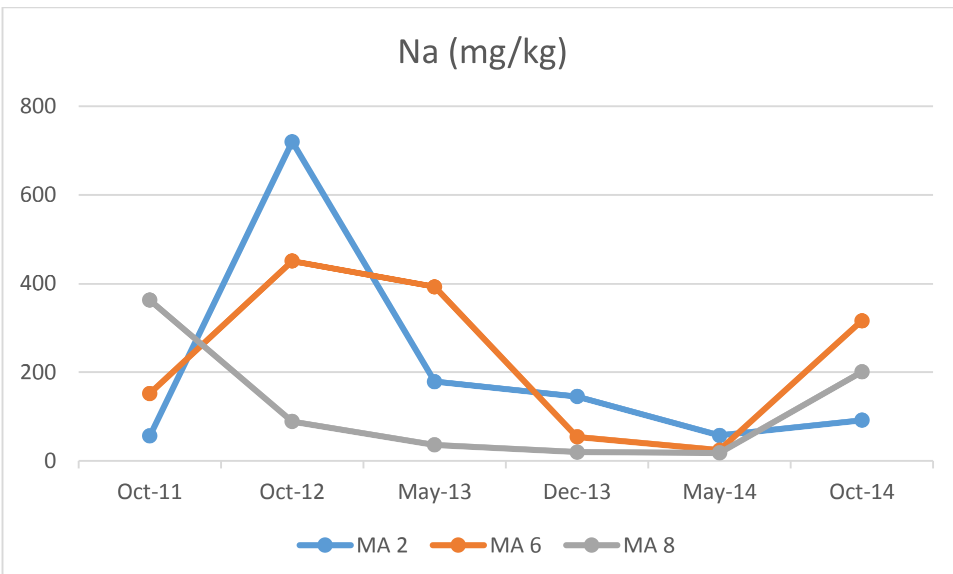
2.1.2.6 Soluble Ca (mg/kg)



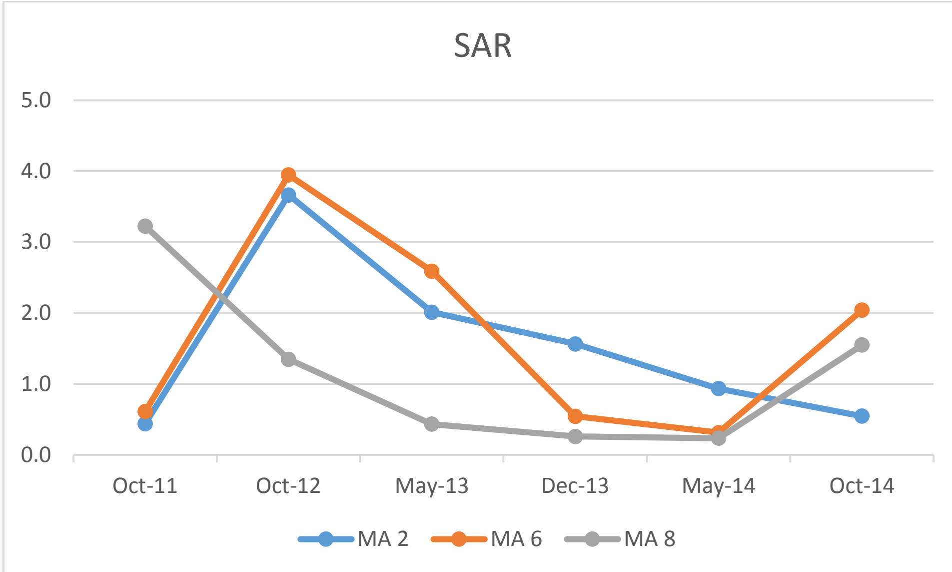
2.1.2.7 Soluble Mg (mg/kg)



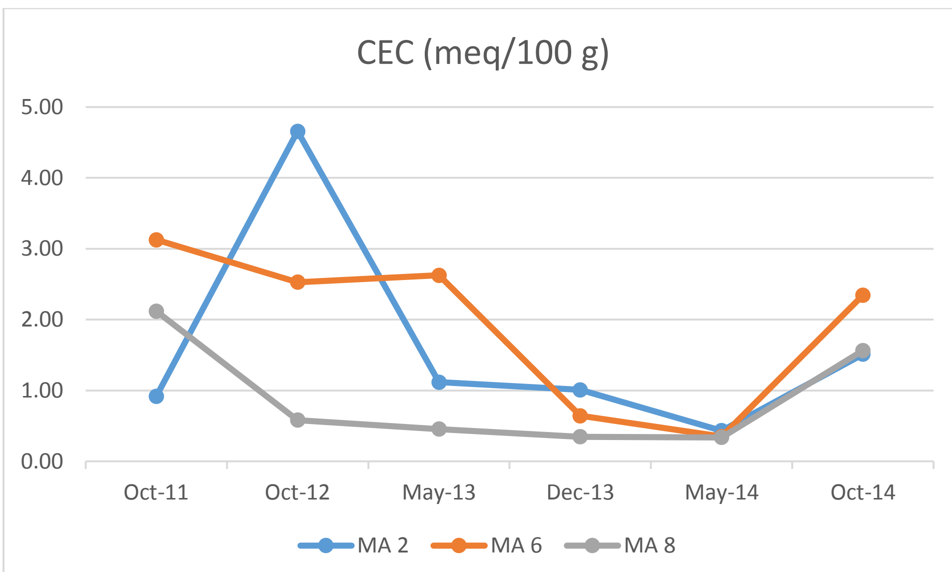
2.1.2.8 Soluble Na (mg/kg)



2.1.2.9 Sodium absorption ratio



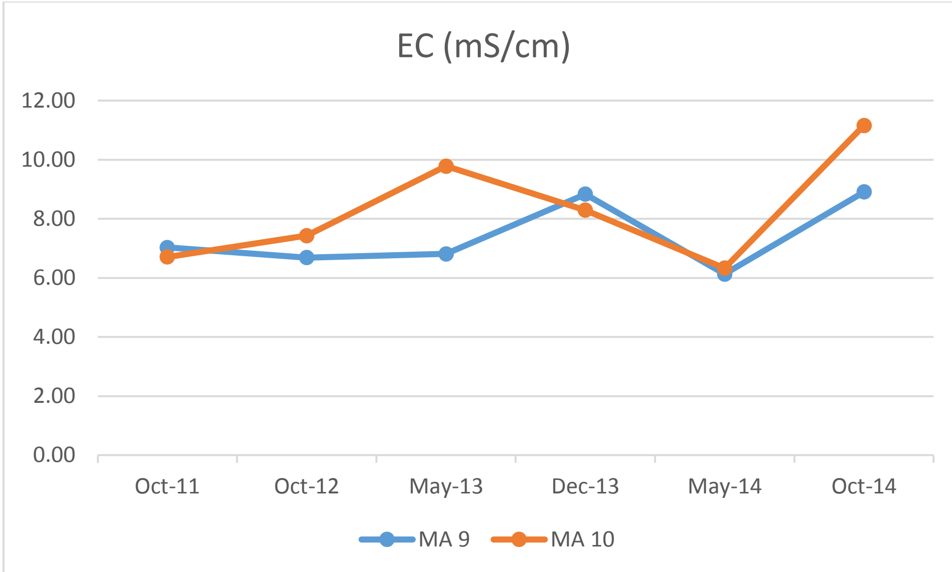
2.1.2.10 Cation exchange capacity



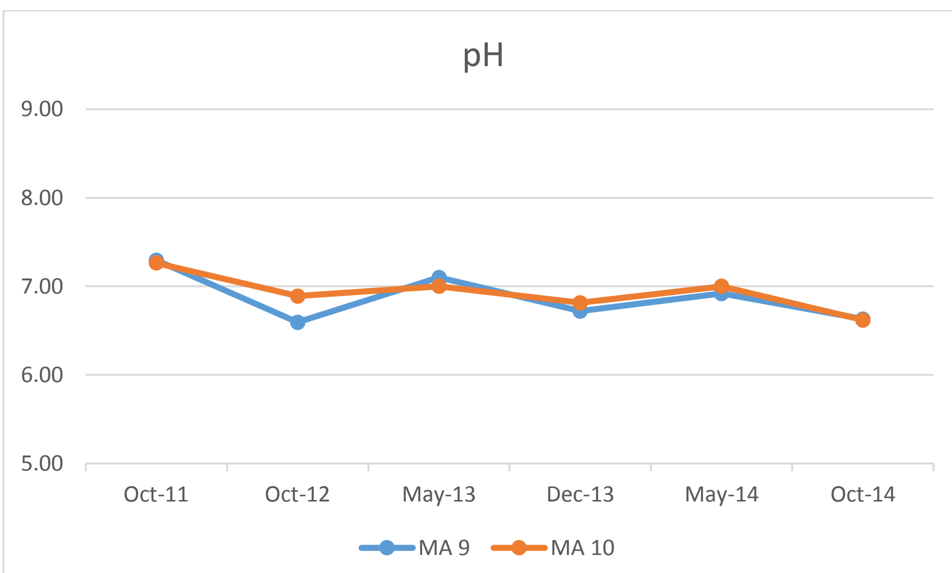
Soil test results from the Low Ridge slope were similar to the Low Ridge area. Electrical conductivity, soil pH, and sodium absorption ratio did not meet any categories for saline, sodic or saline-sodic soil. However, soil nutrients concertation such as P and K might be slightly low for some plant species.

2.1.3 Marsh (MA9 and MA10)

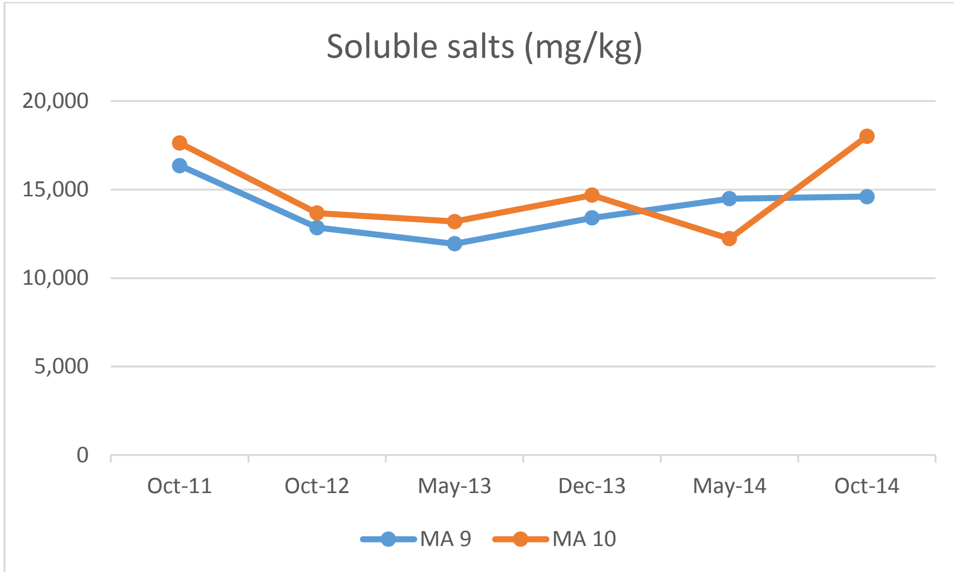
2.1.3.1 Electrical conductivity (mS/cm)



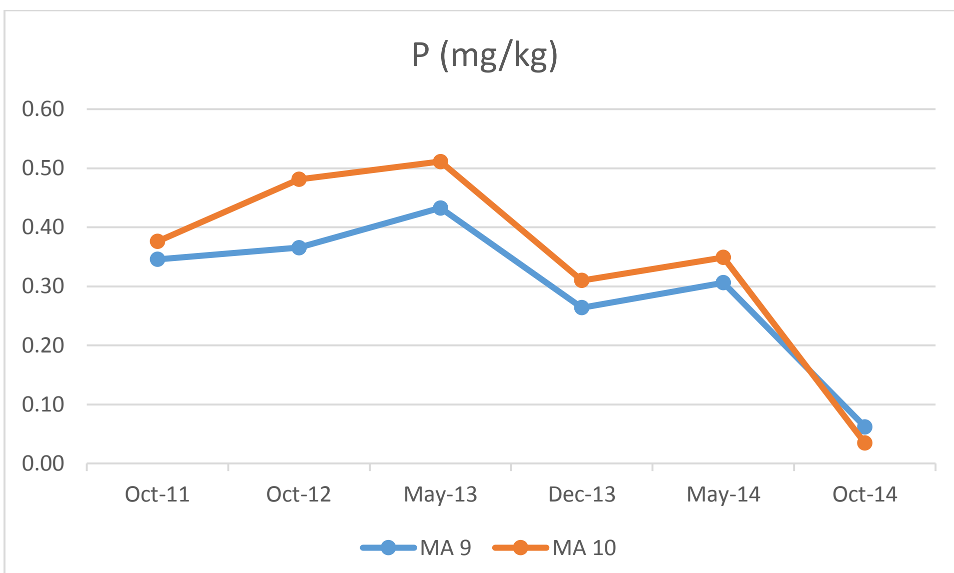
2.1.3.2 pH



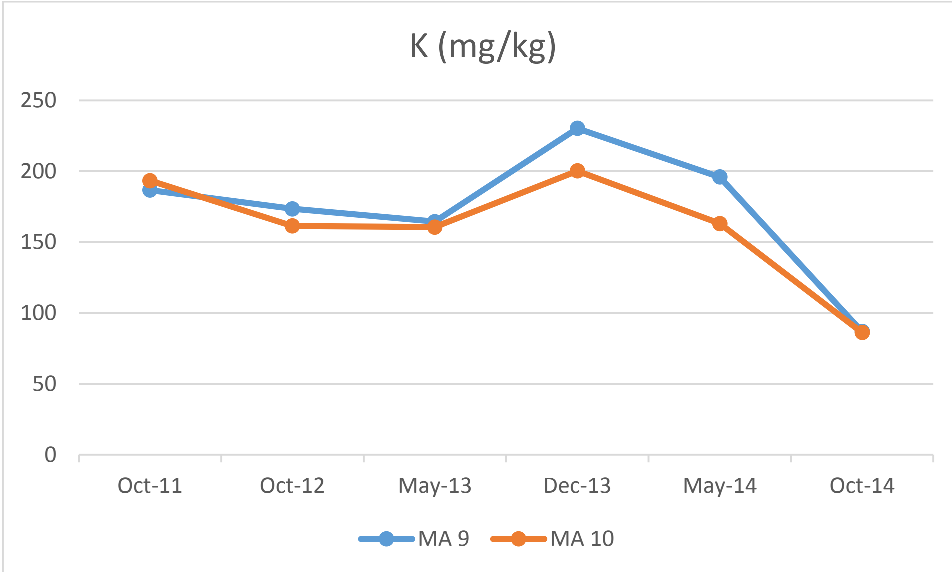
2.1.3.3 Soluble salts (mg/kg)



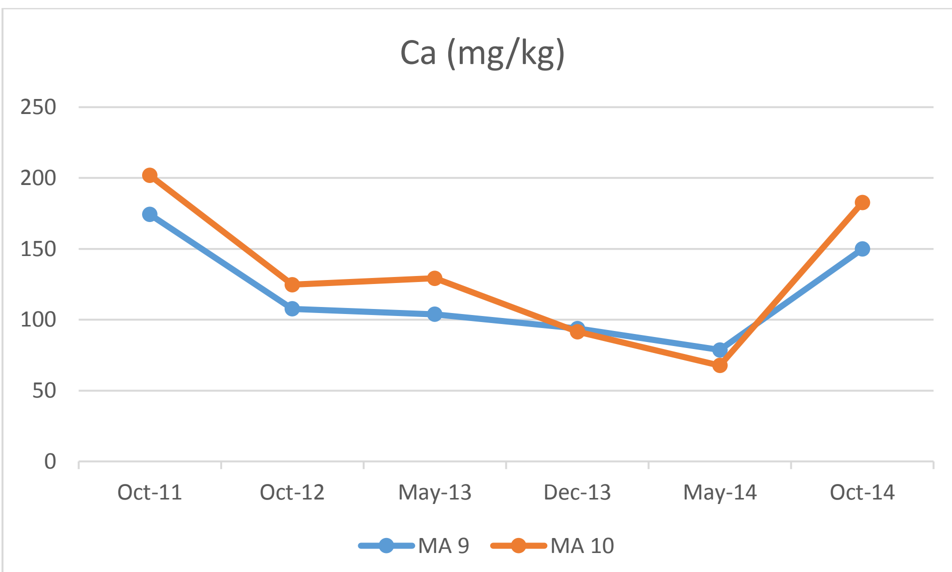
2.1.3.4 Soluble P (mg/kg)



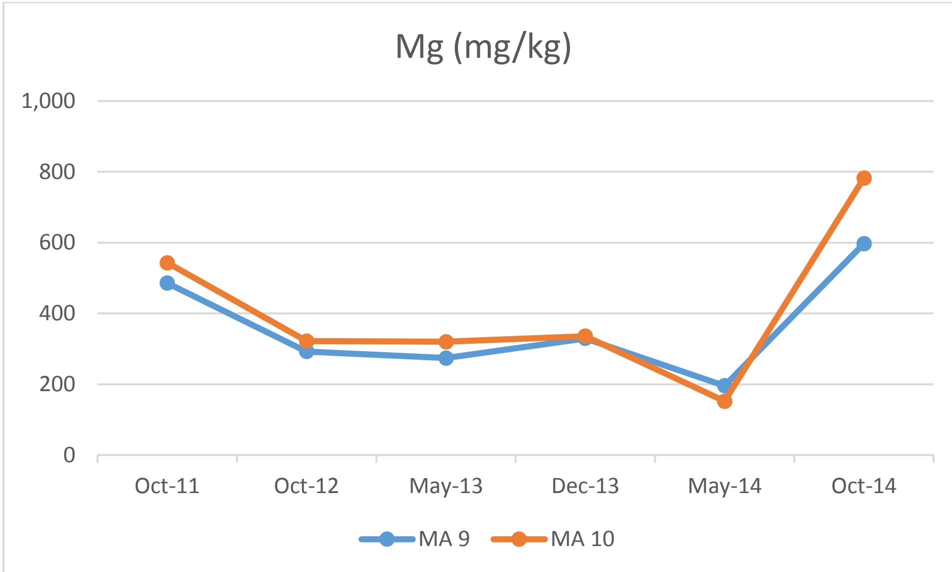
2.1.3.5 Soluble K (mg/kg)



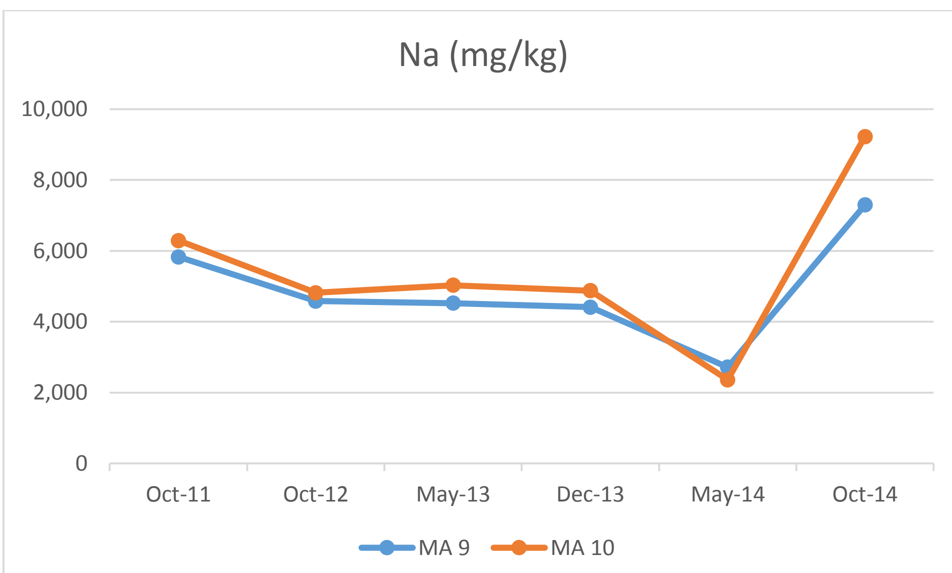
2.1.3.6 Soluble Ca (mg/kg)



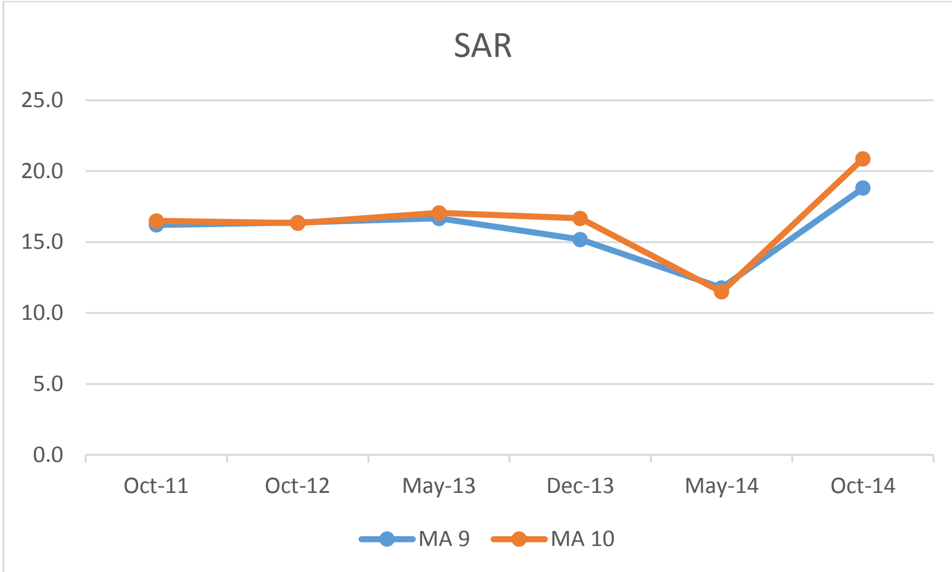
2.1.3.7 Soluble Mg (mg/kg)



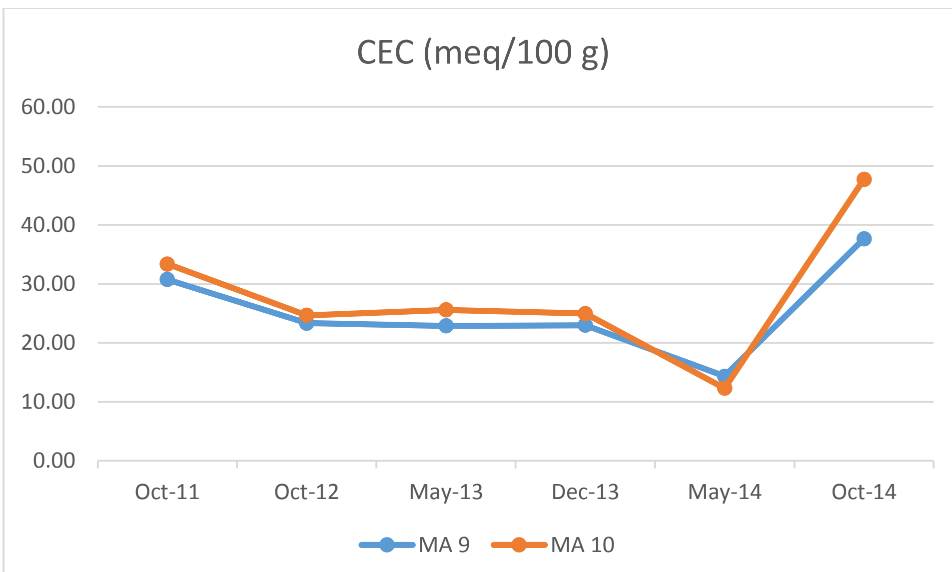
2.1.3.8 Soluble Na (mg/kg)



2.1.3.9 Sodium absorption ratio



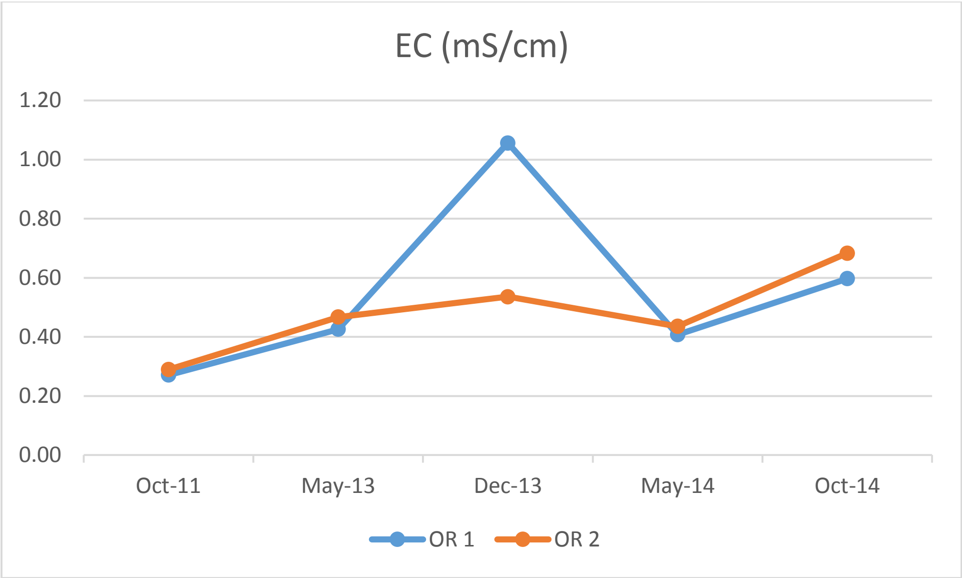
2.1.3.10 Cation exchange capacity



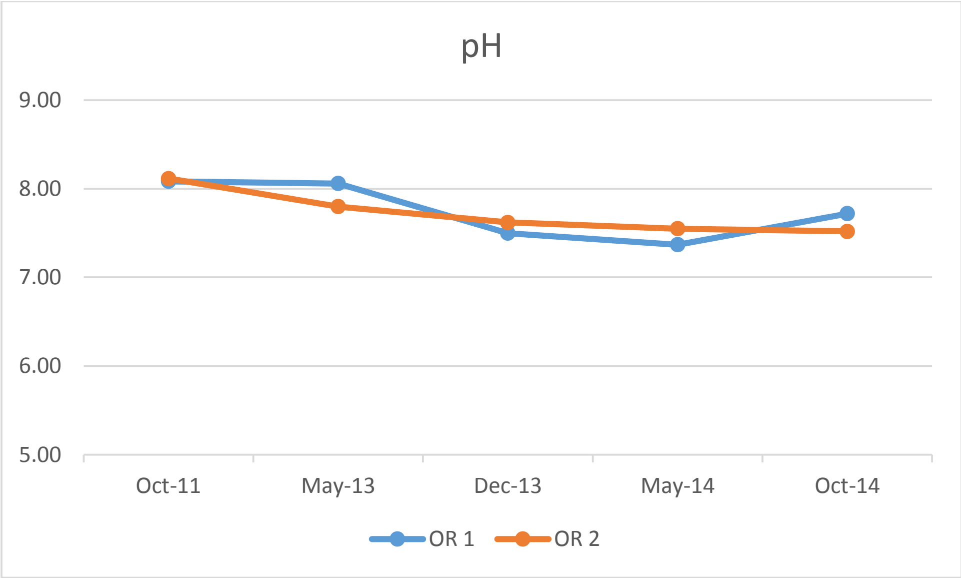
Unlike the soil test results for the Low Ridge and the Low Ridge slope, the marsh area were high in EC (>4.0 mS/cm), pH were lower than 8.5, and sodium absorption ratio were greater than 13. The site MA9 and MA10 would be classified as saline-sodic soil. Halophytic plant species, such as smooth cordgrass or black mangrove would be suitable for this area.

2.2 Old Ridge (OR): This site was created in 2003. Only two samples were collected from the Old Ridge. The average of salinity related factors appeared to be the lowest as compared to other locations and would likely not restrict plant growth.

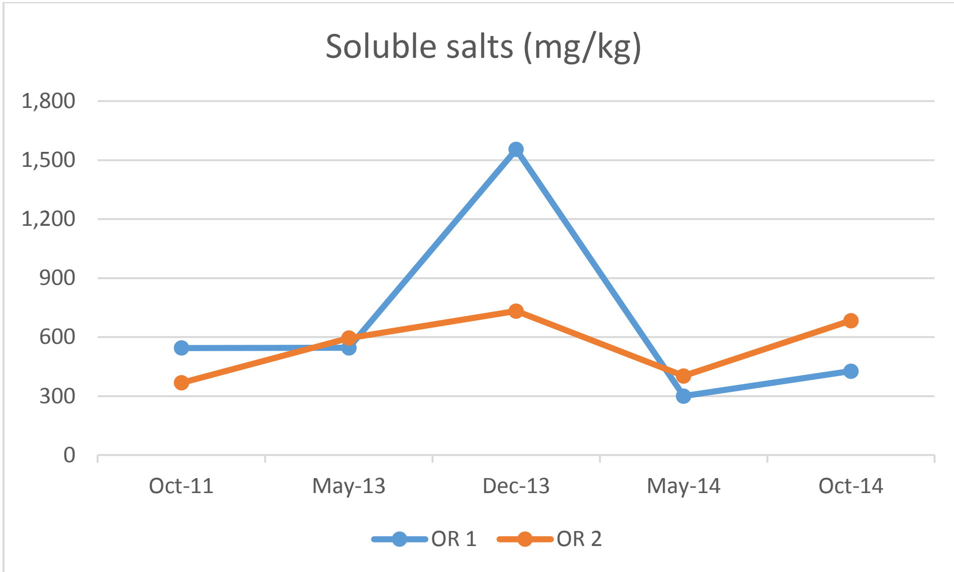
2.2.1 Electrical conductivity (mS/cm)



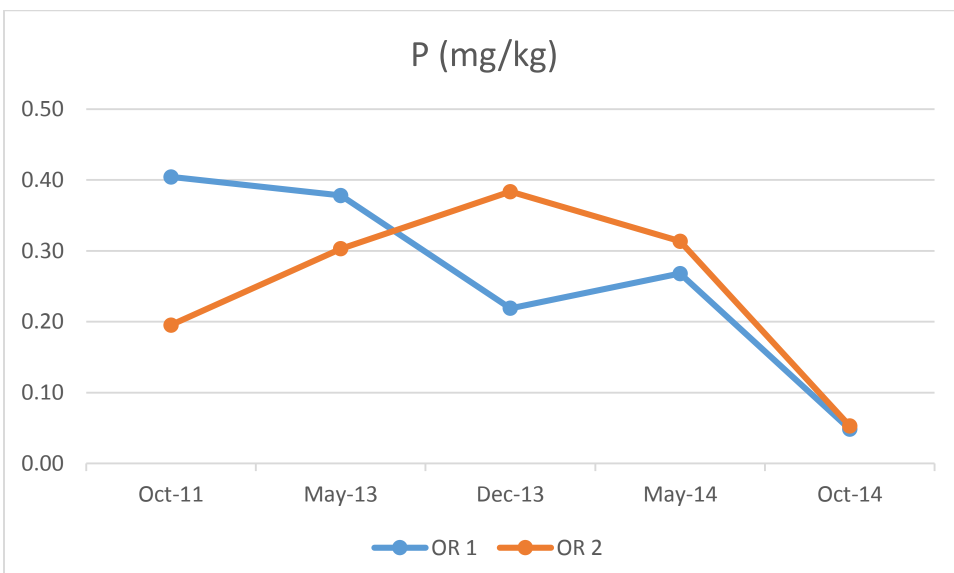
2.2.2 pH



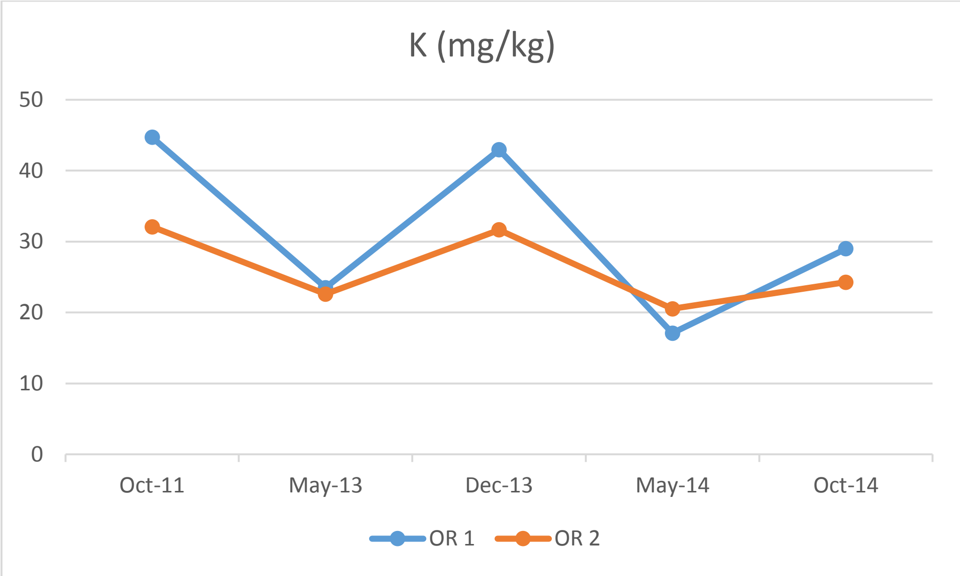
2.2.3 Soluble salts (mg/kg)



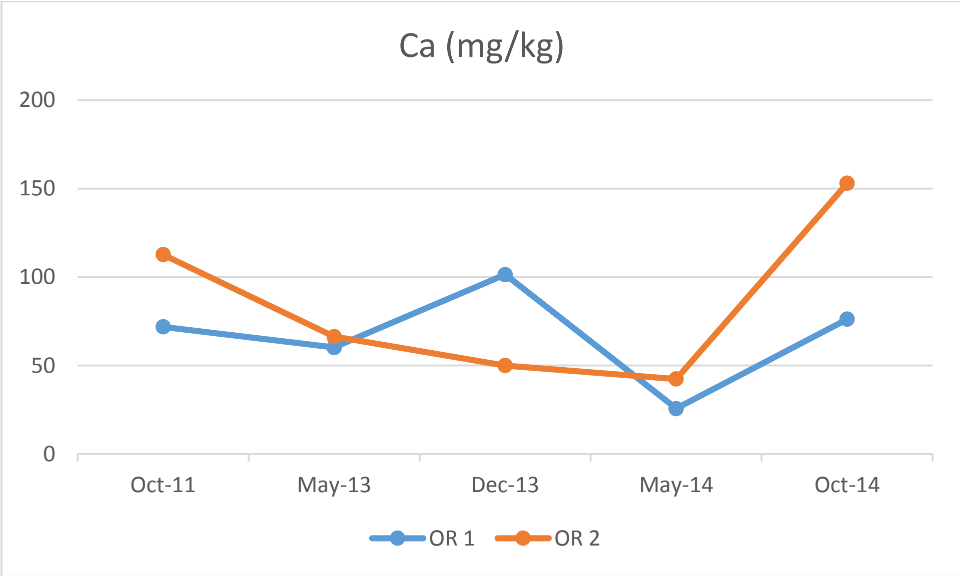
2.2.4 Soluble P (mg/kg)



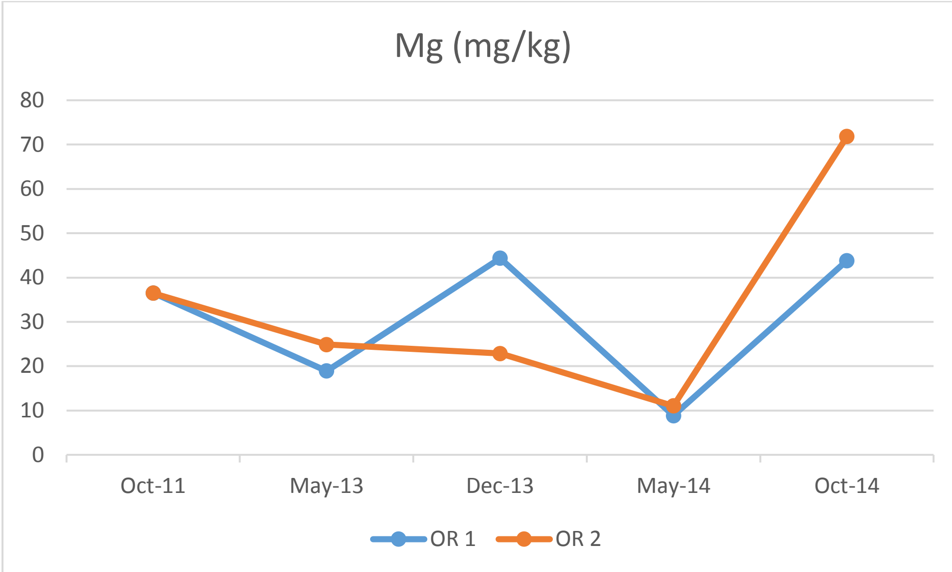
2.2.5 Soluble K (mg/kg)



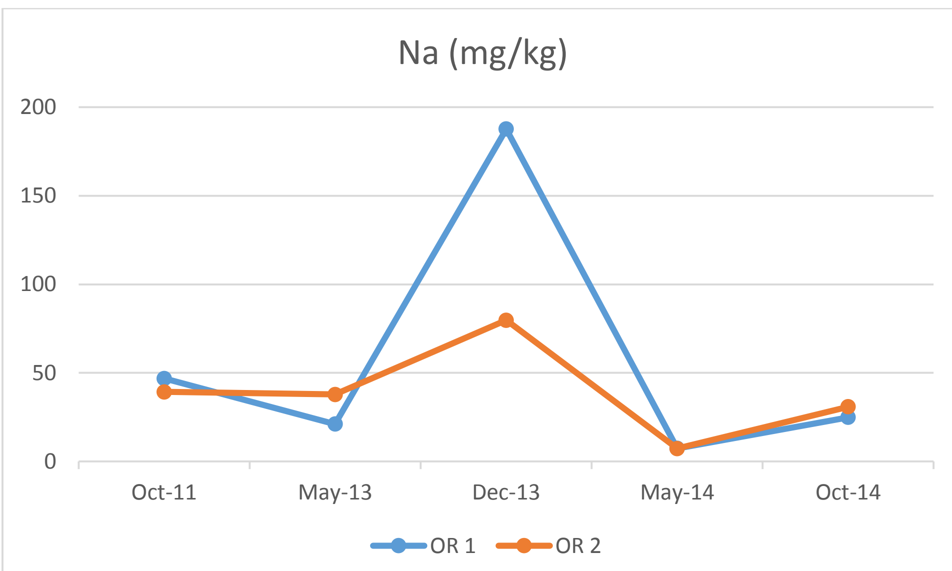
2.2.6 Soluble Ca (mg/kg)



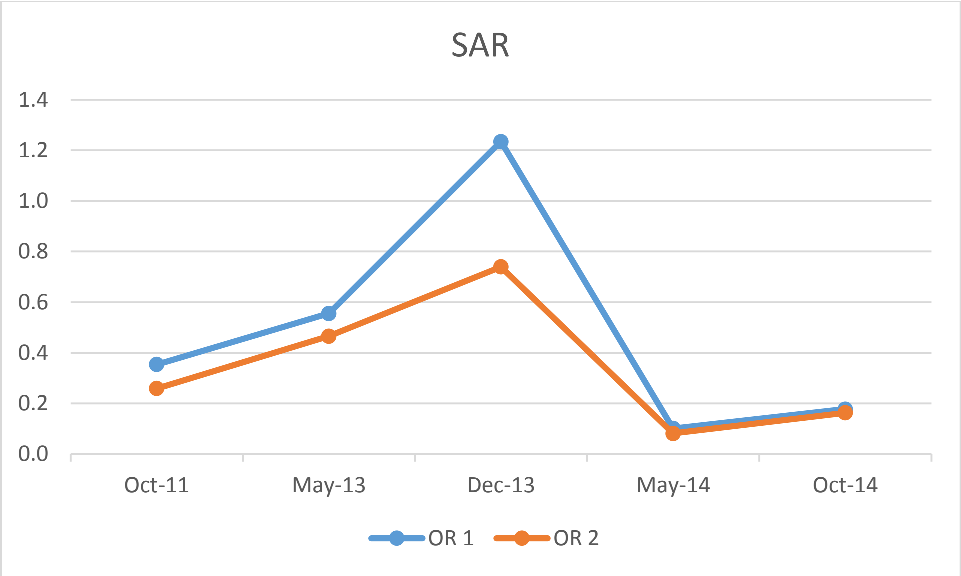
2.2.7 Soluble Mg (mg/kg)



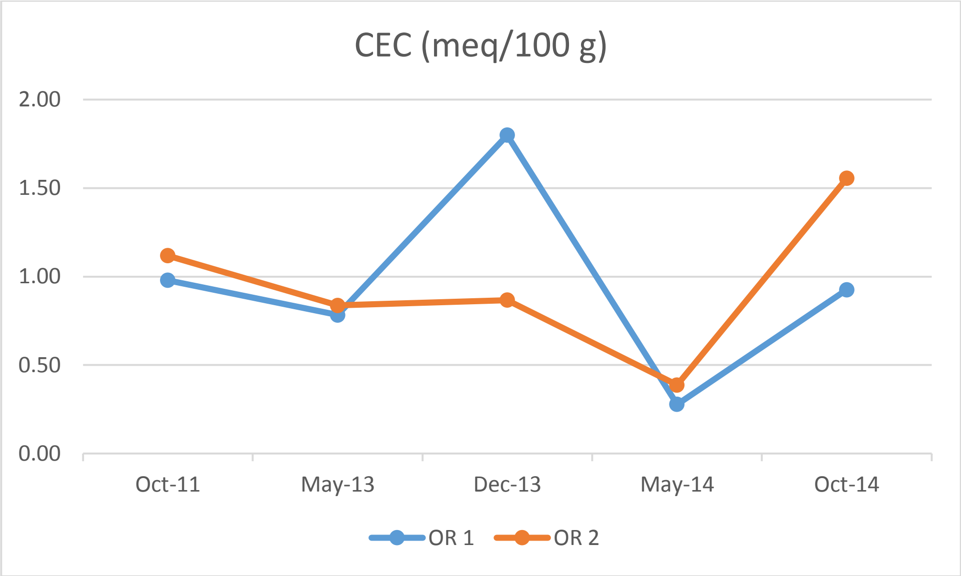
2.2.8 Soluble Na (mg/kg)



2.2.9 Sodium absorption ratio



2.2.10 Cation exchange capacity (meq/100 g soil)

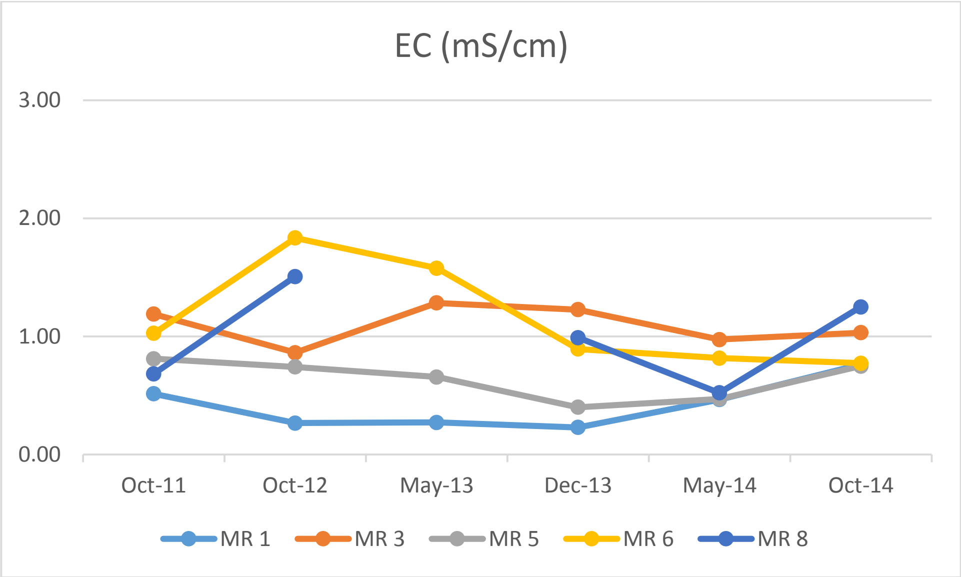


EC, pH, and SAR were lower than the minimum requirement for any soil salinity categories. The test results were similar to the Mitigation Area (both Low Ridge and Low Ridge slope), which indicated that the soil condition could be ready for many plant species from minimum to high salt tolerant.

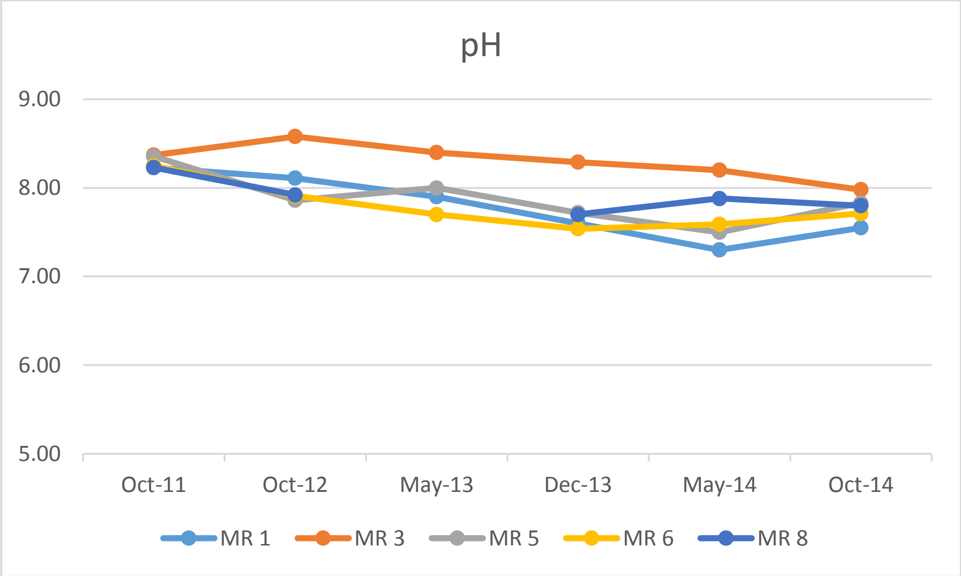
2.3 Middle Ridge (MR1-MR10). Ten samples were collected from this site that was created in summer 2005. Five samples were collected from ridge top (MR1, MR3, MR5, MR6, and MR8); four samples from marsh area (MR2, MR4, MR7, and MR9); and one sample from ridge slope (MR10). In addition to Middle Ridge area, an additional site collected from Middle Ridge North (MRN1), which was created from a pipeline pipe slurry outfall consisting entirely of oyster shell in summer 2011.

2.3.1 Ridge Top (MR1, MR3, MR5, MR6, and MR8)

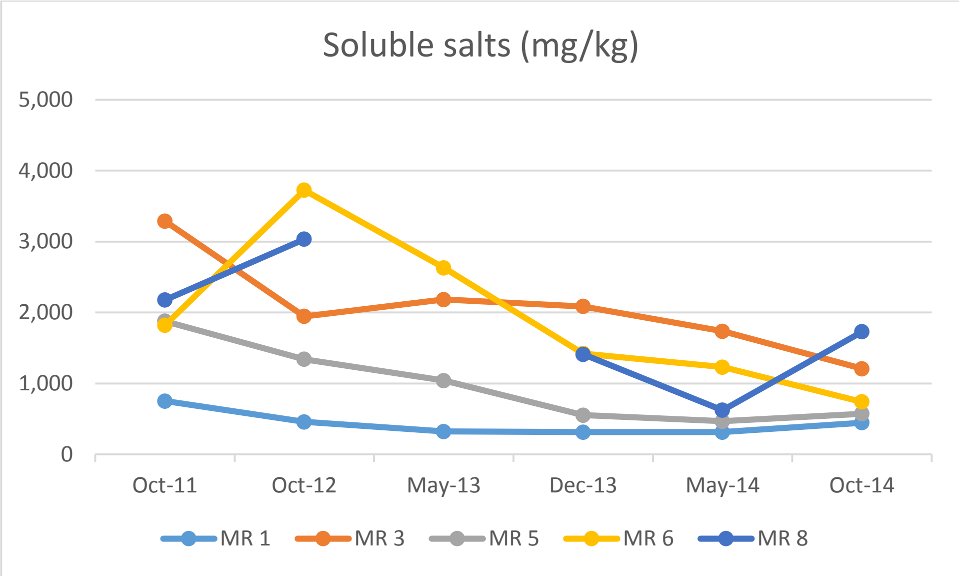
2.3.1.1 Electrical conductivity (mS/cm)



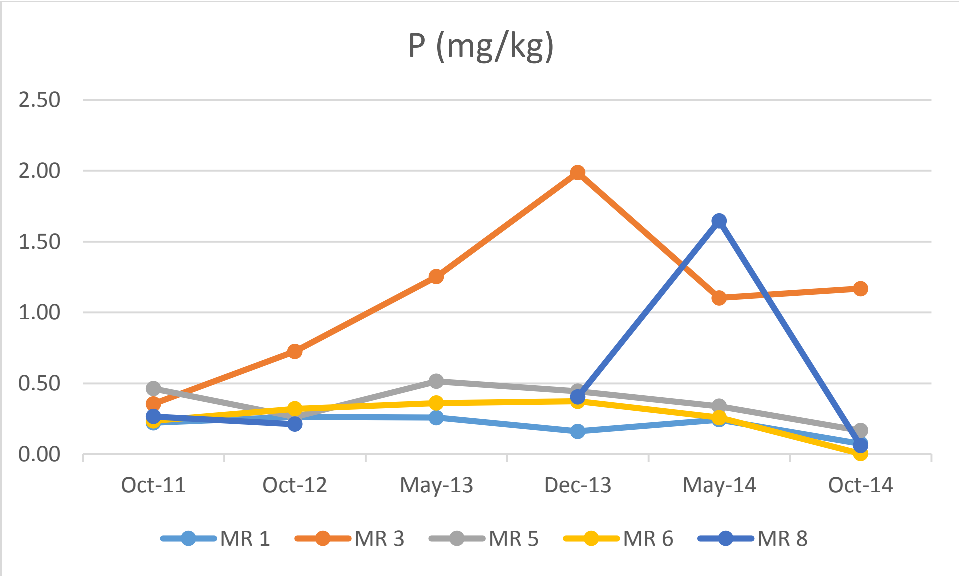
2.3.1.2 pH



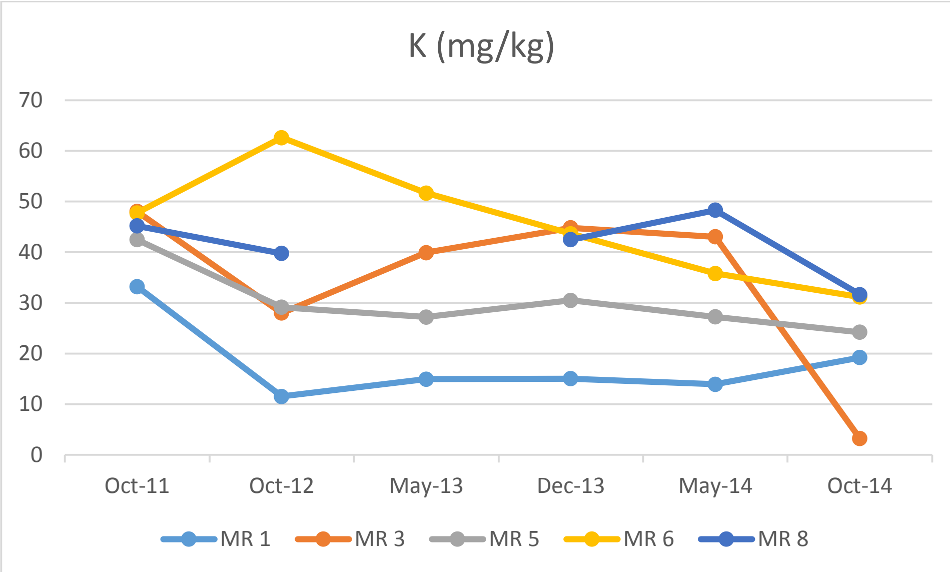
2.3.1.3 Soluble salts (mg/kg)



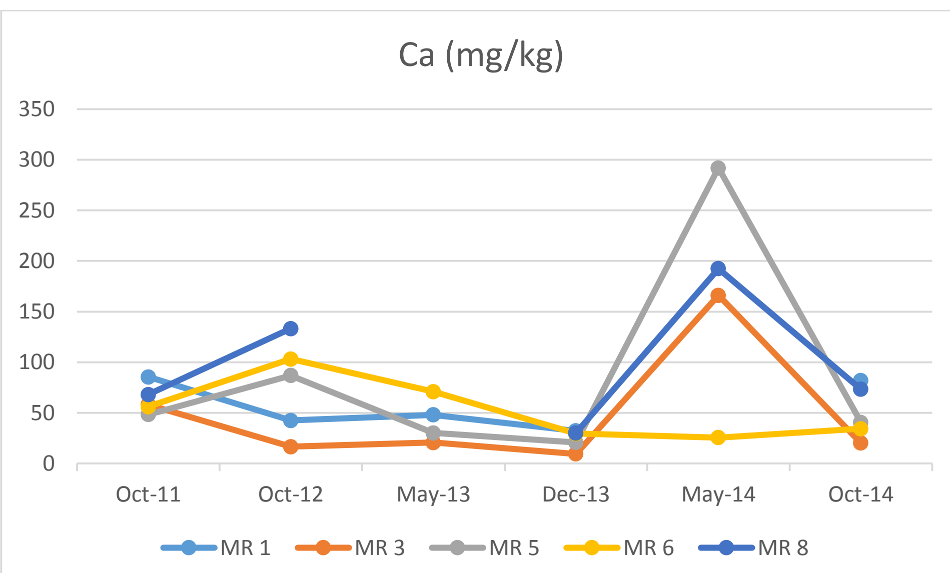
2.3.1.4 Soluble P (mg/kg)



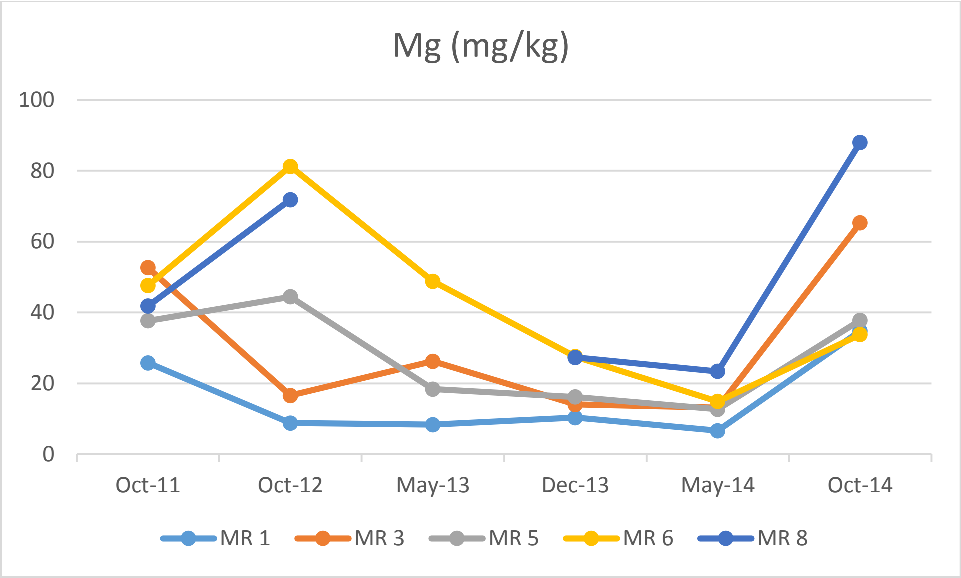
2.3.1.5 Soluble K (mg/kg)



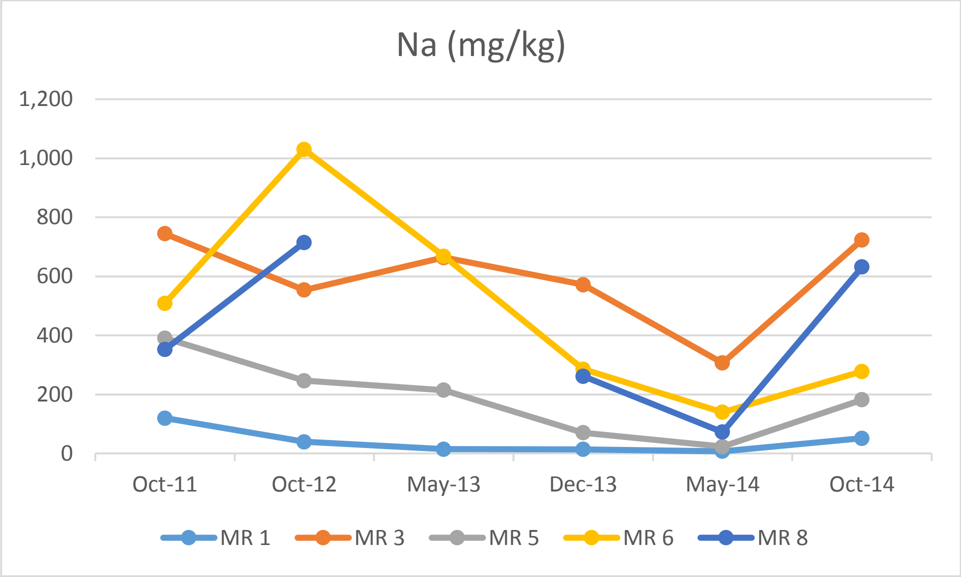
2.3.1.6 Soluble Ca (mg/kg)



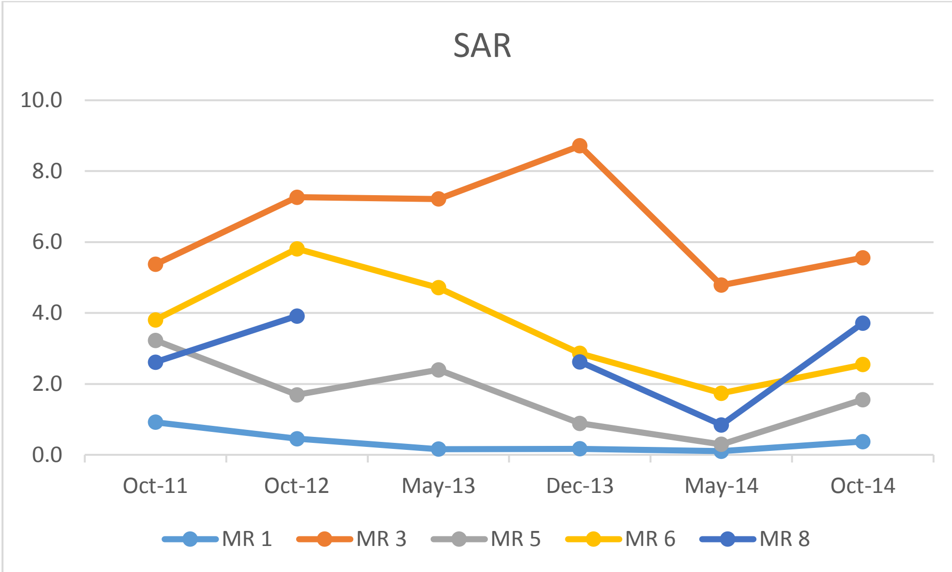
2.3.1.7 Soluble Mg (mg/kg)



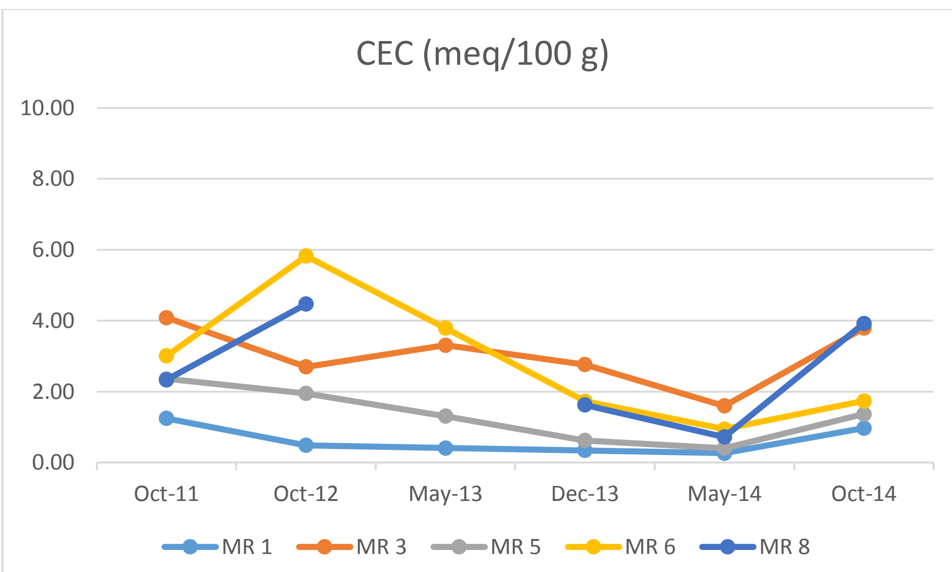
2.3.1.8 Soluble Na (mg/kg)



2.3.1.9 Sodium absorption ratio



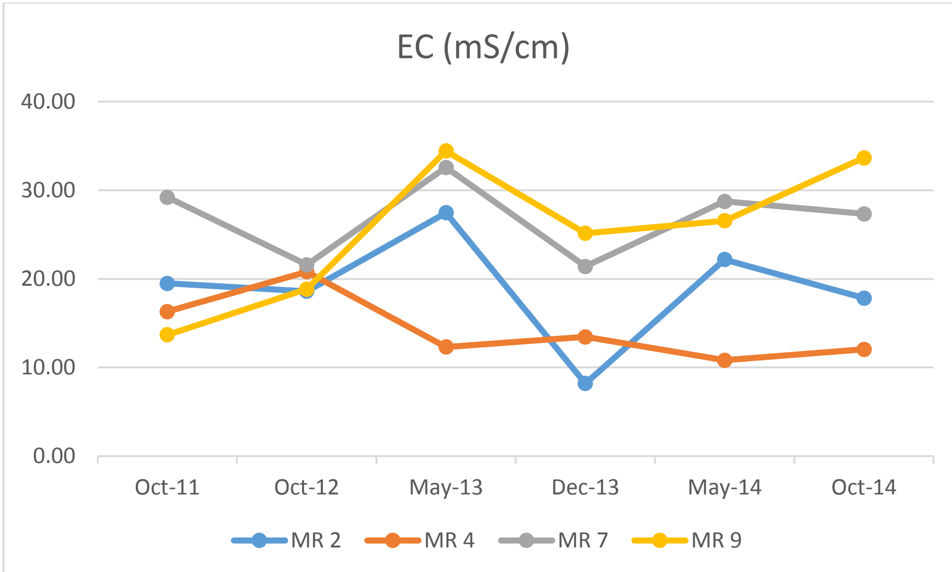
2.3.1.10 Cation exchange capacity (meq/100 g soil)



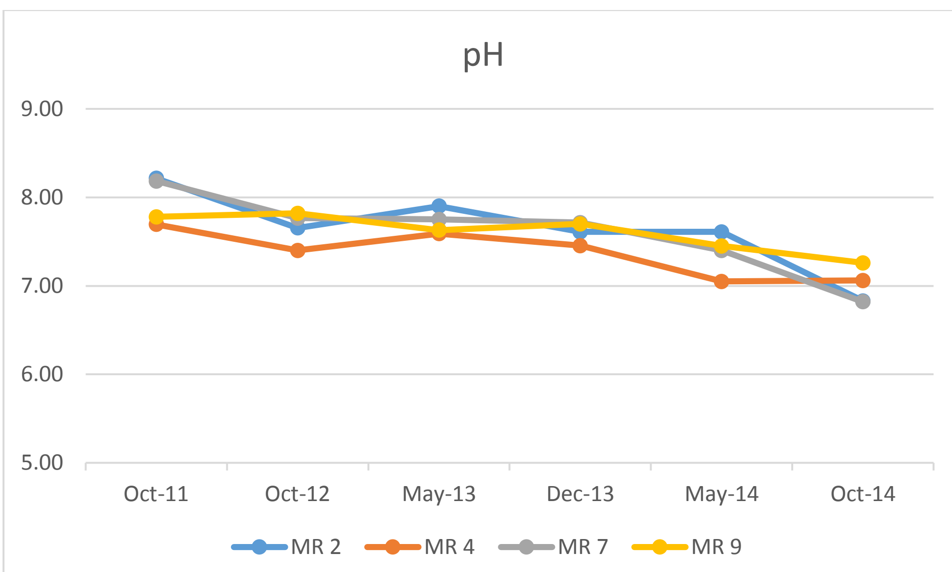
Soil test results from the Ridge Top of Middle Ridge area were similar to the Mitigation Area (Low Ridge and Low Ridge slope), particularly for the EC, pH, and SAR, which were lower than the minimum requirement for any soil salinity categories. The test results indicated that the soil conditions could be ready for many plant species. However, soluble sodium were high that might impact some plant species.

2.3.2 Marsh (MR2, MR4, MR7, and MR9)

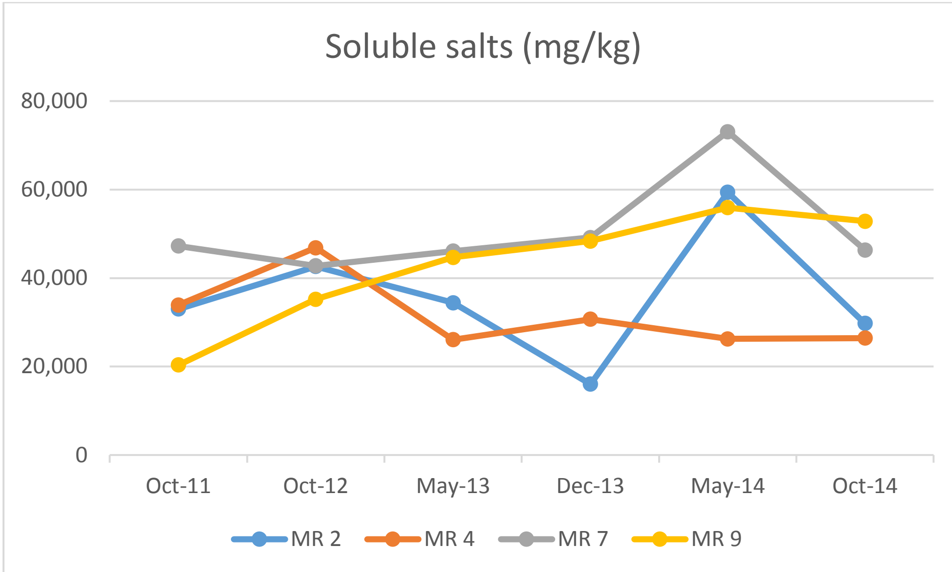
2.3.2.1 Soluble salts (mg/kg)



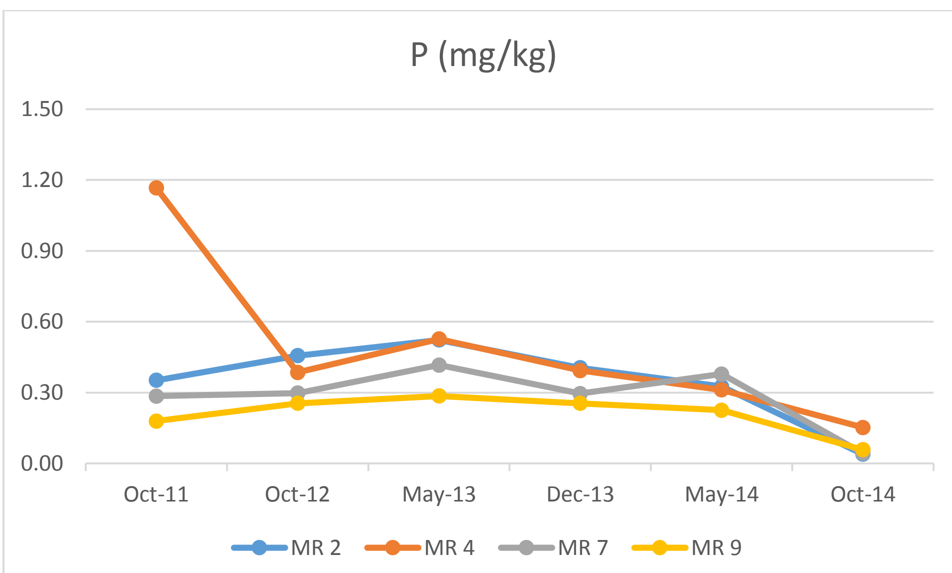
2.3.2.2 pH



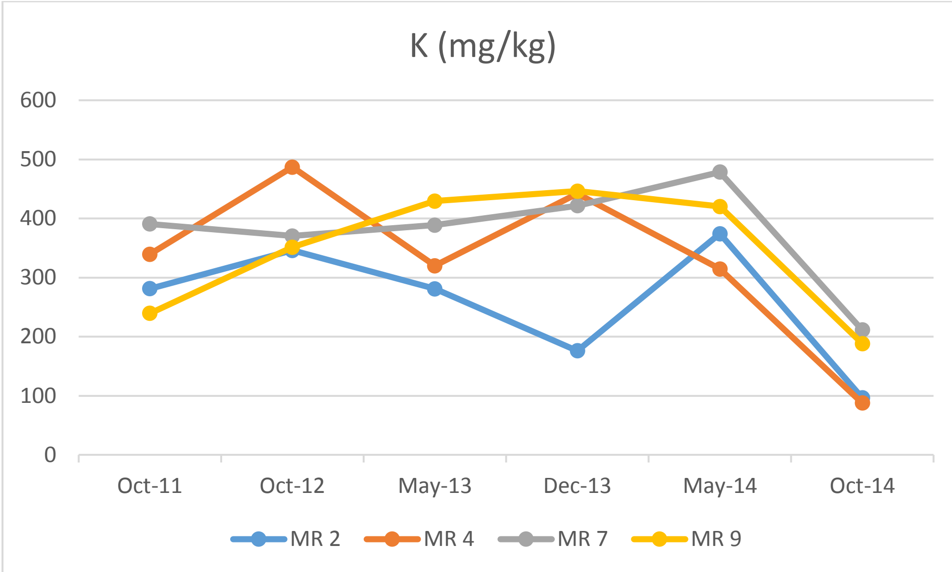
2.3.2.3 Soluble salts (mg/kg)



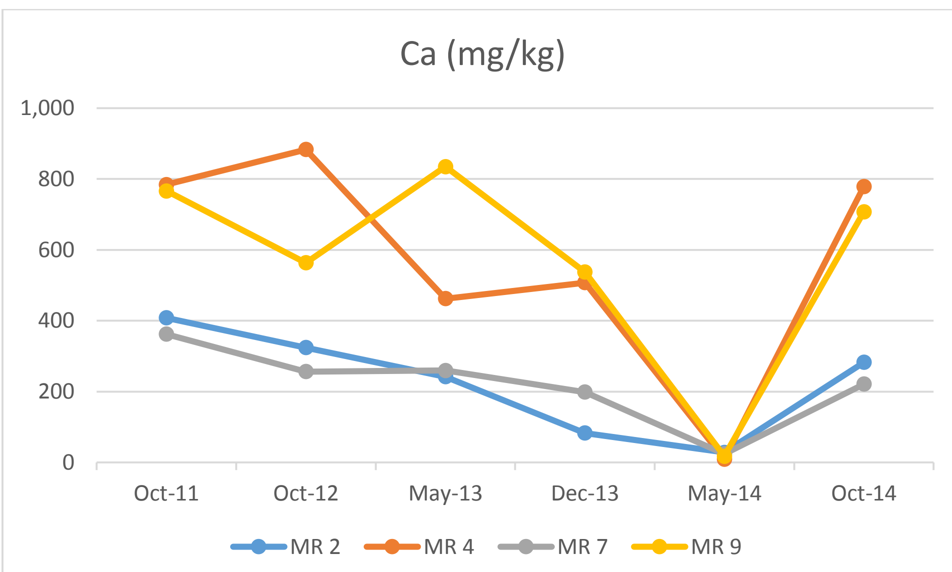
2.3.2.4 Soluble P (mg/kg)



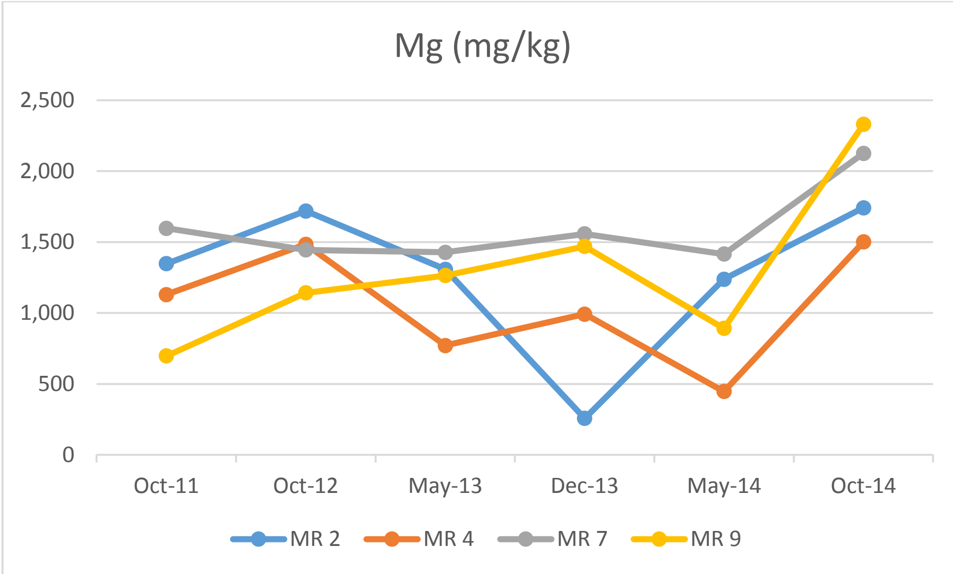
2.3.2.5 Soluble K (mg/kg)



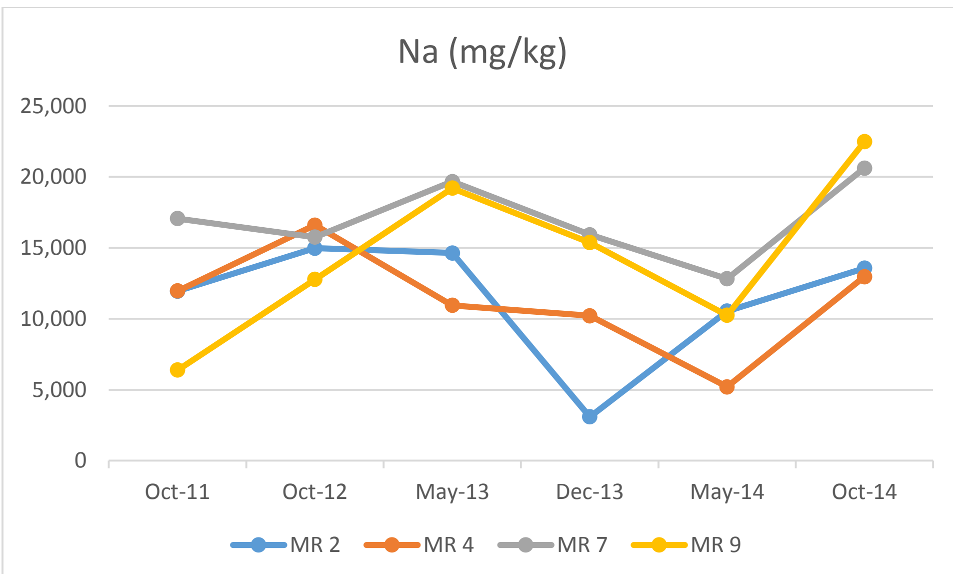
2.3.2.6 Soluble Ca (mg/kg)



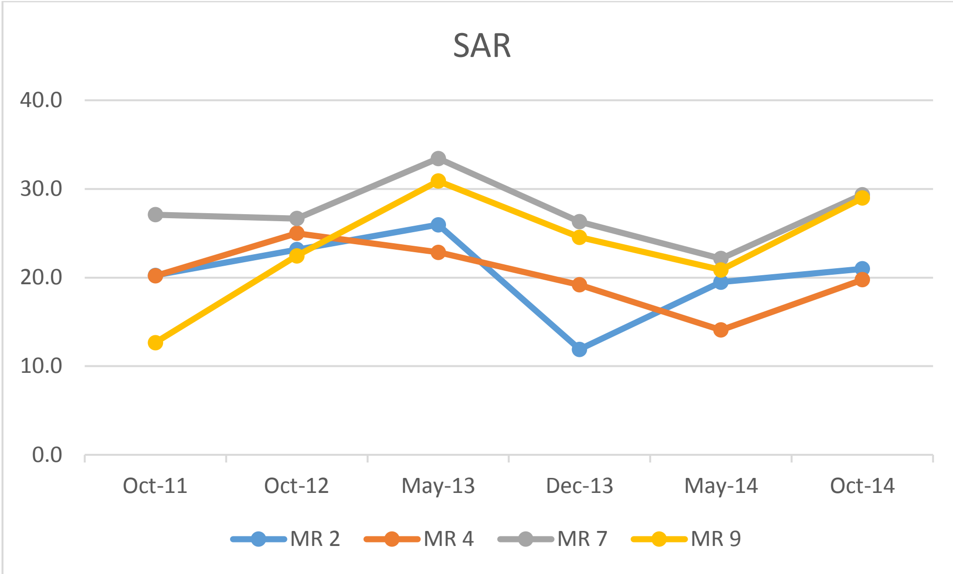
2.3.2.7 Soluble Mg (mg/kg)



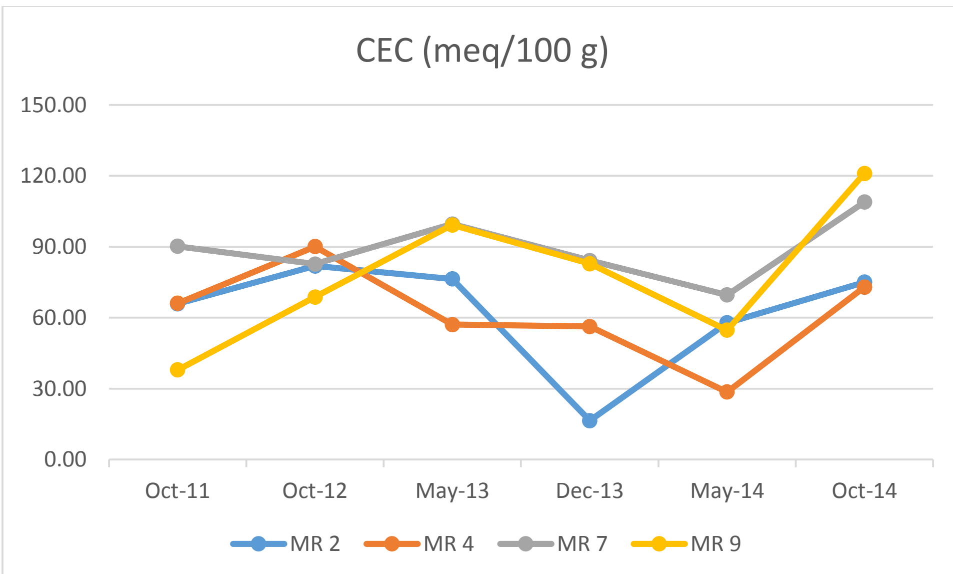
2.3.2.8 Soluble Na (mg/kg)



2.3.2.9 Sodium absorption ratio



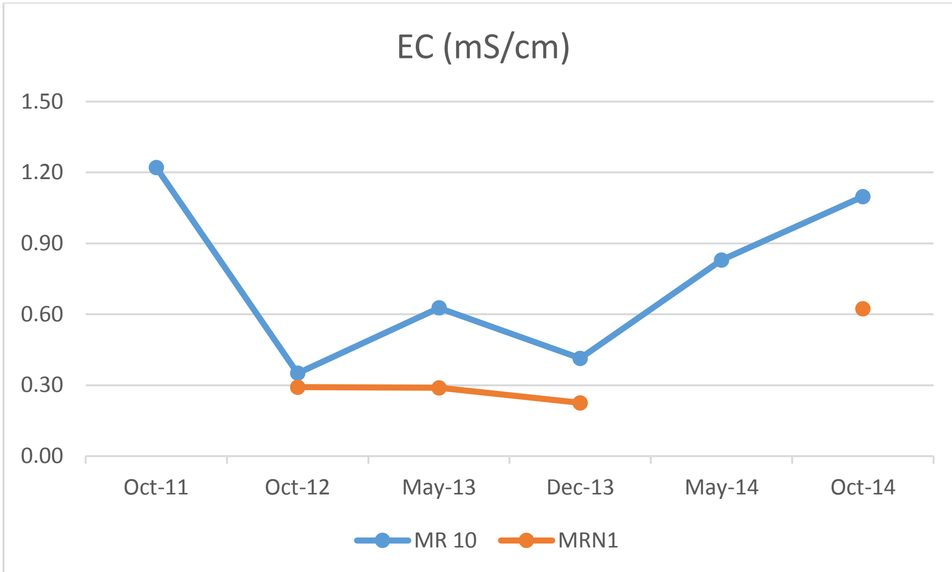
2.3.2.10 Cation exchange capacity (meq/100 g soil)



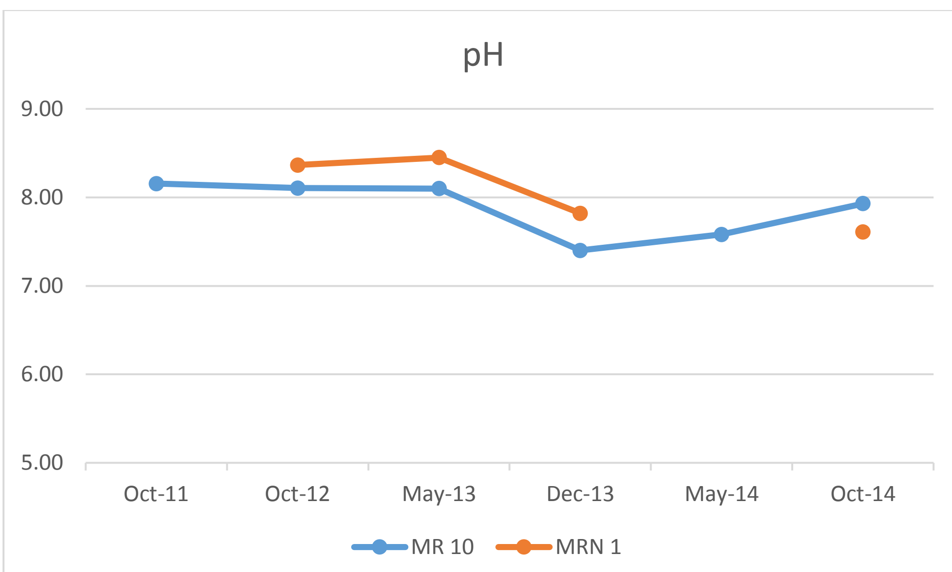
EC from this area were greater than 4.0 mS/cm, pH were below 8.5 and SAR were higher than13. These 4 sites (MR2, MR4, MR7, and MR9) would be classified as saline-sodic soil. Soluble P were also low (< 1.0 ppm). Soluble Ca were unusual dropped in May 2014 for the site MR4 and MR9 (below 20 mg/kg as compared to >400 mg/kg from other sampling times). This might be because of sample preparation and analysis processes.

2.3.3 Middle Ridge Slope (MR10) and Middle Ridge North (MRN1)

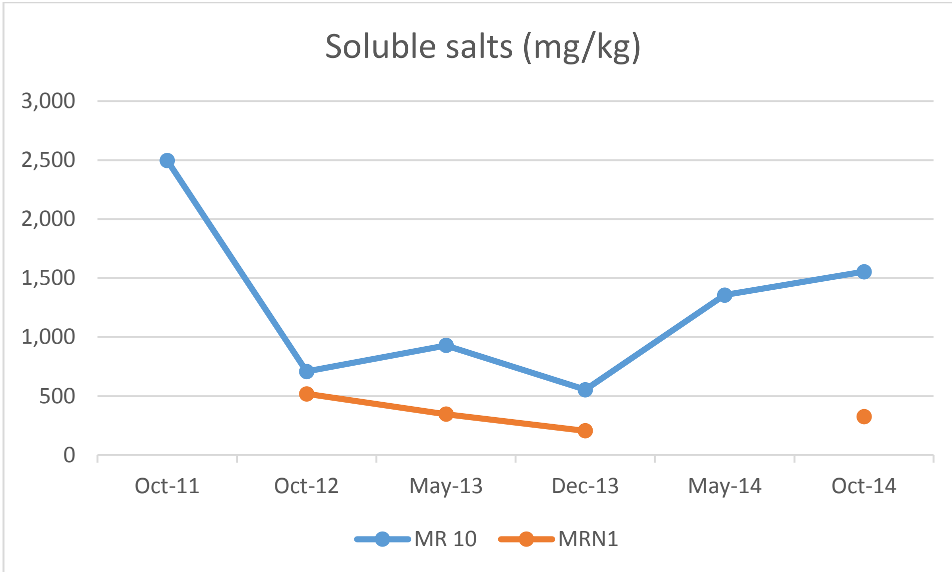
2.3.3.1 Electrical conductivity (mS/cm)



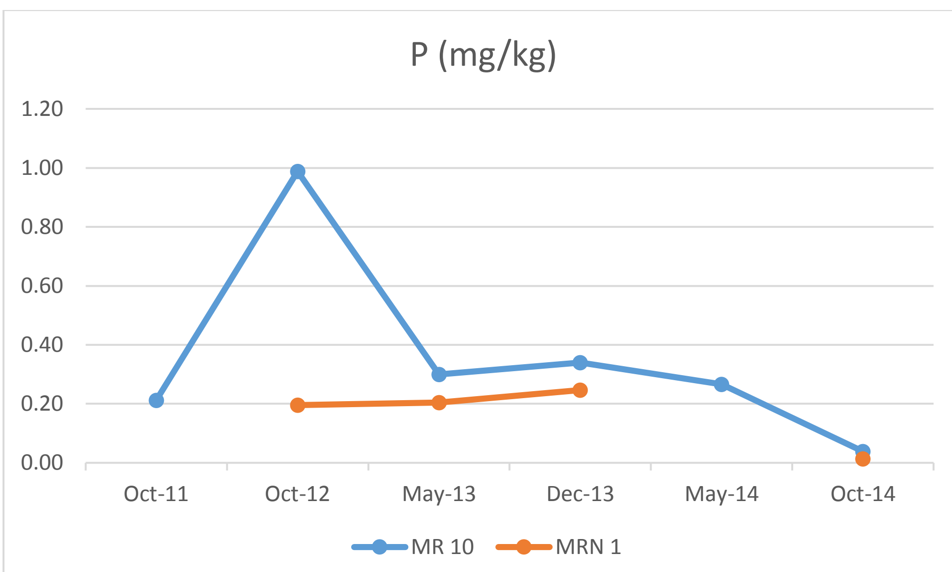
2.3.3.2 pH



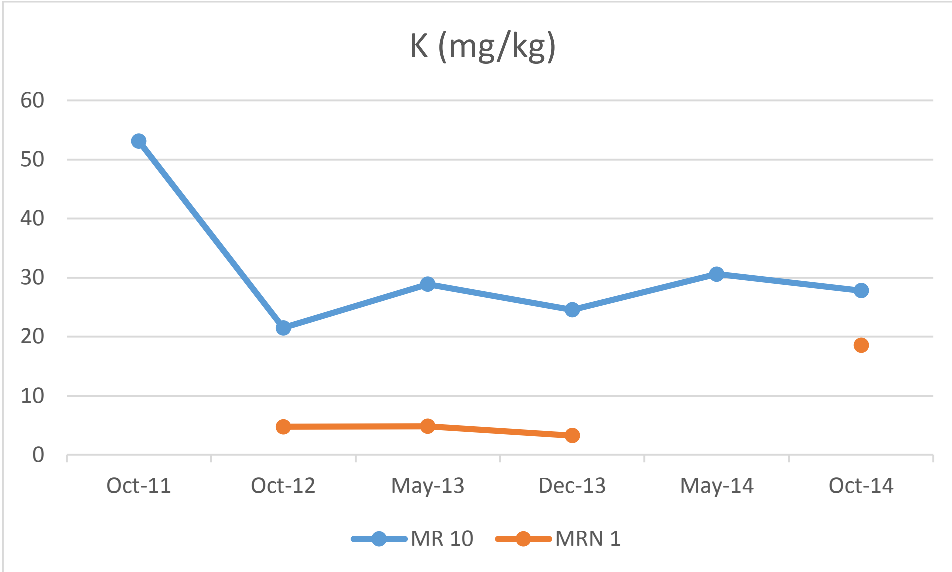
2.3.3.3 Soluble salts (mg/kg)



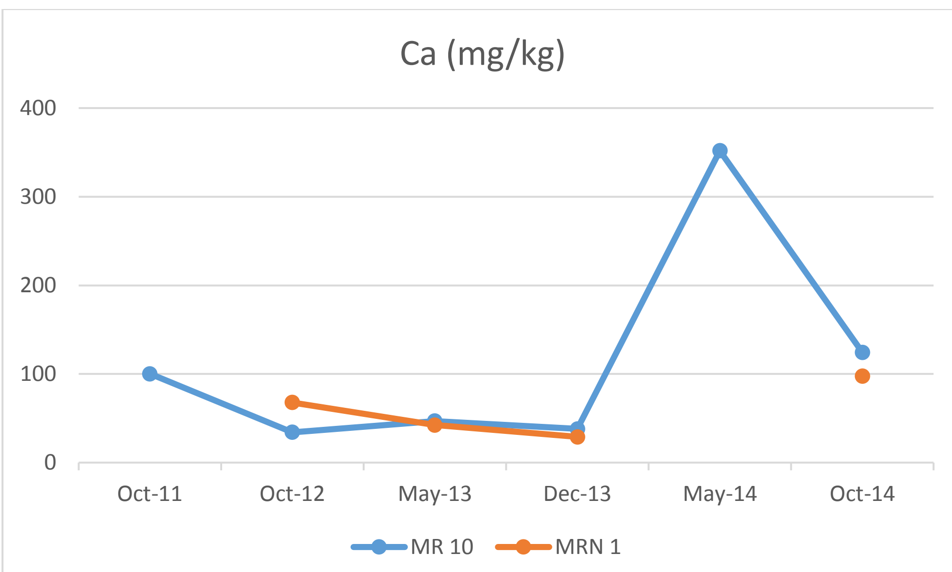
2.3.3.4 Soluble P (mg/kg)



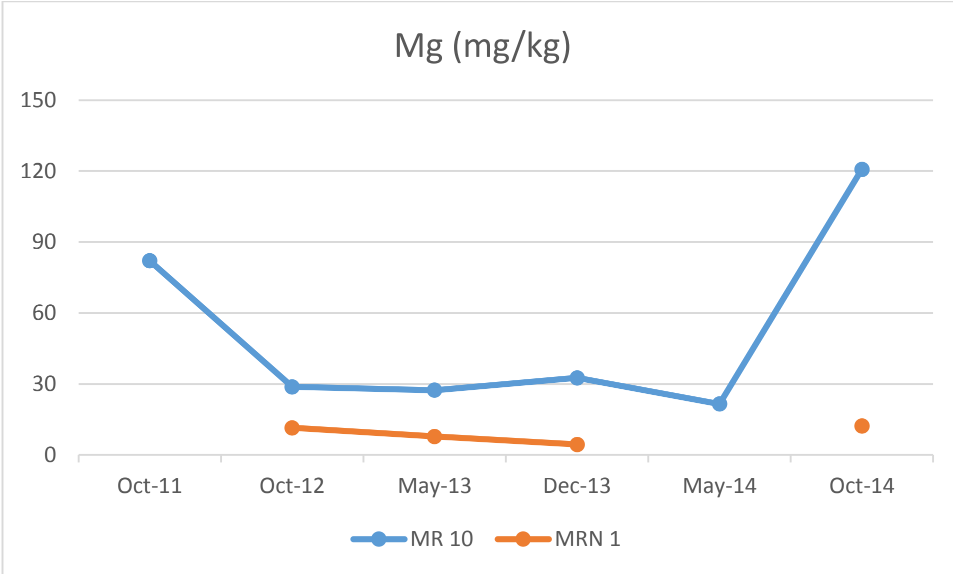
2.3.3.5 Soluble K (mg/kg)



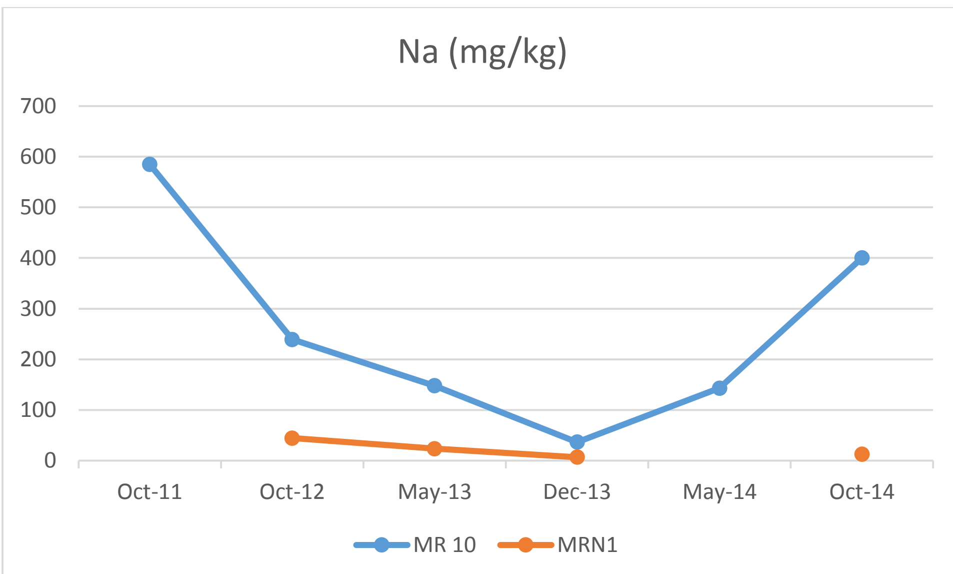
2.3.3.6 Soluble Ca (mg/kg)



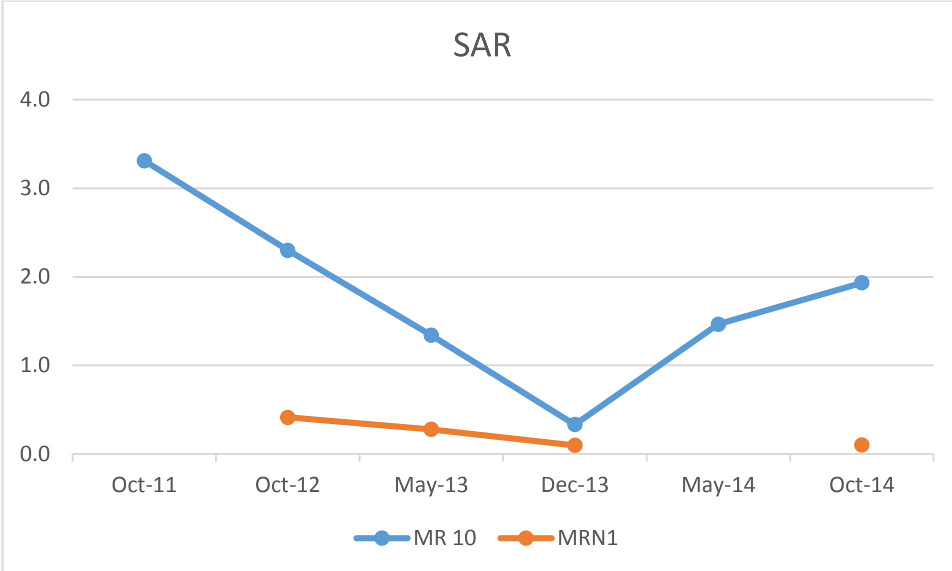
2.3.3.7 Soluble Mg (mg/kg)



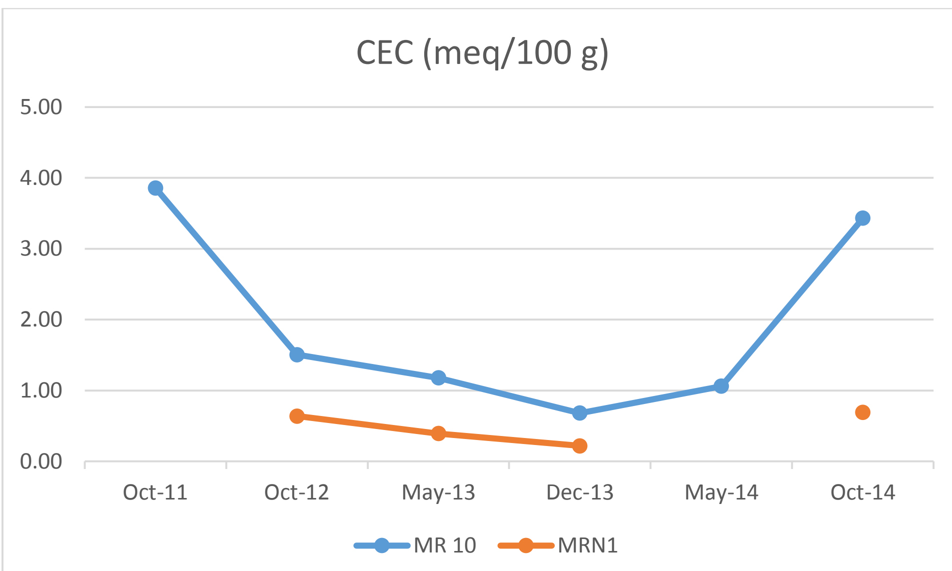
2.3.3.8 Soluble Na (mg/kg)



2.3.3.9 Sodium absorption ratio



2.3.3.10 Cation exchange capacity (meq/100 g soil)

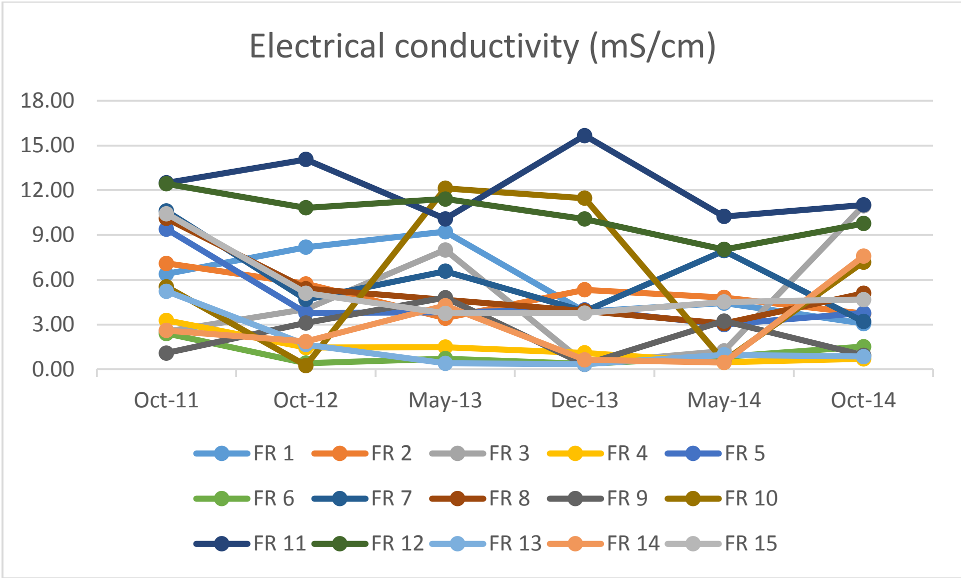


MR10 and MRN1 are formed at different time but the test results were in the same range, which can plot in the same chart. The MR10 ridge slope site is from a created ridge in 2005. The MRN1 high marsh site is located at a dredge pipeline slurry outfall at a marsh creation site just north and adjacent to the ridge and consisting almost entirely of oyster shell. Although MRN1 created several years later, the salinity results were lower than MR10. This because of the composition of materials are different. Higher content of oyster shell and clam shell had potential to decrease salinity problem and enhance plant growth, which can be observed in the mitigation area (MA) that created in 2001. Both MR10 and MRN1 did not meet any categories of saline soil.

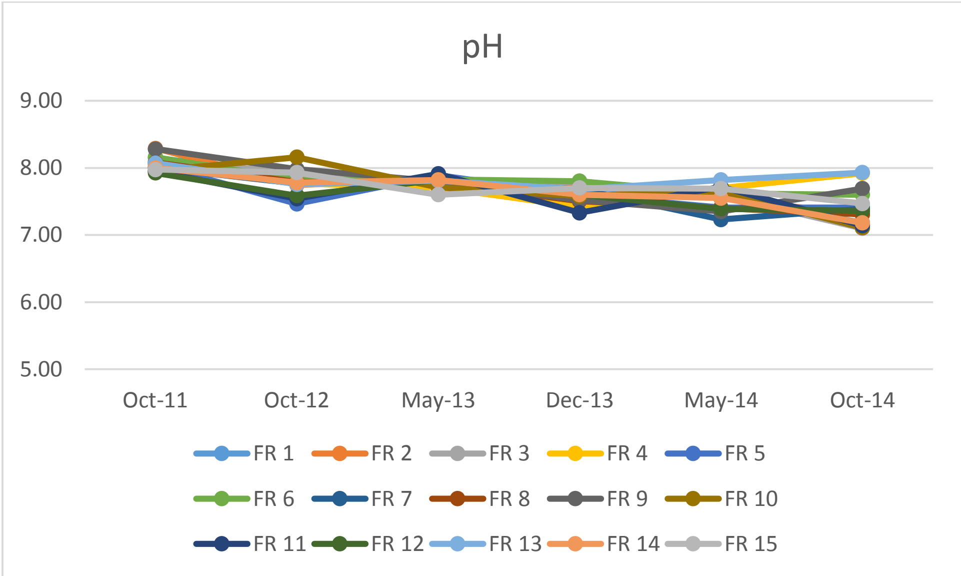
2.4 Far Ridge Area (FR): This site was constructed in fall of 2008. There were 27 samples collected from this site which were broken down into 3 different landforms: Ridge top (FR1-15), Far Ridge slope (FRN7, FRN13) and Marsh area (FRN1-5, FRS1-5). The graphs below display value and variation of each parameter.

2.4.1. Ridge top (FR1-FR15)

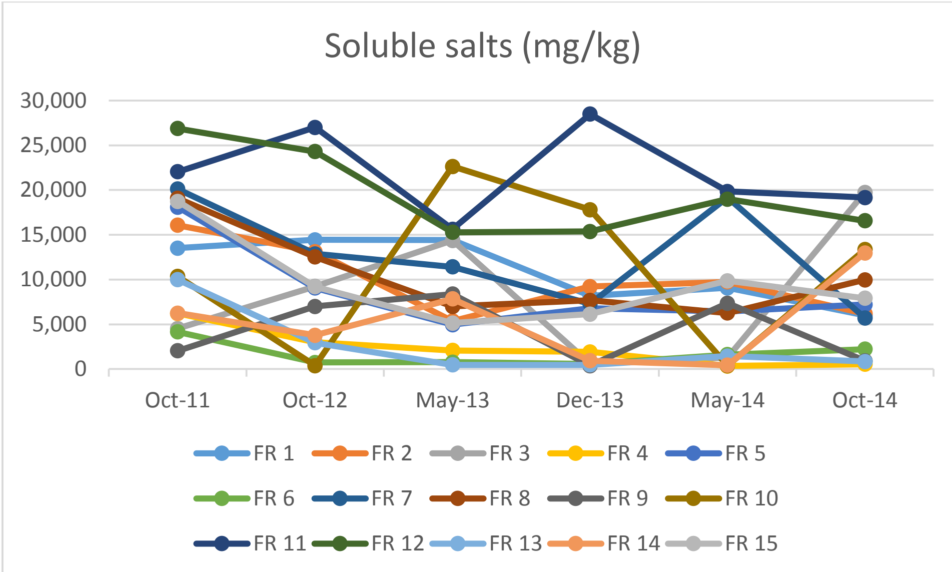
2.4.1.1 Electrical conductivity (mS/cm)



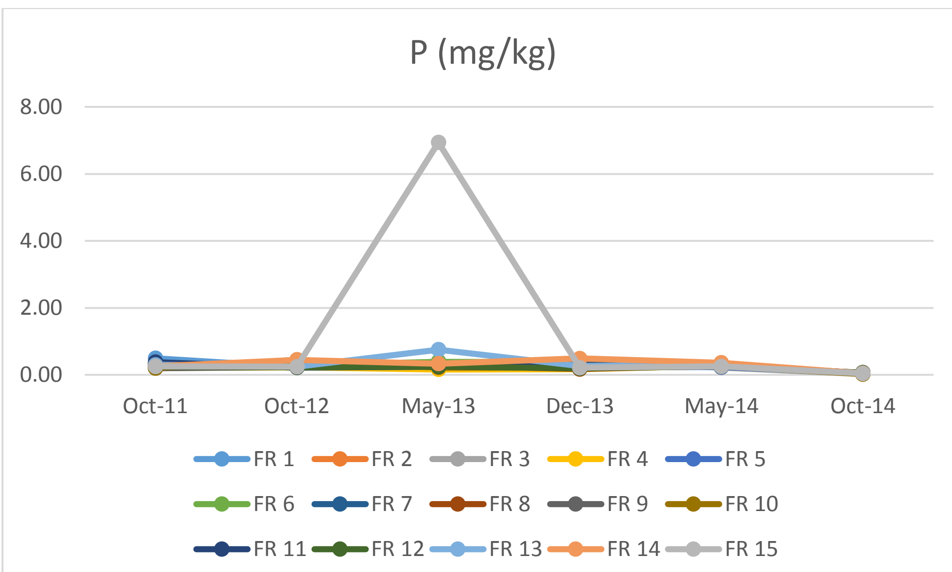
2.4.1.2 pH



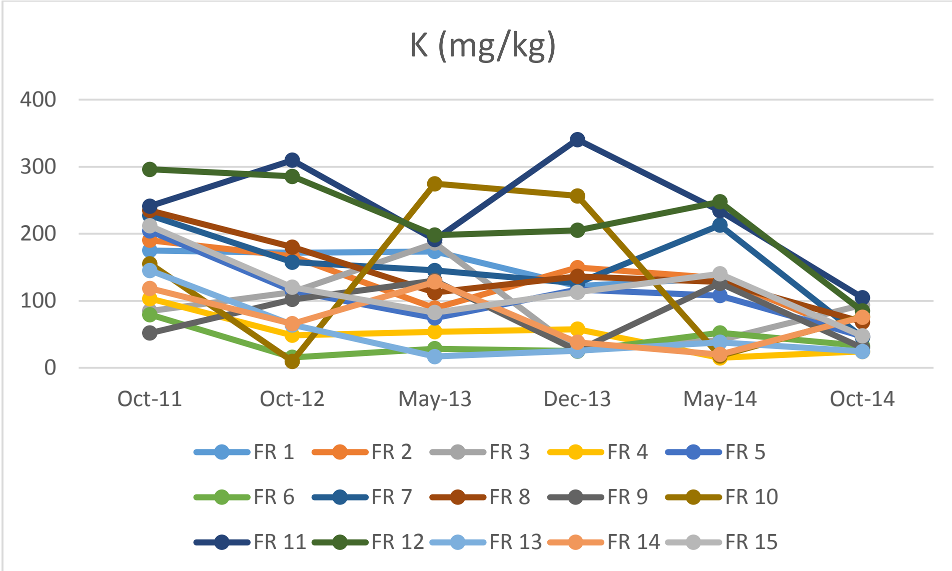
2.4.1.3 Soluble salts (mg/kg)



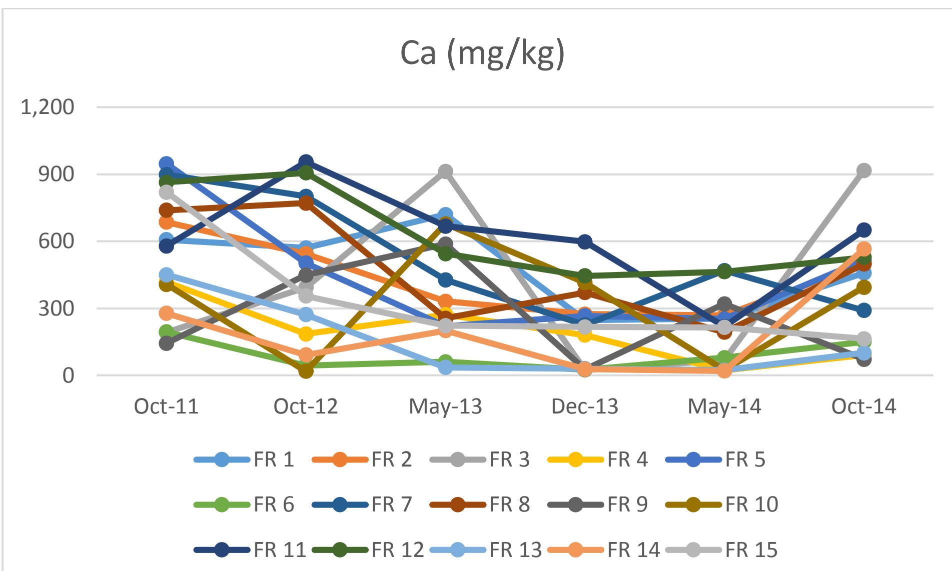
2.4.1.4 Soluble P (mg/kg)



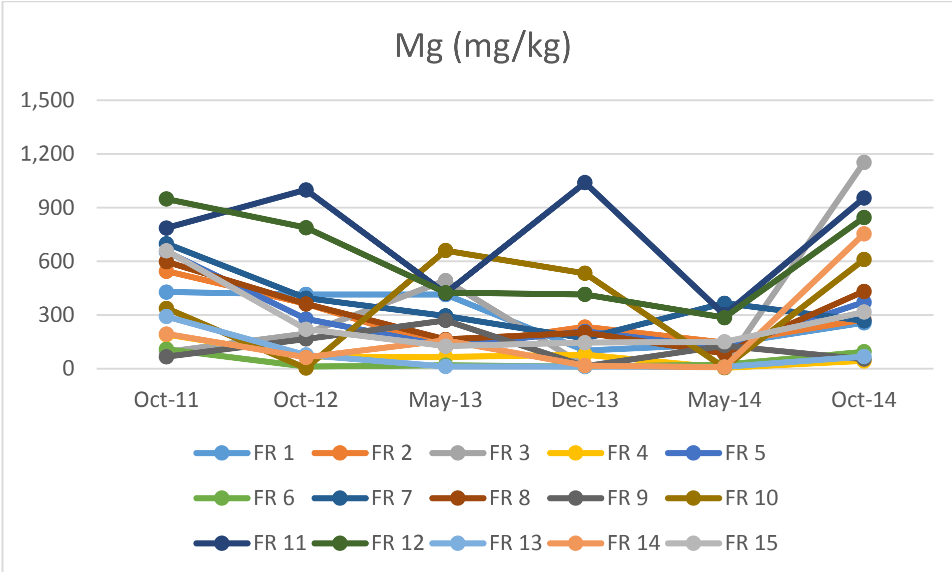
2.4.1.5 Soluble K (mg/kg)



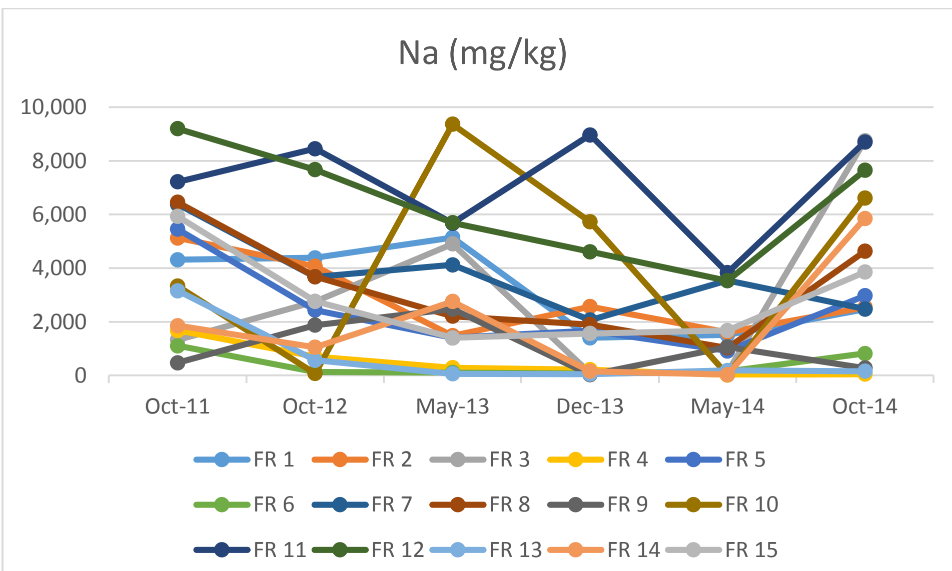
2.4.1.6 Soluble Ca (mg/kg)



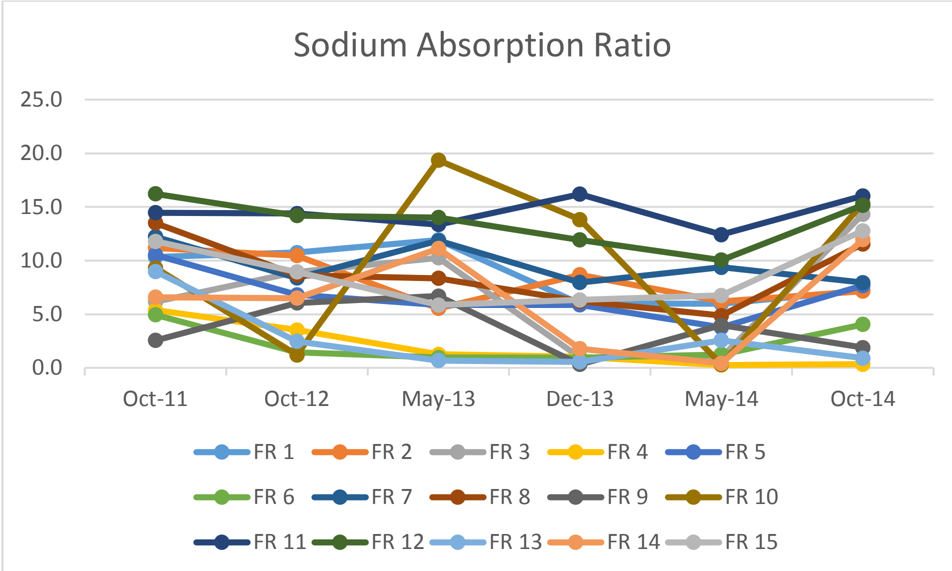
2.4.1.7 Soluble Mg (mg/kg)



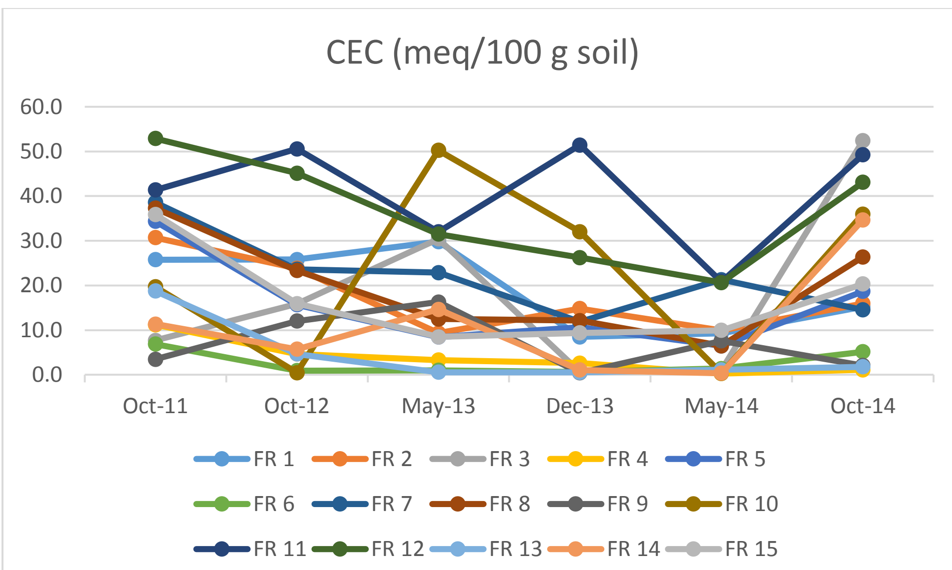
2.4.1.8 Soluble Na (mg/kg)



2.4.1.9 Sodium absorption ratio



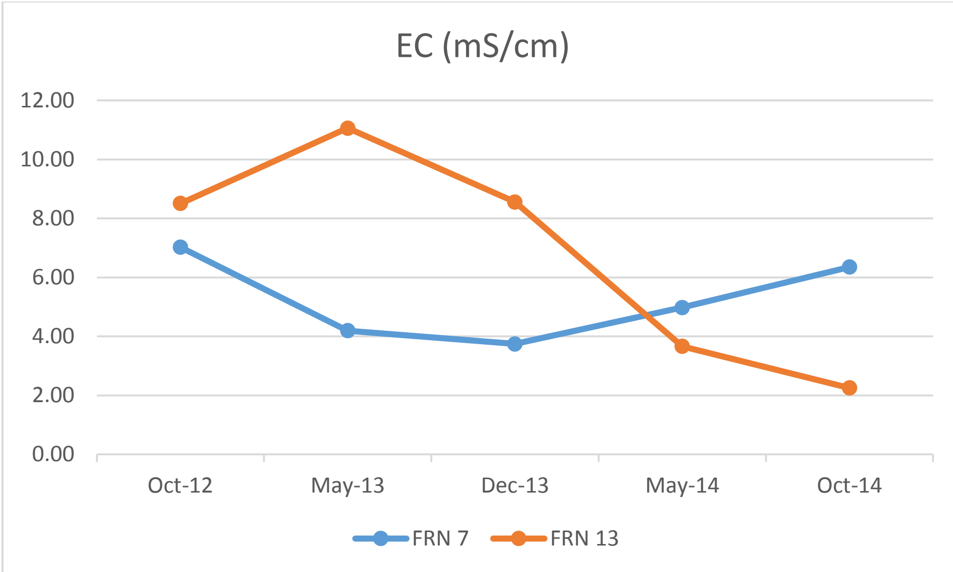
2.4.1.10 Cation exchange capacity (meq/100 g soil)



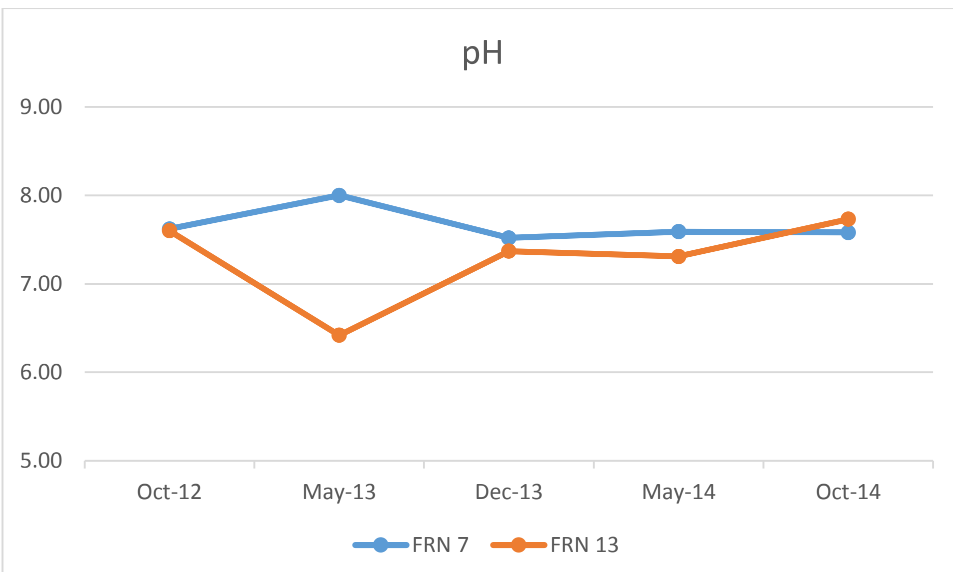
Test results of the Far Ridge (Ridge top; FR1-FR15) varied from the sites and time of sampling. Even though the landform of the sample are similar, the parent materials of each sites could be different. For example, FR4 and FR13 did not show salinity problem, while FR11 and FR12 show saline-sodic potential. Therefore, this area will need more time to allow the natural dynamic changes to reduce salinity level.

2.4.2 Far Ridge slope (FRN 7 and FRN 13)

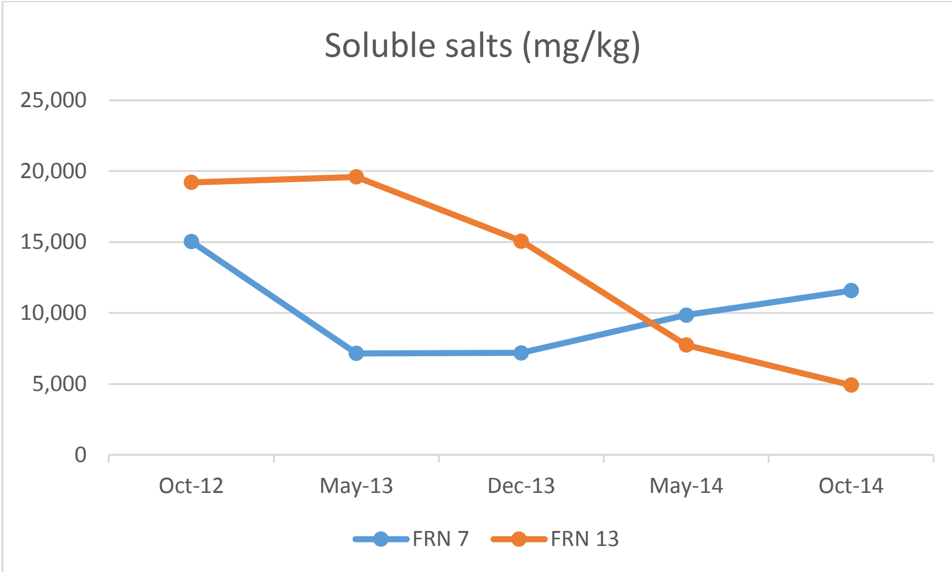
2.4.2.1 Electrical conductivity (mS/cm)



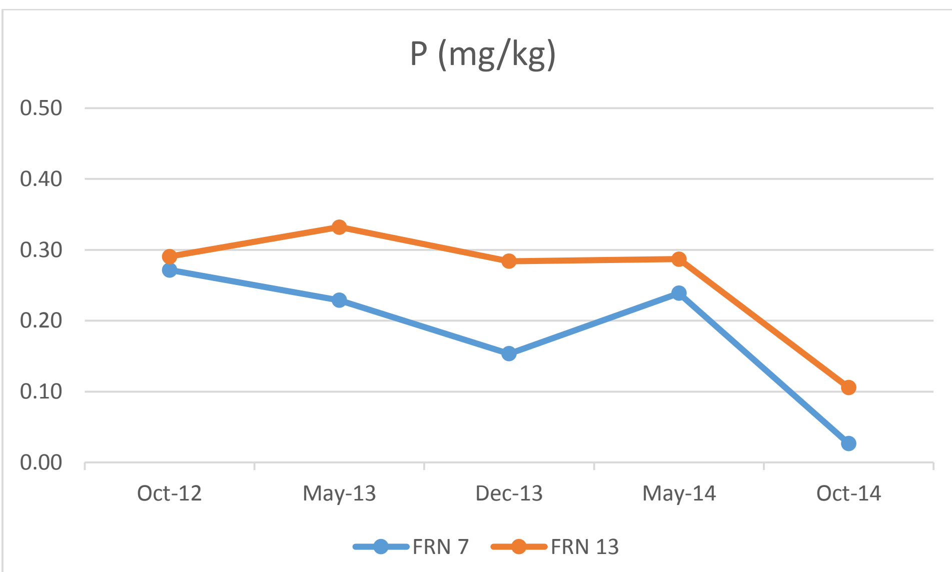
2.4.2.2 pH



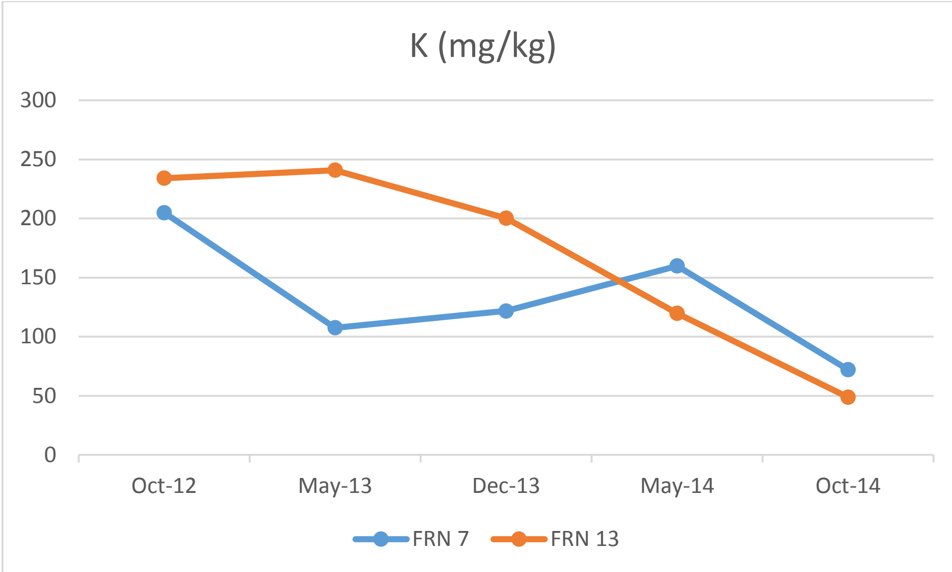
2.4.2.3 Soluble salts (mg/kg)



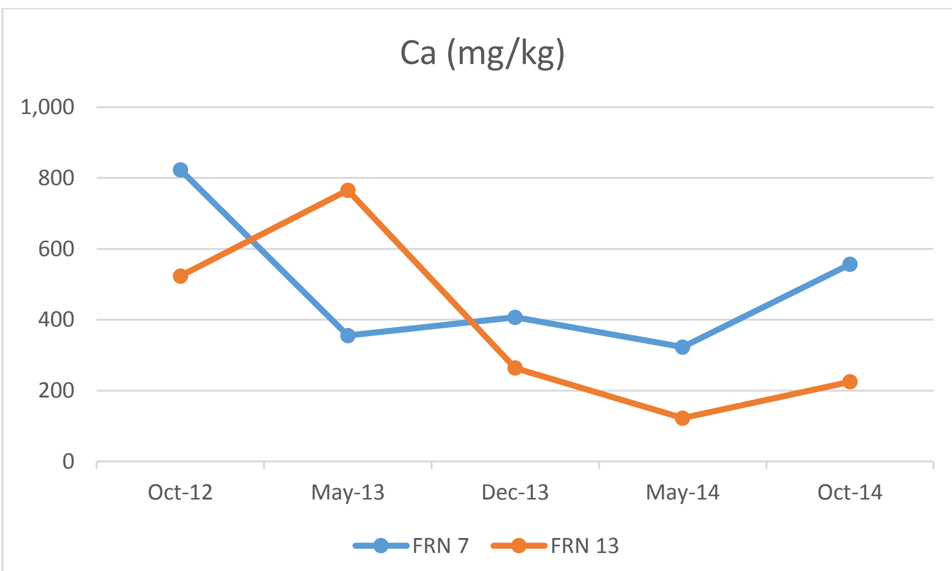
2.4.2.4 Soluble P (mg/kg)



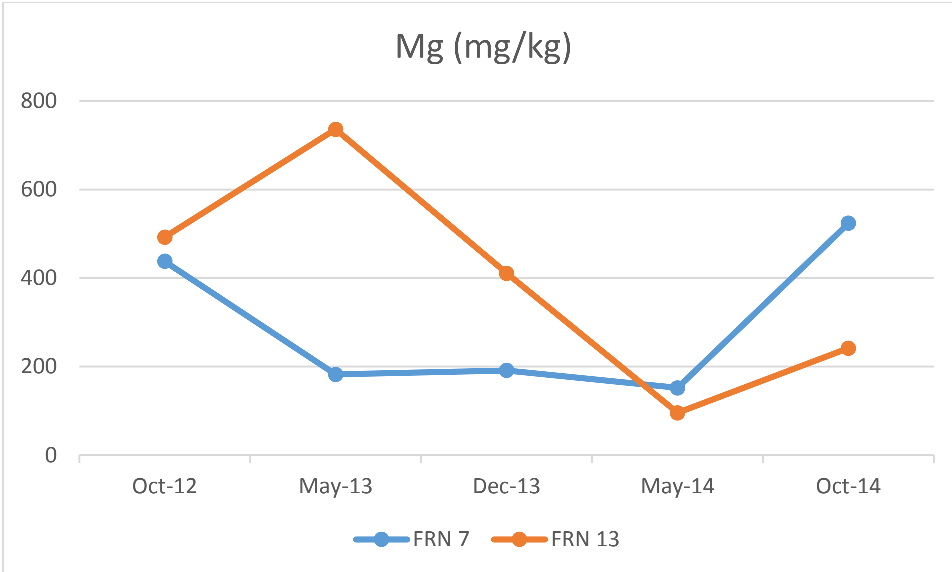
2.4.2.5 Soluble K (mg/kg)



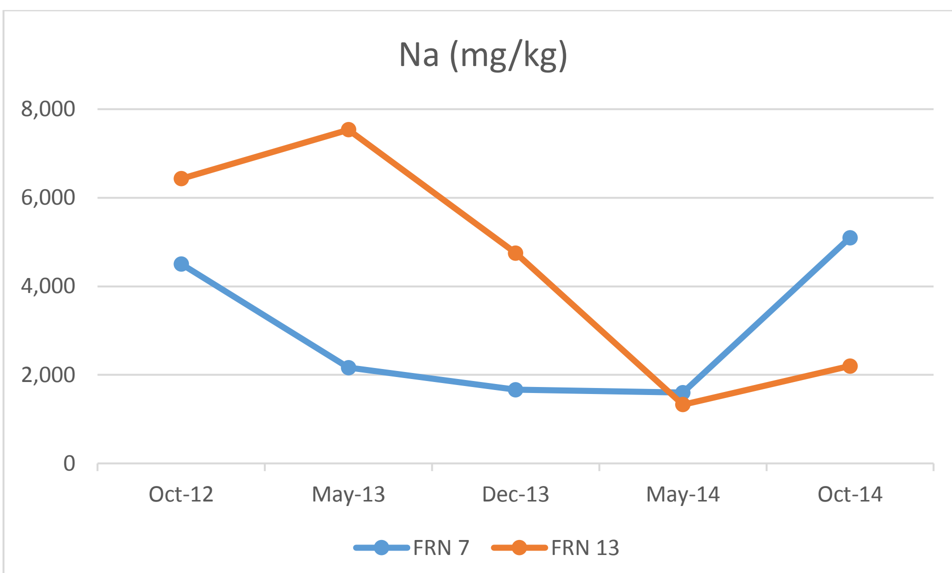
2.4.2.6 Soluble Ca (mg/kg)



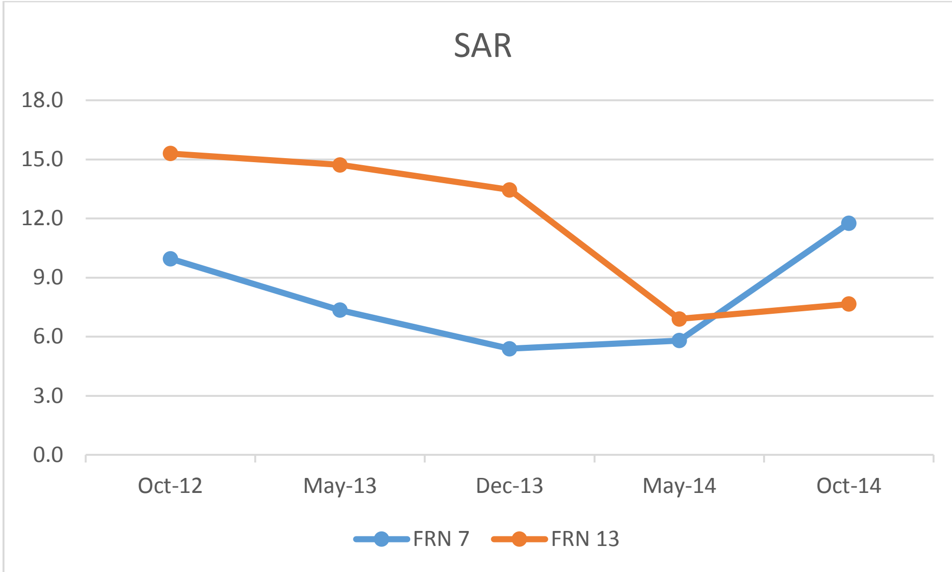
2.4.2.7 Soluble Mg (mg/kg)



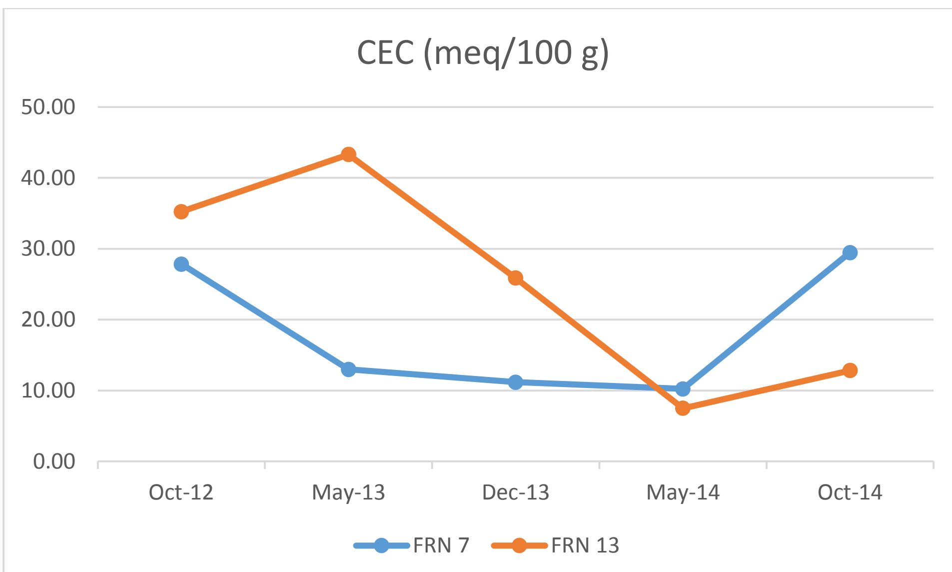
2.4.2.8 Soluble Na (mg/kg)



2.4.2.9 Sodium absorption ratio



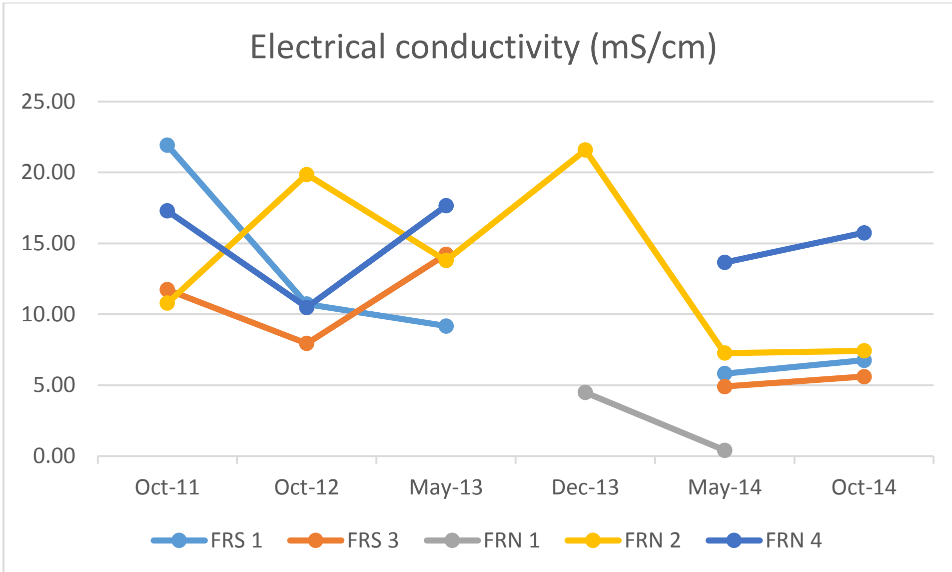
2.4.2.10 Cation exchange capacity (meq/100 g soil)



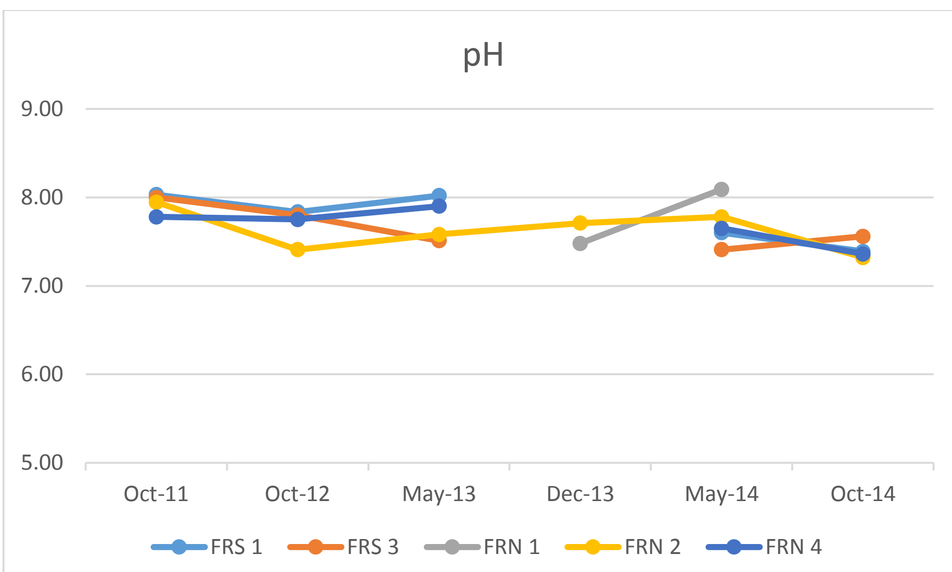
By topography, Ridge slope sites could be the place that accumulated washed-off elements from the Ridge top. The washed-off elements, such as Na can limit the plant growth where it passes through. Even though the salinity parameter seem to be not very high, the dynamic change would be a big variable. Therefore, these sites will be suitable for plant after Ridge top already has plant establishment.

2.4.3 Marsh (FRN 1-5 and FRS 1-5)

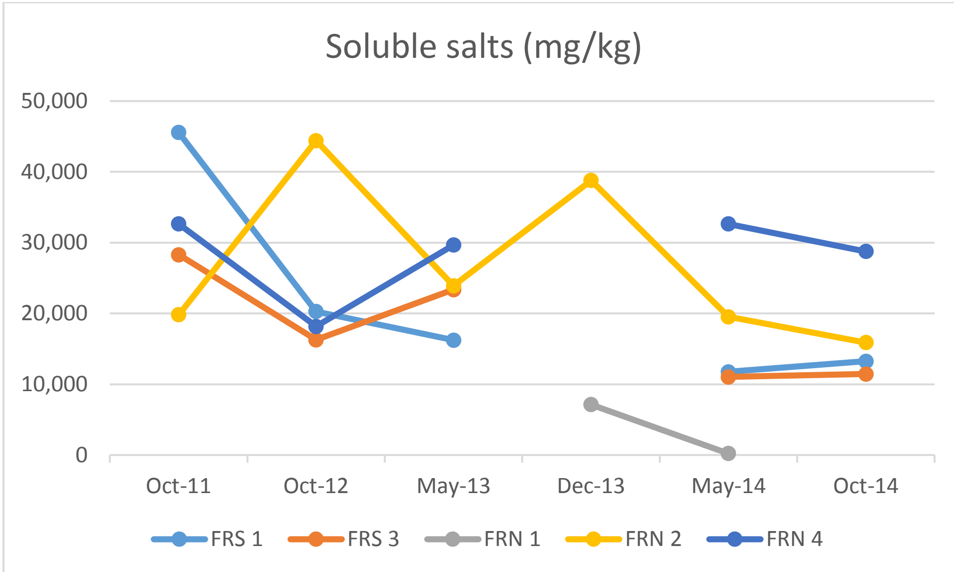
2.4.3.1 Electrical conductivity (mS/cm)



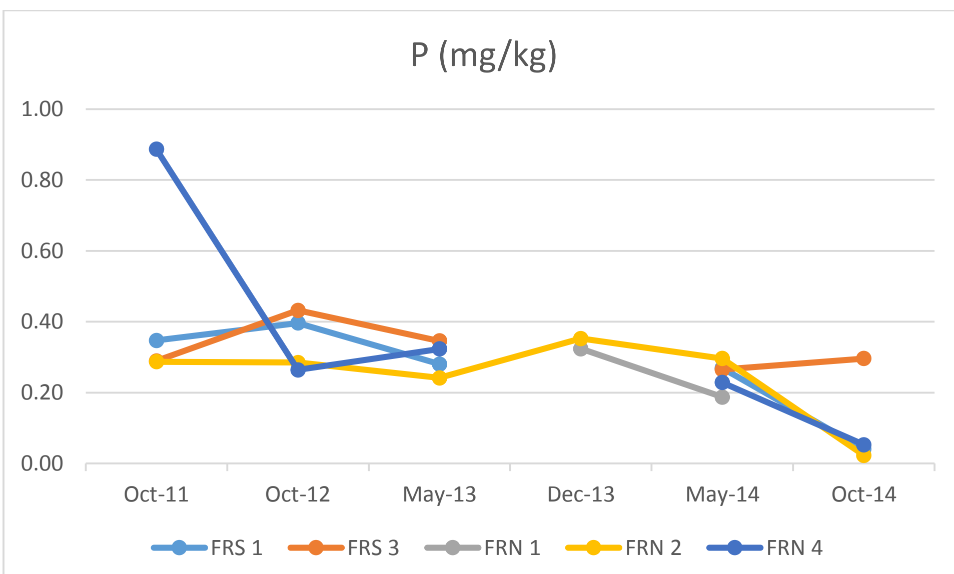
2.4.3.2 pH



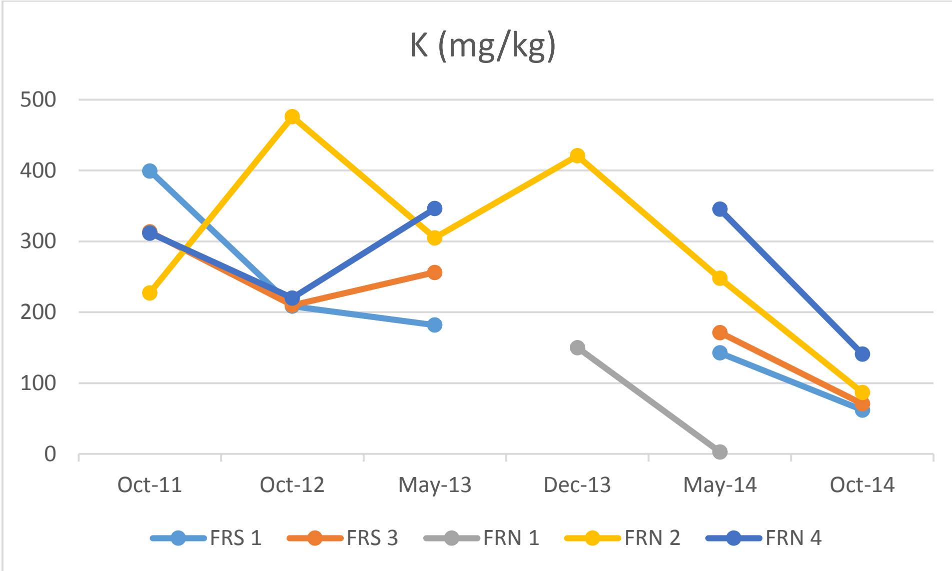
2.4.3.3 Soluble salts (mg/kg)



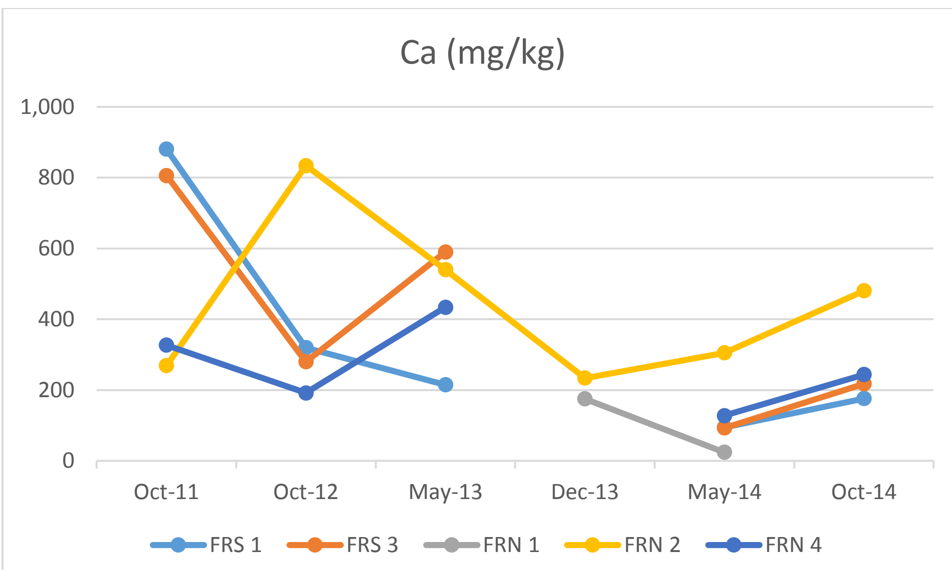
2.4.3.4 Soluble P (mg/kg)



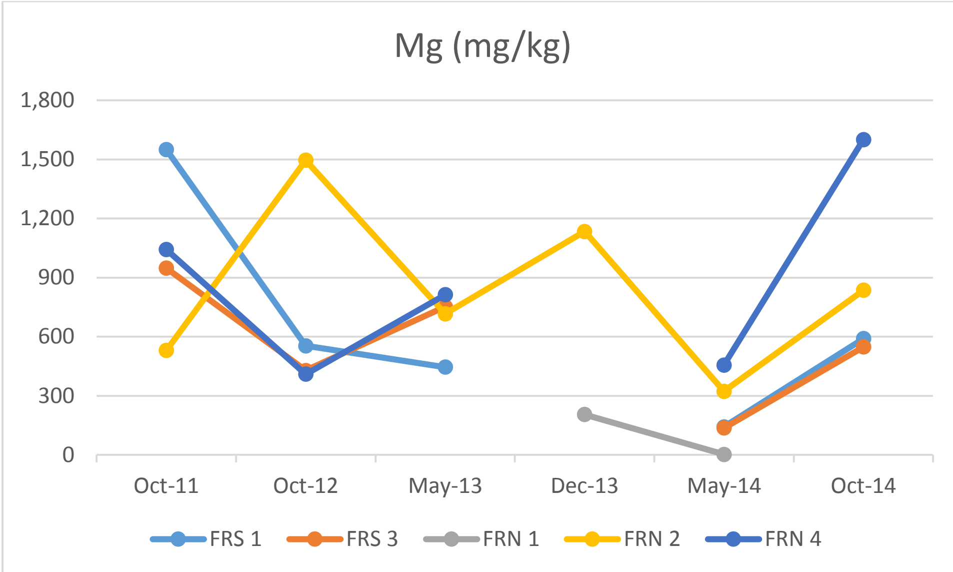
2.4.3.5 Soluble K (mg/kg)



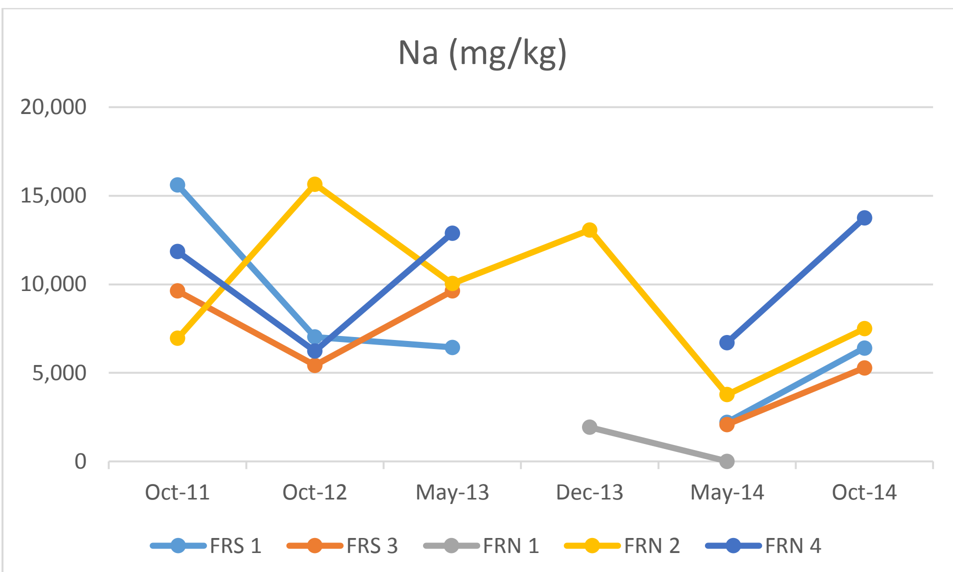
2.4.3.6 Soluble Ca (mg/kg)



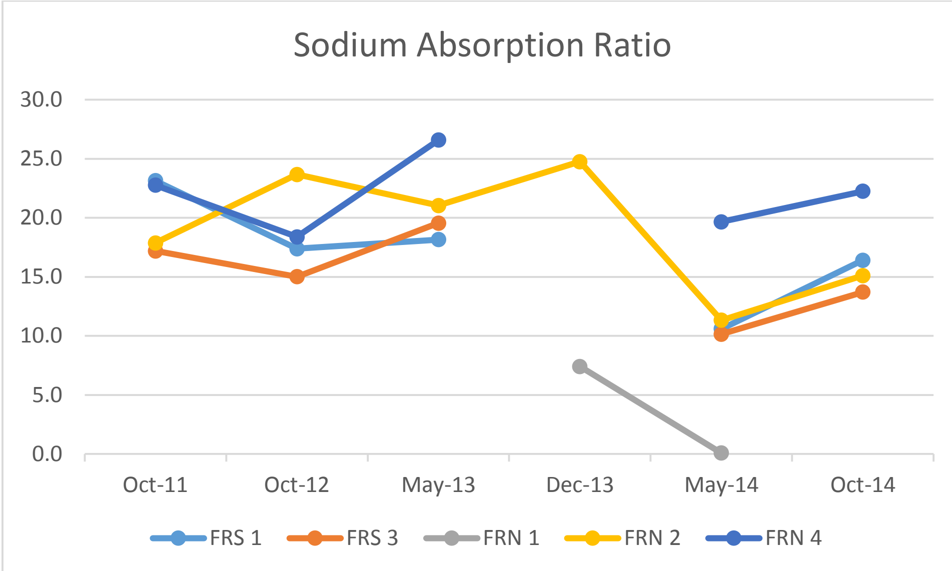
2.4.3.7 Soluble Mg (mg/kg)



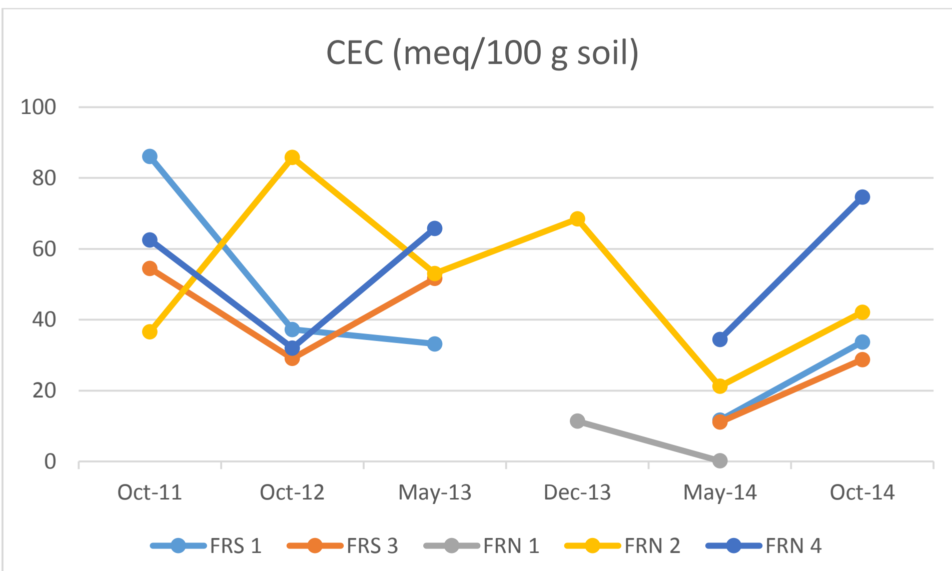
2.4.3.8 Soluble Na (mg/kg)



2.4.3.9 Sodium absorption ratio



2.4.3.10 Cation exchange capacity (meq/100 g soil)



The test results from these marsh sites were highly variation as compared to the marsh from mitigation area (MA9, MA10), and middle ridge area (MR2, MR4, MR7, and MR9). The data indicated that the dynamic change still far from equilibrium point. However, in the marsh which influenced by sea water would be related to quality of sea water.

Overall, soil pH within individual sampling sites were not highly different. The lower pH values were found in the marsh area and the lowest was 6.38, while the highest pH (8.45) was found in Middle Ridge North (MRN1). This site was created in 2011 using a pipeline slurry outfall consisting entirely of oyster shell which would explain the high pH value.

Water extractable phosphorus (P) levels were very low in all sites. The maximum was 6.9 mg/kg in Far Ridge area. The average was less than 1 mg/kg. However, it would not be a limiting factor for plant growth in the salt-affected environment because the method used for the analysis was based on a "water soluble" method.

Extractable potassium (K) was also based on a "water soluble" method. The lowest level was 6.8 mg/kg in Mitigation Area and the highest level was observed in Middle Ridge area (486 mg/kg). This level would not likely be a limiting factor for plant growth in a saltmarsh environment.

Extractable calcium (Ca) was lowest in Mitigation area (5.9 mg/kg) and the highest (954 mg/kg) in the Far Ridge area. The lowest concentration of water soluble magnesium (Mg) was observed in Far Ridge area (2.3 mg/kg) and the highest concentration was observed in Middle Ridge area (2,330 mg/kg). Sulfur concentration was lowest in Middle Ridge area (1.7 mg/kg) and highest in Far Ridge area (2,016 mg/kg).

Water soluble micronutrient (Fe and MN) and Cation Exchange Capacity (CEC). In this assay, soil micronutrient was limited to only two metals; iron (Fe) and manganese (Mn). The lowest Fe level was near 0 mg/kg in all sampling areas, and the highest concentration was observed in Middle Ridge area (130 mg/kg). The concentration of Mn has a similar trend as the concentration of Fe, where the lowest value was near 0 mg/kg in all sites and the highest value observed only in the Far Ridge area (13.2 ppm).

Cation exchange capacity was calculated based on the sum of cations method (Ca, Mg, K, and Na). Therefore, the CEC values were highly influenced by saline environment, which contain high sodium and calcium concentration. The lowest CEC was observed in Far Ridge area (0.2 meq/100 g soil), and the highest was found in Middle Ridge area (121 meq/100 g soil).

3 Comparison and correlation of results from the A&L lab (Mehlich III extraction) and the LSU Lab (1:2 water extraction).

This comparison between the results of the two extraction methods; a) the 212 samples were analyzed at the A&L Lab by Mehlich III extraction. These samples were collected from 6 different times in May 2008, January 2009, August 2009, January 2010, August 2010, and February 2011, with b) the 256 samples were analyzed at the LSU lab by water extraction method for macro and micro nutrient content. These 256 samples were also collected from 6 different times in October 2012, May 2013, December 2013, May 2014, and October 2014. Electrical conductivity and pH were analyzed based on soil slurry from both labs. The ratio of 1:1 of soil and water was used at the A&L lab and the ratio of 1:2 was used at the LSU lab. Due to the difference in the sampling times, the data for the comparison was calculated from an average of all the sampling times of each site. Although this comparison is not the best approach, it is the only way to compare the two methods from available data. Simple linear correlation coefficients and graphs were obtained for each pair of the results. Most of the test results from both labs were comparable, which could be used as a baseline information for future studies, particularly for monitoring salinity and nutrient content of the sites. The graphs below are some comparisons of the important parameters for soil in the saltmarsh environment.

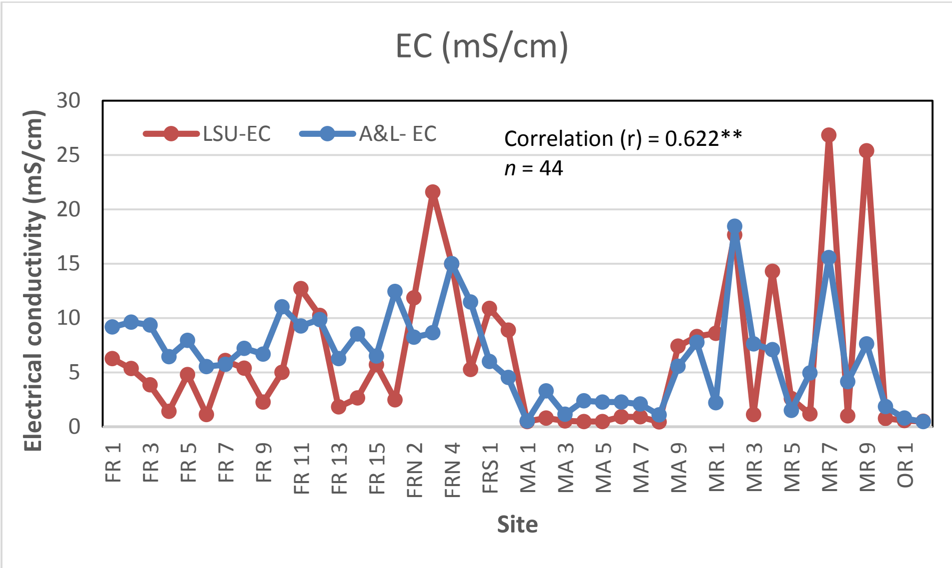


Figure 3.1. Correlation of EC between A&L and the LSU soil testing laboratory. Even though the time frame for sampling are different (2008-2011 for the A&L lab and 2012-2014 for the LSU lab), the trend of results are the same pattern.

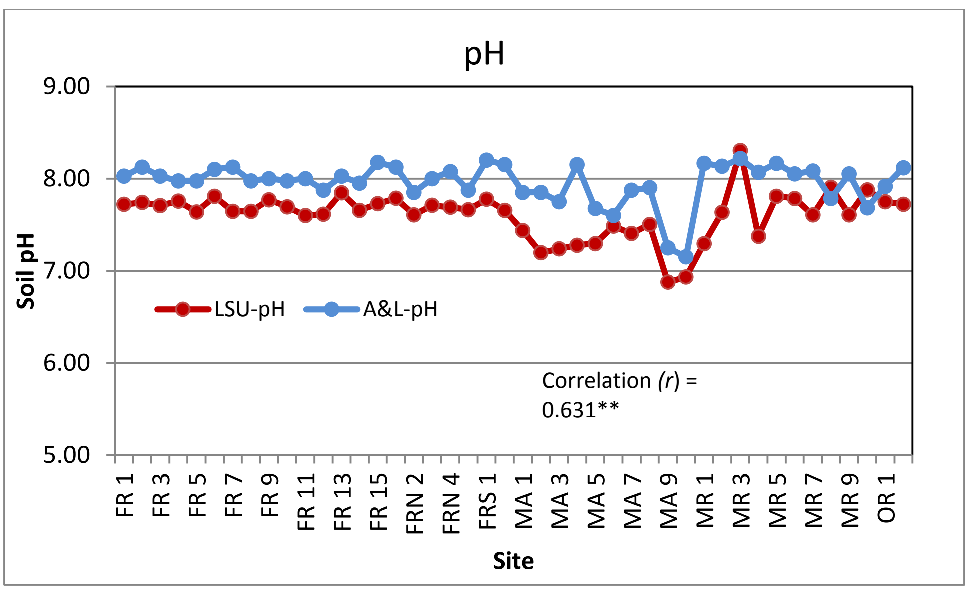


Figure 3.2. Comparison of pH between the A&L and the LSU lab. pH of the A&L lab were higher than the LSU lab that might be the deferent of the soil slurry of 1:1 of the A&L lab as compared to 1:2 of the LSU lab.

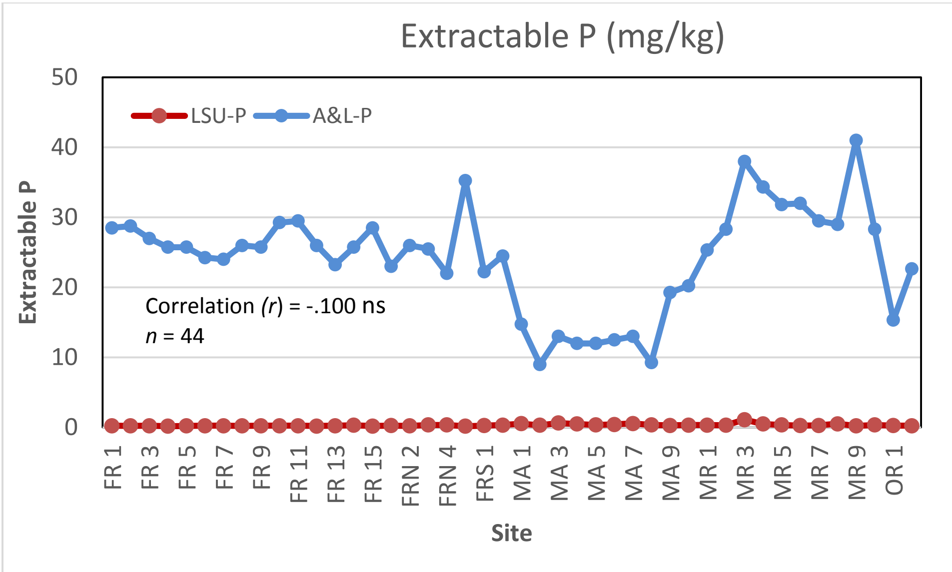


Figure 3.3. Comparison of phosphorus (P) concentrations between A&L and the LSU soil testing laboratory. The values from two labs were not related and the higher values were observed for the data from A&L lab because of the Mehlich III (an acid mixture) has a stronger potential to remove not only P in the pore water but also from the soil particles, while at the LSU Lab, only P in porewater can be released by water extraction.

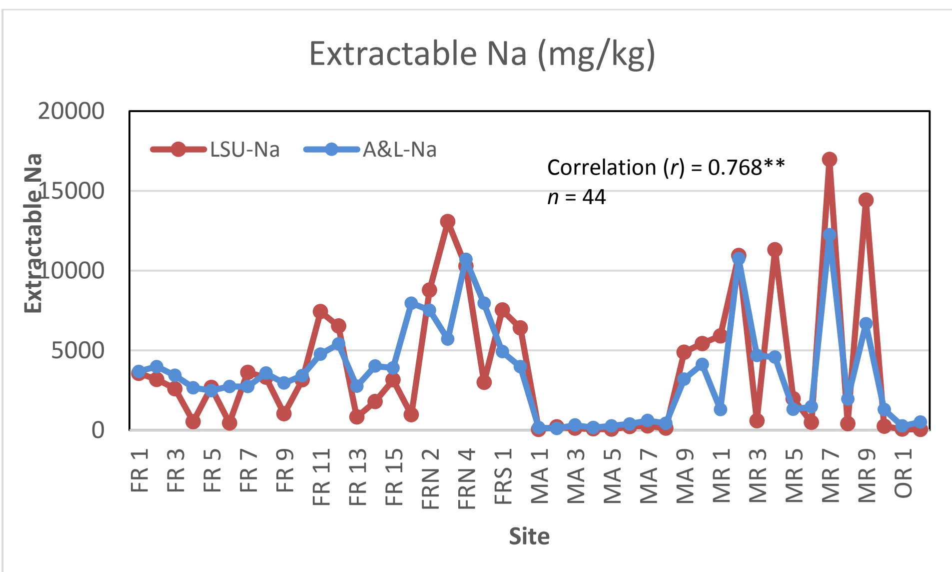


Figure 3.4. Comparison of extractable sodium (Na) concentrations between A&L and the LSU soil testing laboratory. Acid extraction and water extraction methods were similar in Na content. This because of the major portion of sodium were in porewater that can be removed either by water or acid reagents.

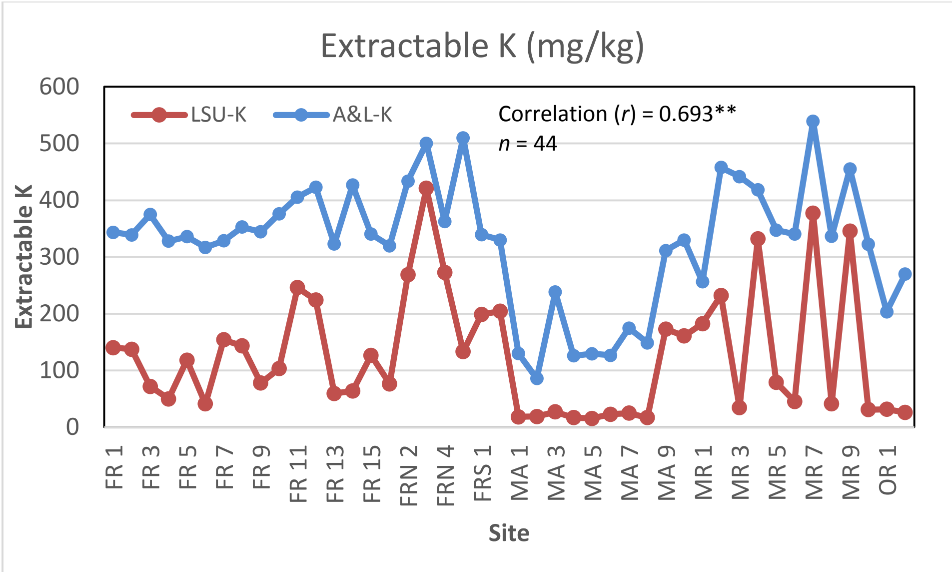


Figure 3.5. Comparison of extractable potassium (K) concentration between A&L and the LSU soil testing laboratory. K was higher with acid extraction. That might be because of K can bind with the soil particle and cannot be easily removed by water extraction.

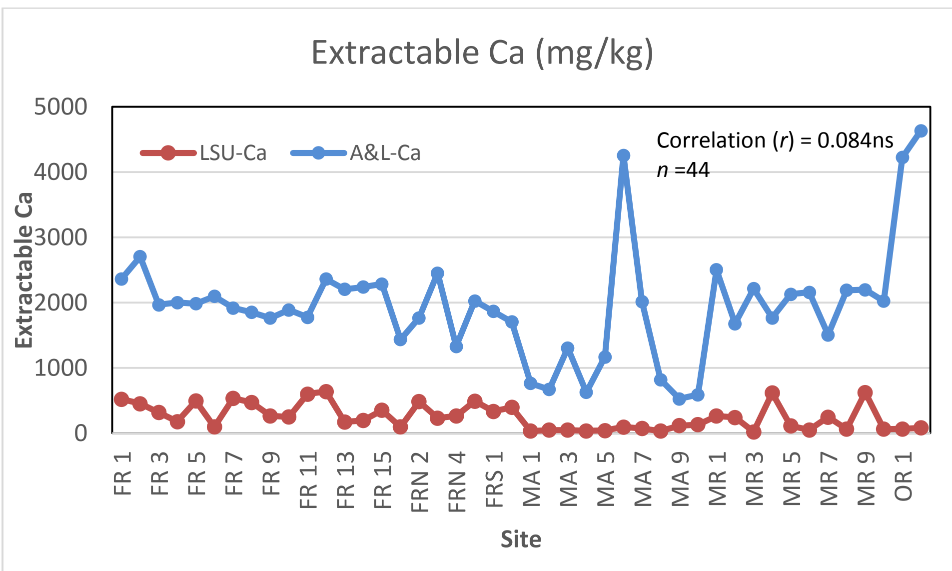


Figure 3.6. Comparison of calcium (Ca) concentrations between A&L and the LSU soil testing laboratory. Ca was higher when extracted with acid that might include the calcium from both oyster shell and Ca ions that bind with the soil particles.

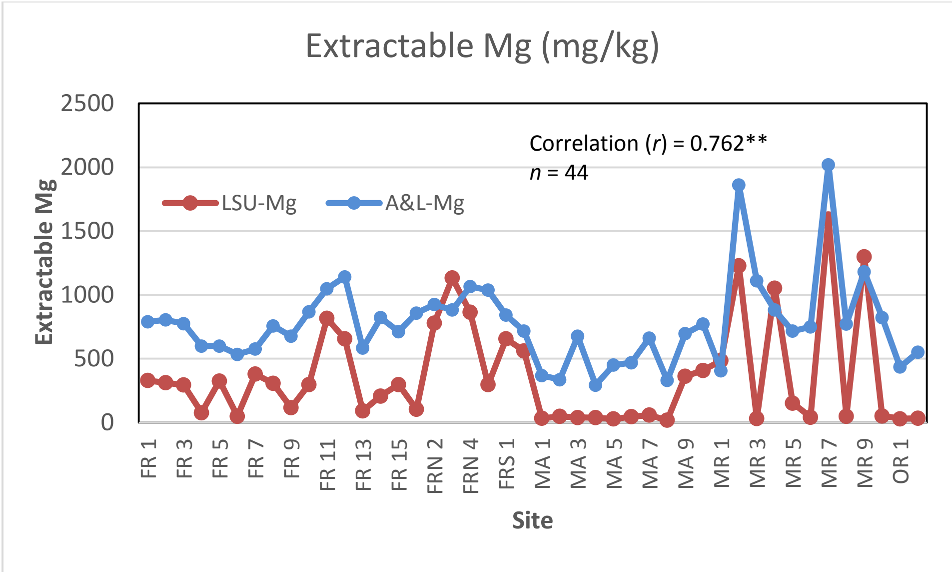


Figure 3.7. Comparison of magnesium (Mg) concentrations between A&L and the LSU soil testing laboratory. Extractable Mg were similar trend with K, and Ca. It was higher with the acid extraction.

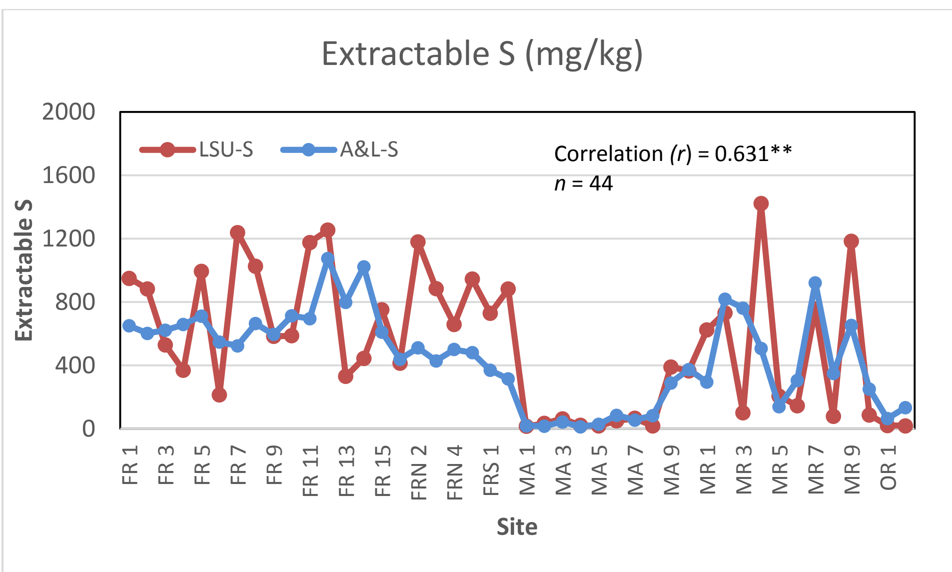


Figure 3.8. Comparison of sulfur (S) concentrations between A&L and the LSU soil testing laboratory. The concentration of S has the same trend with Na that indicated both Na and S were highly dissolved in the water and mostly hold in the porewater instead of binding with soil particles.

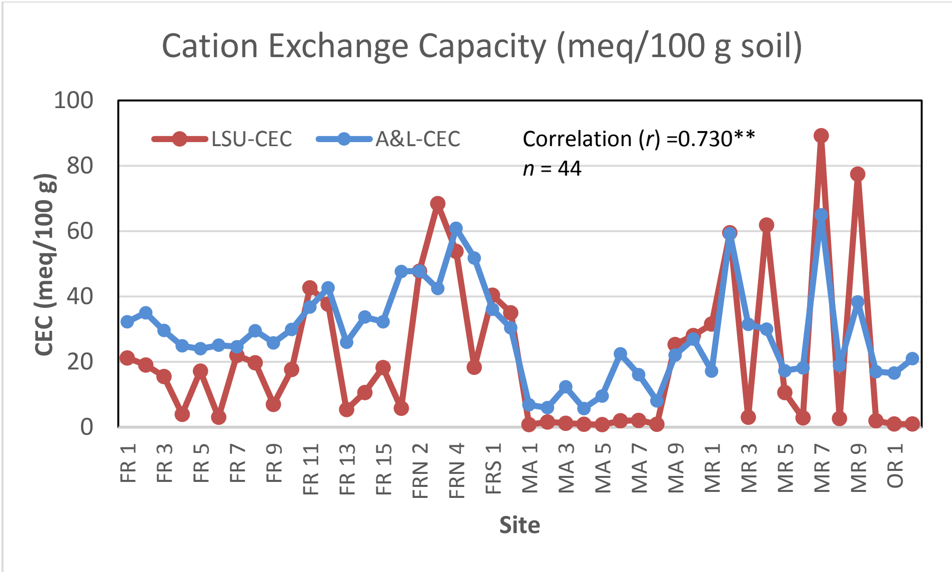


Figure 3.9. Comparison of CEC (cation exchange capacity) between A&L and the LSU soil testing laboratory. CEC was higher with acid extraction in most sites that because of the higher concentration of the cations.

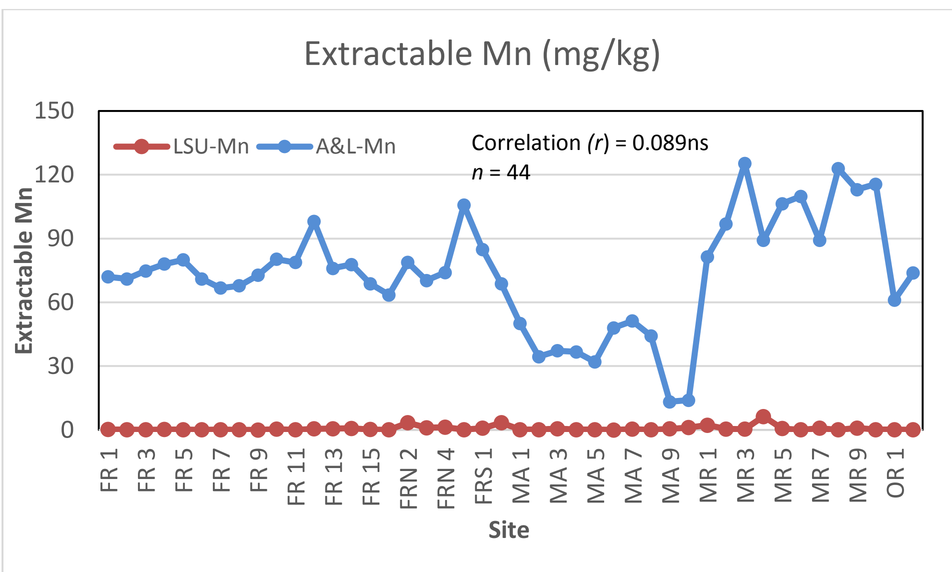


Figure 3.10. Comparison of manganese (Mn) between the A&L and the LSU soil testing laboratory. Mn were higher in the acid extraction than water extraction. This also can explain that Mn is mostly bind with soil particles and would not easily remove by water.

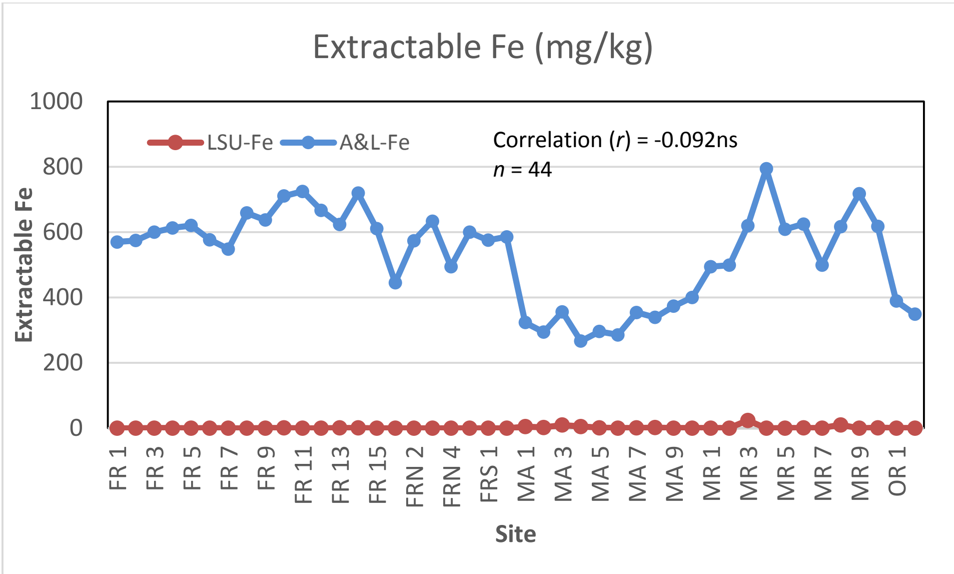


Figure 3.11. Comparison of Iron (Fe) between the A&L and the LSU soil testing laboratory. Fe were significantly higher with acid extraction method than water extraction. Fe is an oxidative element which can binding with other elements under different oxidation-reduction condition.

From the comparison charts above, pH and EC from both labs were determined in the same method (under soil slurry) but the ratio between soil and water might be different. From the pH value, the A&L lab would be used the ratio of 1:1 which the LSU lab used 1:2. The trend was the same with EC, except for some sites that the LSU lab has higher values that might be because of different in sampling times.

The macronutrient content i.e. phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) were significantly higher by acid extraction. However, sodium (Na) and sulfur (S) were not deferent from both methods. These macronutrients are important to plant growth and seem to be adequate for most plant species. These elements are not major limiting factors for plant growth for the coastal or saltmarsh environments. The limiting factors for the plant growth would be the high level of salinity, which includes sodium (Na), soluble salts, and electrical conductivity or salinity.

CEC by the sum of cation methods or also known as effective cation exchange capacity (ECEC) is generally high in coastal saltmarsh environments due to the high content of cations such as sodium (Na), calcium (Ca), Magnesium (Mg), and potassium (K). Usually, the direct CEC measurement will only include the sodium and other cations that bind to the exchangeable sites in the soil particles and would be a good indicator of soil fertility. However, these CEC values are not a good indicator for soil fertility status in coastal saltmarsh environments because this method of CEC calculation includes both the sodium that binds to the exchangeable sites in the soil particles and the free sodium in the porewater. Thus, the sodium amount can be very excessive and lead to higher levels of CEC than the actual amount. Unfortunately, both the A&L and LSU labs did not provide the direct CEC measurement, so this method should not be used to determine soil fertility.

Micronutrient (Mn and Fe) were significantly higher by acid extraction as compared to water extraction. However, at the beginning step for introducing plant species for saltmarsh restoration, micronutrient would not be a major factor for consideration. As soon as the salinity decreased (electrical conductivity or salinity) to certain level for specific plant species that would be the proper time to start restoration by planting.

SUMMARY

Soil test package from the A&L lab included several parameters, particularly for soil fertility evaluation and nutrient management for agricultural production The parameters included were organic matter, CEC, pH (and pH buffer), electrical conductivity, nitrate, macronutrients (P, K, Ca, Mg, S, Na) and micronutrient (Zn, Mn, Fe, Cu, B). Macro- and micronutrient analysis were based on the Mehlich III extraction method.

At the LSU lab, the “flood” package is an analysis method for soil in salt-affected environments such as levee, marsh, and constructed or restoration sites. The test parameters included pH, electrical conductivity (and salinity), soluble salts, CEC, SAR, macronutrients (P, K, Ca, Mg, Na, S) and micronutrients (Fe, Mn, Cl). Macro- and micronutrients were analyzed based on 1:2 (soil: water ratio) water extraction.

A comparison between the same test results from each lab (as shown in section 3 above), show a very close correlation to one another. The correlation between EC, pH, K, Mg, Na, S, CEC, and electrical conductivity are highly significant with the *r* values of 0.622**, 0.631**, 0.693**, 0.762**, 0.768**, 0.631**, and 0.730, respectively. However, the correlation between P, Ca, Fe, and Mn were not significantly related (-0.100ns, 0.084ns, -0.092ns and 0.089ns, respectively). The highly significant correlation indicated that either test results from the A&L lab or the LSU lab can be used for interpretation of the soil property status of each location.

Salinity (or electrical conductivity) of soils from the LSU Lab can be used as a standard for selecting a specific plant species which has a different degree of salt tolerance to grow in each location. SAR can be used as an indicator of the level of difficulty for reclamation of salt-affected soil. Although reclamation for the establishment of non-halophyte plants would not be the best option for saltmarsh restoration, the information for physical and chemical properties of the soil should be learned before introducing a specific plant species to each location.

Overall, the soil test results were highly related to the sampling locations from both labs, particularly, the salinity parameters. These salinity related factors are likely to be major limiting factors for plant growth. The older constructed marshes ridges would contain lower levels of these limiting factors due to the dynamic cycle that occurs over a long period of time. From a nutrient concentration standpoint, nutrient levels would be sufficient for the growth of most wetland plant species. Therefore, following marsh and ridge creation utilizing saline marsh sediments, non-halophytic plant species should not be immediately introduced to the area, because the higher salinity related parameters would restrict plant growth.

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APPENDIX

Appendix Figure 1. Map of the entire area of sampling sites.

Appendix Figure 2. Map of sampling sites for Mitigation Area.

Appendix Figure 3. Map of sampling sites for Middle Ridge area.

Appendix Figure 4. Map of sampling sites for Far Ridge area.

Appendix Table 2. Soil physical and chemical properties for samples collected in May 2008 (A&L Lab)

Sample ID	O.M. (%)	CEC (meq/100g)	pH	Buffer pH	EC (mS/cm)	P	K	Ca	Mg	S	Na (mg/Kg)	Zn	Mn	Fe	Cu	B	NO_3
OR 1	1.3	30.7	8.50	6.98	2.07	18	396	12970	920	134	512	6.4	118	574	3.6	2.0	10
OR 2	1.6	26.9	8.50	6.98	0.36	30	448	9562	900	462	1838	6.6	130	558	2.6	3.0	12
MR 1	0.9	12.6	8.90	6.98	1.22	44	524	2370	648	330	2202	5.8	164	814	2.0	3.8	10
MR 2	0.5	57.0	8.30	6.88	26.00	36	708	1784	3182	1594	18598	4.0	108	682	1.4	7.4	10
MR 3	0.7	43.4	8.20	6.93	11.30	60	822	3982	2528	2280	11410	6.6	228	1078	3.4	5.2	12
MR 4	0.5	28.1	8.40	6.97	2.75	62	594	2580	1314	726	7918	5.4	152	1518	1.0	4.4	10
MR 5	1.0	19.1	8.30	6.96	2.73	54	614	3620	1400	352	2666	8.2	200	1210	3.8	3.4	10
MR 6	1.2	19.8	8.40	6.96	20.10	64	670	3550	1482	530	2880	8.0	232	1416	2.4	4.2	10
MR 7	0.6	65.9	8.10	6.85	6.61	42	762	2724	3746	2320	20800	5.0	158	854	1.8	6.2	10
MR 8	1.3	29.9	8.10	6.95	15.60	46	754	4162	1976	1082	6080	7.8	244	1342	2.4	5.6	10
MR 9	0.9	57.0	8.20	6.93	5.08	76	830	2978	3008	1680	17756	7.6	248	1308	2.6	8.2	10
MR 10	1.7	26.4	8.50	6.97	0.75	60	816	4308	2014	1126	4212	8.8	334	1614	1.4	7.6	10

EC = Electrical conductivity

Appendix Table 3. Soil physical and chemical properties for samples collected in January 2009 (A&L Lab)

Sample ID	O.M.	CEC	pH	Buffer pH	EC	P	K	Ca	Mg	S	Na	Zn	Mn	Fe	Cu	B	NO_3
	(%)	(meq/100g)			(mS/cm)						(mg/Kg)						
MA 1	2.1	8.0	8.00	7.00	0.33	13	164	867	378	31	304	4.3	50	327	1.1	1.2	7
MA 2	1.5	5.9	8.10	6.98	0.29	9	101	640	267	23	246	3.2	31	298	0.8	0.8	5
MA 3	2.5	11.2	8.30	6.96	0.23	12	213	1189	579	18	360	4.6	45	372	1.4	1.6	5
MA 4	1.1	6.7	8.30	7.00	0.40	13	172	719	267	20	324	3.4	42	279	0.7	0.6	5
MA 5	1.8	10.4	7.90	7.00	0.91	12	158	1263	362	34	526	3.8	38	313	0.9	0.7	5
MA 6	3.9	20.5	8.00	7.00	0.99	13	166	3567	462	94	575	3.9	43	380	1.1	1.7	5
MA 7	3.8	18.3	7.60	6.96	2.39	15	234	1742	598	105	1432	5.7	63	392	1.2	2.1	5
MA 8	0.8	8.0	7.90	6.99	1.11	9	154	842	315	95	439	3.1	38	353	0.7	0.9	5
MA 9	0.9	17.2	7.50	6.97	5.51	20	281	500	507	195	2452	3.7	11	345	0.9	2.0	5
MA 10	1.5	26.4	7.00	6.98	7.41	26	346	689	697	351	4035	5.0	14	483	1.2	3.0	5
OR 1	2.2	13.2	7.80	6.97	0.81	18	220	1753	464	109	499	5.1	42	472	1.3	1.5	5
OR 2	1.9	24.2	8.50	7.00	0.46	21	222	4850	387	51	344	4.1	64	261	1.5	1.0	5
MR 1	0.9	20.6	8.20	6.99	3.77	30	274	2171	403	423	1901	6.8	71	598	1.7	2.2	5
MR 2	0.6	65.1	8.30	6.96	19.90	34	468	2049	1666	689	9911	3.5	100	561	1.3	4.4	5
MR 3	1.1	59.9	7.90	6.97	14.60	40	534	2525	1575	940	8421	5.2	142	648	3.3	4.4	5
MR 4	1.4	39.1	8.10	7.00	10.10	33	447	1919	927	550	5361	4.6	102	782	1.1	3.9	5
MR 5	1.5	16.9	8.10	7.00	1.97	29	303	1805	559	233	1085	3.8	88	565	2.0	1.7	5
MR 6	3.0	17.8	8.00	6.98	2.09	32	296	1929	611	266	1094	4.5	83	520	2.0	2.0	5
MR 7	1.3	79.1	8.00	6.96	22.00	38	725	1640	1674	809	13340	4.4	89	457	1.3	5.0	5
MR 8	1.1	18.0	7.70	7.00	1.87	34	360	1907	576	293	1187	4.9	117	521	2.4	2.7	5
MR 9	0.6	33.1	8.00	6.99	8.45	49	397	1638	691	344	4687	4.1	91	669	1.0	3.1	5
MR 10	3.4	18.7	8.10	6.96	0.98	34	344	2081	783	168	835	7.1	94	514	2.8	2.5	5
FR 1	1.3	39.2	8.00	6.98	12.10	36	420	2881	859	717	4641	9.3	98	716	2.2	3.5	5
FR 2	1.0	37.9	8.10	6.98	9.55	35	367	2519	817	684	4786	8.4	90	719	1.5	2.9	5
FR 3	0.9	35.3	8.10	6.99	8.62	31	353	2532	750	589	4311	8.6	85	672	2.4	2.7	5
FR 4	0.9	32.0	7.90	7.00	8.51	30	337	2188	698	640	3950	8.1	96	649	1.9	2.9	5
FR 5	1.0	25.9	8.10	6.99	5.10	31	337	2107	630	662	2754	8.6	116	710	1.9	2.9	5
FR 6	0.7	30.4	8.00	6.99	5.92	26	324	2317	660	566	3537	6.9	90	591	1.6	2.3	5
FR 7	0.7	25.5	8.10	7.00	6.22	23	295	2045	546	469	2888	6.0	77	596	1.5	2.2	5
FR 8	1.3	29.7	8.00	7.00	6.47	29	361	2284	670	601	3374	8.8	86	756	1.6	3.1	5
FR 9	1.1	34.6	7.90	6.98	0.94	33	373	2270	757	699	4353	8.5	89	766	1.5	3.1	5
FR 10	1.5	45.9	8.00	6.97	12.90	38	462	2296	1121	736	6233	10.5	115	780	1.5	3.6	5
FR 11	1.3	44.8	8.00	6.97	11.80	33	431	2090	1105	620	6212	10.3	109	763	1.4	3.6	5
FR 12	1.5	50.3	8.00	6.98	11.80	27	485	2665	1199	963	6763	10.3	123	769	1.8	3.9	5
FR 13	0.9	34.9	7.90	7.00	9.80	27	353	2478	771	900	4218	8.3	96	693	1.9	2.9	5
FR 14	1.8	49.0	7.80	6.94	13.50	30	476	3015	1081	1365	6351	10.4	110	767	1.6	4.0	5
FR 15	0.7	33.6	8.10	6.99	8.15	35	342	2567	676	644	4008	7.3	85	726	1.3	2.6	5
FRN 1	0.8	46.4	8.10	7.00	14.70	25	378	1702	1044	599	7075	5.3	67	483	1.3	3.4	5
FRN 2	2.1	36.8	7.90	6.98	9.75	27	418	2046	871	523	4836	8.3	81	648	2.0	4.5	5
FRN 3	2.3	38.2	8.00	6.99	9.25	29	466	2369	909	538	4778	6.1	73	712	1.5	4.0	5
FRN 4	1.0	41.9	8.00	6.99	11.70	26	390	1833	822	441	6306	7.2	82	596	1.3	3.2	5
FRN 5	2.2	45.7	7.70	6.99	11.00	38	489	2213	1019	488	6422	12.4	115	702	1.8	4.5	5
FRS 1	0.9	42.8	8.10	6.99	11.80	26	405	2048	996	517	6006	4.9	75	675	1.6	3.5	5
FRS 2	0.7	39.1	8.40	6.99	10.50	26	353	2172	807	399	5406	6.1	83	547	1.4	3.1	5
FRS 3	1.3	31.3	8.30	7.00	6.89	32	395	2027	768	340	3780	5.4	74	724	1.2	3.5	5
FRS 4	1.0	59.1	8.40	6.98	16.50	32	503	2636	1331	648	8576	4.4	69	668	1.1	4.0	5
FRS 5	1.2	31.5	8.10	7.00	7.21	32	405	2088	688	483	3920	8.1	135	680	2.0	3.8	5

Appendix Table 4. Soil physical and chemical properties for samples collected in August 2009 (A&L Lab)

Sample ID	O.M.	CEC	pH	Buffer pH	EC	P	K	Ca	Mg	S	Na	Zn	Mn	Fe	Cu	B	NO_3
	(%)	(meq/100g)			(mS/cm)						(mg/Kg)						
MA 1	1.1	6.8	8.10	6.97	0.14	9	121	761	337	18	207	2.9	47	274	0.8	0.7	6
MA 2	0.8	5.4	7.90	6.98	0.10	8	88	598	289	20	149	2.5	37	263	0.8	0.6	5
MA 3	3.9	16.3	7.20	6.88	0.70	16	331	1633	771	111	724	5.7	39	314	2.1	2.3	6
MA 4	1.1	6.3	8.20	6.97	0.12	11	125	663	316	14	219	3.1	41	277	0.9	0.5	6
MA 5	3.6	10.2	7.70	6.93	0.23	13	127	1088	471	39	452	6.0	32	292	1.2	1.2	8
MA 6	3.6	23.9	7.40	6.90	0.87	16	124	4382	464	156	631	4.4	52	224	1.2	1.8	15
MA 7	5.2	16.8	7.70	6.90	0.55	10	129	2344	597	71	611	4.0	49	277	1.1	1.9	14
MA 8	1.0	9.0	7.60	6.97	0.73	9	150	808	357	122	628	2.8	53	302	0.7	1.2	5
MA 9	1.3	27.9	7.20	6.98	3.80	17	255	543	797	351	4370	4.2	15	299	1.1	2.9	5
MA 10	2.4	34.6	7.00	6.91	9.17	18	288	652	949	471	5540	4.8	16	357	1.3	3.8	5
OR 1	2.3	12.2	8.10	6.95	0.35	15	224	1741	414	61	364	3.8	52	484	1.5	1.5	5
OR 2	4.2	21.0	7.90	6.96	0.33	21	205	3940	512	54	239	5.8	64	282	1.7	1.8	7
MR 1	1.1	29.0	8.00	6.97	4.86	19	241	3384	555	503	2492	6.4	71	425	1.7	2.3	5
MR 2	0.8	68.7	8.00	6.89	13.80	19	434	1526	1993	688	10665	3.8	90	463	1.3	3.9	5
MR 3	0.8	21.7	8.30	6.98	2.73	31	287	1606	578	454	2359	3.3	88	484	1.5	3.0	5
MR 4	1.0	31.5	7.90	6.96	5.40	32	304	1494	746	350	4400	3.6	87	645	0.7	2.7	5
MR 5	1.4	15.8	7.80	6.93	0.84	30	297	1966	555	70	705	3.7	105	467	2.1	1.4	5
MR 6	1.5	19.5	8.00	6.96	1.26	22	286	1936	668	275	1387	4.0	92	466	2.0	1.9	5
MR 7	1.0	82.5	7.90	6.91	12.90	22	499	1337	2544	758	13007	3.4	83	462	1.1	5.4	5
MR 8	1.0	21.4	7.80	7.00	2.78	25	260	1751	645	355	2048	3.7	97	475	2.0	2.1	5
MR 9	1.8	40.4	7.80	6.95	6.52	31	336	1602	1042	502	5823	3.9	110	585	1.0	4.4	5
MR 10	3.3	13.0	7.80	6.95	0.59	21	208	1429	599	57	523	5.1	73	388	1.8	1.5	5
FR 1	1.7	26.7	8.00	6.96	12.50	25	293	2196	776	761	2619	7.9	63	450	3.6	3.4	8
FR 2	1.3	29.5	8.00	6.97	12.70	24	274	2910	740	594	2687	7.6	56	424	3.4	2.9	9
FR 3	1.1	25.8	7.90	7.00	13.00	26	293	1633	864	743	2755	7.1	62	450	3.4	3.1	8
FR 4	1.0	17.4	8.00	6.98	5.35	24	244	1396	379	462	1934	6.3	52	488	2.8	3.1	7.66
FR 5	1.0	21.7	7.90	7.00	9.91	25	267	1511	581	642	2456	6.8	57	468	3.3	3.3	15
FR 6	0.9	17.5	8.20	6.99	4.54	21	231	1810	335	348	1661	5.7	57	390	3.3	2.3	12.8
FR 7	1.2	19.7	8.00	7.00	2.88	22	254	1605	417	399	2199	4.3	57	387	3.1	2.8	7.64
FR 8	1.5	24.9	7.80	7.00	5.86	25	298	1515	796	734	2773	8.0	54	493	3.5	3.5	7.11
FR 9	1.3	24.2	7.90	6.95	13.80	25	287	1339	836	665	2727	8.1	64	508	2.3	2.6	7
FR 10	1.3	26.4	7.80	6.97	14.90	26	296	1508	987	834	2794	8.1	62	585	3.4	3.5	7
FR 11	1.4	26.1	7.90	6.95	14.90	26	312	1481	974	752	2765	8.9	74	594	2.6	3.5	7
FR 12	1.4	24.7	7.80	6.96	14.40	27	293	1372	873	768	2730	8.4	82	541	2.5	3.4	7
FR 13	1.6	22.9	7.90	7.00	7.71	24	279	2033	602	977	2198	8.4	70	540	2.8	3.2	7
FR 14	2.0	24.0	7.90	6.96	11.80	24	298	1752	663	808	2589	8.2	65	532	2.7	3.5	7
FR 15	0.9	20.5	8.20	6.97	6.49	24	238	1872	427	456	2126	5.5	61	472	2.7	2.4	8
FRN 1	0.8	34.3	8.30	6.96	14.40	21	289	1389	914	384	4845	4.1	72	447	0.9	3.1	6
FRN 2	2.6	41.8	7.90	6.96	13.90	27	430	1596	1121	482	5955	7.0	85	544	1.3	4.6	5
FRN 3	1.7	35.5	8.10	6.99	9.58	17	380	3136	789	340	3725	4.5	59	504	1.6	2.6	5
FRN 4	0.7	54.5	8.10	7.00	20.60	22	411	1239	1427	534	8669	4.8	74	476	1.1	4.0	5
FRN 5	3.3	45.4	8.00	6.98	15.00	28	514	1950	1254	497	6163	10.3	102	546	1.5	5.2	5
FRS 1	0.6	34.0	8.10	6.97	6.83	19	278	1575	926	383	4593	2.6	87	513	1.3	2.7	8
FRS 2	0.6	31.1	8.00	6.99	5.70	18	271	2020	718	514	3910	4.5	81	451	1.1	3.2	9
FRS 3	1.1	33.2	7.90	6.97	6.74	24	334	1696	830	389	4455	3.7	58	557	0.9	2.9	6
FRS 4	2.8	41.7	7.90	7.00	15.20	17	432	1747	1073	515	5881	3.9	81	563	0.9	4.6	6
FRS 5	3.3	55.2	7.80	6.97	17.00	27	665	2194	1369	517	7919	10.7	164	547	2.3	6.5	6

Appendix Table 5. Soil physical and chemical properties for samples collected in January 2010 (A&L Lab)

Sample ID	O.M. (%)	CEC (meq/100g)	pH	Buffer pH	EC (mS/cm)	P	K	Ca	Mg	S	Na (mg/Kg)	Zn	Mn	Fe	Cu	B	NO_3
MA 1	1.0	6.6	8.00	6.96	1.47	21	128	760	381	16	93	3.6	56	372	0.9	0.7	5
MA 2	1.9	6.1	7.60	6.97	12.60	10	77	735	363	15	45	3.0	37	282	0.8	0.6	5
MA 3	3.2	11.1	7.30	6.92	3.45	13	176	1324	656	25	96	5.6	24	333	1.3	1.4	5
MA 4	1.2	5.5	8.20	6.99	8.92	13	122	639	314	11	69	3.6	36	275	0.7	0.5	5
MA 5	2.0	8.5	7.80	6.95	7.75	14	131	1324	365	12	47	3.7	33	264	0.8	0.6	5
MA 6	4.9	19.3	7.60	6.96	6.92	13	110	3538	520	49	244	4.1	51	297	1.2	1.9	5
MA 7	4.9	16.6	8.30	6.93	4.93	13	205	2174	817	26	280	6.9	47	365	1.5	2.3	5
MA 8	0.8	9.9	8.00	6.99	2.03	10	179	1023	386	103	579	3.4	44	405	0.8	1.5	5
MA 9	1.5	15.7	7.20	6.95	6.65	24	346	546	687	242	1723	5.6	19	409	1.3	3.5	5
MA 10	1.0	16.8	7.40	6.95	8.37	18	344	518	673	307	2021	4.1	15	340	0.8	2.9	5
OR 1	2.5	16.7	8.00	6.96	0.34	14	161	3334	343	27	128	3.5	57	280	1.8	1.1	5
OR 2	3.1	18.6	7.90	6.93	0.83	17	417	2522	712	173	495	5.2	65	464	3.0	2.6	5
MR 1	0.8	14.5	8.20	6.98	2.23	19	209	2115	296	283	768	5.2	65	428	1.3	1.9	5
MR 2	0.6	43.7	8.20	6.93	18.60	24	381	1534	1254	523	6224	3.3	89	413	1.1	3.5	5
MR 3	0.8	31.1	8.00	6.94	11.20	28	436	1721	841	648	3856	3.5	103	498	1.9	2.8	5
MR 4	0.7	20.2	8.10	6.98	7.83	15	254	1183	484	136	2579	1.9	57	500	0.4	1.4	5
MR 5	3.6	15.2	8.00	6.95	0.12	26	258	1534	566	100	951	4.8	77	481	1.5	2.0	5
MR 6	2.3	16.6	7.70	6.95	2.76	22	261	1856	546	313	1030	3.7	85	453	1.9	2.0	5
MR 7	0.9	42.6	8.10	6.91	21.50	22	351	1011	1273	482	6447	3.2	65	384	1.1	3.4	5
MR 8	0.7	10.8	7.90	6.97	0.17	15	173	1589	346	77	335	2.2	84	430	1.0	0.8	5
MR 9	1.8	28.3	8.00	6.96	9.07	32	351	1676	742	422	3493	4.5	111	643	0.9	3.7	5
MR 10	3.0	10.4	8.00	6.95	0.92	16	187	1256	492	37	285	3.6	67	395	1.5	1.3	5
FR 1	0.7	22.7	8.20	6.97	7.54	27	315	2507	640	509	1649	7.5	60	596	1.4	2.4	6
FR 2	0.7	27.5	8.10	6.98	9.00	32	358	2941	767	559	2091	7.6	71	639	1.9	2.6	5
FR 3	0.9	22.8	8.10	6.97	8.72	29	390	1821	761	617	2023	7.8	76	701	1.5	2.9	5
FR 4	1.1	26.0	7.90	6.96	6.68	31	403	2471	824	978	2053	9.0	85	758	1.6	3.7	5
FR 5	1.0	21.3	7.80	6.93	9.00	27	356	2096	632	802	1682	8.0	70	708	1.9	2.9	14
FR 6	0.6	17.3	7.90	7.00	4.10	27	280	2143	433	585	1112	7.2	65	637	1.5	2.3	5
FR 7	0.8	21.3	8.30	6.97	7.10	23	326	2149	592	524	1726	4.8	66	522	1.3	1.8	5
FR 8	1.1	22.9	7.90	6.97	8.17	27	395	2178	689	696	1865	8.0	60	794	1.5	3.0	5
FR 9	0.8	19.0	8.00	6.97	6.16	25	330	1950	563	654	1426	7.5	67	674	1.6	2.5	7
FR 10	0.9	26.4	8.00	6.95	11.60	32	405	2227	833	758	2359	9.1	80	854	1.2	2.9	5
FR 11	1.0	29.5	8.00	6.94	0.23	31	434	1983	1052	686	2882	9.1	69	858	1.4	3.1	5
FR 12	1.1	30.8	7.70	6.95	0.21	26	441	2779	972	1281	2598	9.5	90	766	1.6	3.5	5
FR 13	0.8	16.7	7.90	6.97	0.31	23	274	2328	394	608	873	9.1	67	685	1.5	1.8	5
FR 14	0.9	21.9	8.00	6.98	0.15	24	390	1879	676	821	1911	8.5	67	777	1.5	3.1	5
FR 15	0.7	22.1	8.00	6.99	0.16	26	340	2199	611	492	1828	6.6	60	670	1.6	2.2	5
FRN 1	0.6	32.3	8.00	6.97	11.50	22	298	1662	751	394	4423	4.5	65	414	1.2	3.2	5
FRN 2	2.0	30.8	7.60	6.96	0.96	22	404	1811	770	533	3857	7.0	75	573	1.6	4.1	5
FRN 3	3.3	38.8	7.80	6.95	9.67	28	679	2820	1040	509	4162	6.5	93	620	1.5	5.1	5
FRN 4	0.8	36.1	8.10	6.95	14.70	19	345	1282	872	469	5405	5.1	72	485	1.1	2.9	5
FRN 5	2.4	36.5	7.90	6.95	11.50	40	570	2159	955	411	4437	12.3	114	603	1.6	4.6	5
FRS 1	1.5	28.5	8.30	6.98	0.85	19	376	2128	786	307	3019	4.2	93	584	1.0	2.8	5
FRS 2	1.1	23.8	8.30	6.98	0.63	24	361	2157	598	377	2249	7.3	99	577	1.4	3.4	5
FRS 3	1.2	25.4	8.10	6.99	0.69	23	323	1836	707	307	2737	4.6	69	545	1.2	3.3	5
FRS 4	1.1	28.7	8.50	6.98	8.64	21	372	1876	721	407	3408	4.4	77	605	0.9	3.4	5
FRS 5	2.0	28.1	8.10	6.98	6.48	24	445	2074	777	373	2968	8.7	116	628	1.6	4.8	5

Appendix Table 6. Soil physical and chemical properties for samples collected in August 2010 (A&L Lab)

Sample ID	O.M.	CEC	pH	Buffer pH	EC	P	K	Ca	Mg	S	Na	Zn	Mn	Fe	Cu	B	NO_3
	(%)	(meq/100g)			(mS/cm)						(mg/Kg)						
MA 1	1.5	6.0	7.30	6.96	0.13	16	106	671	380	15	43	4.1	47	321	0.9	0.7	5
MA 2	2.6	6.4	7.80	6.97	0.10	9	77	721	428	14	28	3.4	33	332	1.0	0.6	5
MA 3	3.9	10.7	8.20	6.97	0.13	11	232	1082	701	21	121	5.5	41	406	1.5	1.2	6
MA 4	1.0	4.4	7.90	6.98	0.10	11	84	490	279	8	29	3.3	28	235	0.5	0.4	5
MA 5	3.7	9.1	7.30	6.95	0.14	9	102	1009	603	31	57	5	25	315	1.1	1.0	5
MA 6	4.4	26.0	7.40	6.95	0.26	8	106	5542	431	46	126	3.4	46	241	1.2	1.2	5
MA 7	4.2	12.8	7.90	6.97	0.43	14	131	1811	639	21	106	4.7	46	383	1.1	0.9	7
MA 8	1.0	5.2	8.10	6.99	0.43	9	112	619	263	17	99	2.9	42	297	0.8	0.6	5
MA 9	2.1	27.6	7.10	6.96	6.23	16	363	518	793	373	4284	5.5	8	441	1.7	2.8	5
MA 10	1.7	30.1	7.20	6.97	6.01	19	341	505	768	370	4932	5.6	11	422	1.6	3.2	5
OR 1	1.6	14.2	8.20	6.98	0.57	14	109	2980	243	27	78	2.6	53	236	1.1	0.8	0
OR 2	2.7	17.4	8.00	6.97	0.30	18	149	3404	413	31	90	5.6	59	258	1.5	1.3	0
MR 1	0.7	9.2	7.50	6.99	0.40	16	90	1888	188	39	22	4	45	271	1.1	0.6	0
MR 2	0.8	100.0	8.20	6.92	18.40	27	420	1491	1631	741	18530	3.8	87	368	1.8	3.9	0
MR 3	2.3	20.7	8.30	6.96	1.90	34	284	1830	551	83	1976	4.3	94	473	1.9	2.0	0
MR 4	1.0	38.2	8.00	6.96	6.33	28	355	1213	657	419	6332	4	64	609	1.0	2.8	0
MR 5	1.3	25.1	8.70	6.96	1.35	29	421	2255	681	46	2301	4	100	496	2.7	2.1	0
MR 6	1.8	22.2	8.20	6.96	1.13	26	288	1725	618	162	2300	3.7	88	449	2.2	1.7	0
MR 7	1.2	97.1	7.90	6.95	14.20	24	458	1031	1190	425	19040	4.6	67	428	1.3	4.7	0
MR 8	1.4	21.3	8.10	6.95	2.10	27	259	1839	587	115	2049	3.5	100	488	2.6	1.6	0
MR 9	1.4	45.2	8.00	6.96	6.60	31	408	1392	721	429	7641	4.1	79	607	1.1	3.4	0
MR 10	2.7	18.3	8.20	6.97	6.26	17	191	1485	494	29	1874	3.6	60	383	1.7	1.3	0
FR 1	0.7	40.4	7.90	6.98	4.48	26	346	1884	887	614	5827	7.8	67	517	2.1	2.4	18
FR 2	0.6	45.2	8.30	6.98	7.23	24	357	2461	895	577	6394	6.7	67	515	2.4	2.3	5
FR 3	0.7	34.4	8.00	6.98	7.08	22	463	1894	727	539	4649	7	76	577	2.0	2.3	11
FR 4	0.7	24.1	8.10	6.99	5.13	18	328	1961	496	555	2701	6.5	79	558	1.8	2.1	5
FR 5	0.6	27.2	8.10	6.98	7.70	20	383	2232	557	742	3029	7.3	77	596	2.1	2.5	5
FR 6	0.7	35.2	8.30	7.00	7.56	23	433	2125	711	691	4661	7.6	72	690	1.8	2.2	5
FR 7	1.1	32.1	8.10	6.98	6.64	28	439	1877	746	705	4116	8.3	67	688	2.0	2.8	5
FR 8	0.8	40.6	8.20	6.98	8.30	23	357	1437	875	628	6290	7.2	71	592	1.7	2.6	6
FR 9	0.7	25.5	8.20	7.00	5.77	20	387	1500	550	367	3310	6.1	71	601	1.7	1.8	5
FR 10	0.7	21.0	8.10	6.99	4.64	21	341	1527	533	527	2309	6.6	64	623	1.7	2.1	5
FR 11	0.9	46.8	8.10	6.97	10.10	28	445	1555	1065	726	7218	9.6	63	684	1.8	3.1	5
FR 12	0.8	64.7	8.00	6.95	13.00	24	472	2640	1524	1289	9538	9.5	97	591	2.2	3.6	5
FR 13	0.6	29.3	8.40	6.99	7.17	19	385	1987	568	713	3724	7.5	71	578	1.7	2.2	5
FR 14	1.2	39.9	8.10	6.97	8.66	25	543	2320	868	1099	5231	8.9	69	801	1.8	3.5	5
FR 15	0.8	53.0	8.40	7.00	11.20	29	441	2511	1139	852	7664	6.8	69	574	1.8	2.8	8
FRN 1	2.1	77.7	8.10	6.96	9.10	24	314	994	722	382	15520	4.4	50	438	1.1	2.9	0
FRN 2	0.6	81.8	8.00	6.95	8.27	28	483	1620	935	507	15420	7.8	74	531	2.1	4.5	0
FRN 3	1.5	57.3	8.10	6.98	6.00	28	477	1492	788	331	10160	5.3	56	699	1.2	2.8	0
FRN 4	0.7	110.9	8.10	6.96	13.00	21	305	973	1143	560	22440	5.3	68	420	1.1	3.0	0
FRN 5	1.9	79.5	7.90	6.96	8.33	35	467	1790	922	528	14770	10.1	92	548	2.0	4.0	0
FRS 1	0.8	38.9	8.30	6.98	4.42	25	299	1727	659	272	6049	4	84	529	1.9	2.6	0
FRS 2	0.6	54.6	8.10	6.98	6.45	20	288	1823	577	429	9718	5.3	74	451	1.4	2.7	0
FRS 3	0.7	31.5	8.30	6.99	3.70	19	268	1267	565	225	4950	3.9	74	516	1.3	2.0	0
FRS 4	1.5	36.0	8.10	6.99	3.98	21	335	1829	639	289	5298	4.6	99	568	1.4	2.6	0
FRS 5	1.5	41.9	7.90	6.96	4.64	30	424	1573	745	426	6658	8.8	115	705	1.4	3.6	0

Appendix Table 7. Soil physical and chemical properties for samples collected in February 2011 (A&L Lab)

Sample ID	O.M. (%)	CEC (meq/100g)	pH	Buffer pH	EC (mS/cm)	P	K	Ca	Mg	S	Na (mg/Kg)	Zn	Mn	Fe	Cu	B	NO_3
OR 1	1.2	12.4	6.90	6.96	0.55	13	111	2579	229	35	9	3.7	44	288	1.5	1.0	0
OR 2	2.3	17.7	7.90	6.95	0.41	29	177	3531	385	39	85	4.4	61	270	2.1	1.3	0
MR 1	0.5	17.2	8.20	6.97	0.74	24	199	3101	348	191	419	6.4	72	432	2.4	2.0	0
MR 2	0.6	21.0	7.80	6.95	13.80	30	336	1690	1439	678	574	4.6	107	507	2.1	4.5	0
MR 3	0.7	12.1	8.60	6.98	3.93	35	287	1642	586	174	107	3.7	97	535	2.1	2.6	0
MR 4	2.0	22.8	7.90	6.96	10.00	36	556	2218	1164	869	879	6.1	73	710	1.4	6.2	0
MR 5	1.8	11.7	8.10	6.95	1.86	23	191	1610	538	43	174	4.3	68	433	2.1	1.5	0
MR 6	2.1	13.2	8.00	6.95	2.25	26	241	1962	579	289	96	4.3	79	445	2.6	2.2	0
MR 7	0.7	23.0	8.50	6.94	16.10	29	440	1312	1691	738	872	4.1	73	411	1.6	4.3	0
MR 8	1.0	12.1	7.10	6.96	2.32	27	213	1897	502	175	53.5	3.8	95	446	2.6	1.7	0
MR 9	1.6	25.8	8.30	6.97	9.90	27	409	3910	889	547	591	4.4	39	493	1.8	4.9	0
MR 10	2.2	15.0	5.50	6.92	1.52	22	189	1588	557	95	29.3	4.8	65	411	2.1	1.6	0

Appendix Table 8. Soil physical and chemical properties for samples collected in October 2011 (LSU Lab)

Site	pH (1:2)	EC (mS/cm)	Salinity (ppt)	Salts	P	K	Ca	Mg	Na	S	Cl	Fe	Mn	SAR	CEC (meq/100g)
									(mg/Kg)						
MA 1	7.99	0.2	0.1	370	0.23	27	50	31	19	11	113	0.30	0.09	0.2	0.7
MA 2	7.75	0.2	0.1	508	0.34	16	54	44	56	29	135	0.66	0.47	0.4	0.9
MA 3	7.50	0.6	0.3	1,320	0.44	62	159	102	138	221	270	0.71	2.40	0.7	2.4
MA 4	7.77	0.2	0.1	334	0.32	24	53	26	15	14	220	0.11	0.07	0.1	0.6
MA 5	7.63	0.2	0.1	333	0.36	17	48	30	21	13	167	0.35	0.52	0.2	0.6
MA 6	7.45	1.0	0.5	1,853	0.51	41	277	118	152	63	849	0.16	0.08	0.6	3.1
MA 7	7.77	0.4	0.2	897	0.36	22	122	83	78	77	252	0.28	1.92	0.4	1.7
MA 8	7.90	0.8	0.4	1,398	0.29	25	46	30	363	52	662	0.60	0.61	3.2	2.1
MA 9	7.30	7.0	3.9	16,358	0.35	187	174	486	5,830	477	11,002	0.24	1.50	16.2	30.7
MA 10	7.27	6.7	4.2	17,626	0.38	193	202	543	6,289	525	13,500	1.79	3.85	16.5	33.3
MR 1	8.23	0.5	0.3	750	0.22	33	85	26	120	88	187	0.08	0.12	0.9	1.2
MR 2	8.22	19.5	11.6	33,024	0.35	281	408	1,348	11,951	904	56,024	0.01	0.03	20.2	65.9
MR 3	8.37	1.2	0.6	3,290	0.36	48	58	53	744	177	942	0.04	1.31	5.4	4.1
MR 4	7.70	16.3	9.6	33,920	1.17	339	784	1,130	11,958	1,511	50,663	0.01	15.05	20.2	66.1
MR 5	8.36	0.8	0.4	1,879	0.46	42	48	38	390	91	622	0.02	0.02	3.2	2.4
MR 6	8.25	1.0	0.5	1,819	0.24	48	56	48	508	170	654	0.01	0.01	3.8	3.0
MR 7	8.19	29.2	18.1	47,232	0.29	391	362	1,597	17,066	844	99,830	0.00	1.57	27.1	90.2
MR 8	8.23	0.7	0.4	2,176	0.27	45	68	42	352	106	573	0.01	0.01	2.6	2.3
MR 9	7.78	13.7	8.0	20,352	0.18	240	766	697	6,380	1,228	14,894	0.01	2.64	12.7	37.9
MR 10	8.16	1.2	0.7	2,496	0.21	53	100	82	585	294	774	0.00	0.42	3.3	3.9
FR 1	8.15	6.4	3.5	13,517	0.50	175	607	428	4,312	1,144	3,099	0.04	0.11	10.3	25.8
FR 2	8.29	7.1	3.9	16,077	0.34	190	685	545	5,125	1,227	6,647	0.00	0.05	11.2	30.7
FR 3	8.10	2.5	1.3	4,531	0.30	85	193	94	1,324	528	1,516	0.00	0.01	6.2	7.7
FR 4	8.01	3.3	1.8	6,208	0.20	103	418	190	1,676	919	1,666	0.00	1.09	5.4	11.2
FR 5	8.05	9.4	5.3	18,086	0.30	204	947	654	5,454	1,687	7,445	0.01	0.25	10.5	34.4
FR 6	8.16	2.4	1.3	4,160	0.22	80	195	110	1,105	457	1,466	0.01	0.57	5.0	6.9
FR 7	8.01	10.6	6.0	20,122	0.30	227	898	699	6,375	1,719	12,173	0.00	0.48	12.2	38.6
FR 8	8.08	10.1	5.8	19,072	0.32	235	739	598	6,454	1,542	9,810	0.01	0.15	13.5	37.3
FR 9	8.28	1.1	0.6	2,043	0.20	52	144	67	471	281	744	0.00	0.22	2.6	3.5
FR 10	7.96	5.5	3.1	10,342	0.20	155	407	337	3,331	1,010	314	0.01	1.51	9.3	19.7
FR 11	7.95	12.5	7.2	22,054	0.38	241	579	787	7,215	1,101	19,471	0.01	0.16	14.5	41.4
FR 12	7.93	12.4	7.2	26,880	0.25	296	864	949	9,198	1,634	31,572	0.01	1.52	16.2	52.9
FR 13	8.07	5.2	2.8	9,984	0.30	145	450	292	3,157	1,060	627	0.01	2.97	9.0	18.8
FR 14	8.00	2.6	1.4	6,246	0.25	119	277	194	1,855	890	1,664	0.00	3.35	6.6	11.4
FR 15	7.98	10.4	6.0	18,739	0.25	212	820	659	5,928	1,336	11,525	0.01	0.68	11.8	35.9
FRS 1	8.03	21.9	13.3	45,568	0.35	399	880	1,549	15,607	1,673	84,474	0.01	3.59	23.1	86.1
FRS 3	8.00	11.7	6.8	28,288	0.29	313	806	947	9,625	1,522	33,016	0.02	13.19	17.2	54.5
FRN 2	7.95	10.8	6.2	19,814	0.29	227	269	530	6,953	691	16,475	0.01	4.80	17.9	36.5
FRN 4	7.78	17.3	10.4	32,640	0.89	312	327	1,042	11,846	840	53,516	0.01	4.85	22.8	62.5
OR 1	8.09	0.3	0.1	544	0.40	45	72	37	47	22	163	0.53	0.92	0.4	1.0
OR 2	8.12	0.3	0.2	367	0.20	32	113	36	39	19	177	0.05	0.23	0.3	1.1

Appendix Table 9. Soil physical and chemical properties for samples collected in October 2012 (LSU Lab).

Site	pH (1:2)	EC (mS/cm)	Salinity (ppt)	Salts	P	K	Ca	Mg	Na	S	Cl	Fe	Mn	SAR	CEC (meq/100g)
									(mg/Kg)						
MA 1	7.56	0.3	0.1	594	1.21	11	12	7	142	27	107	6.80	0.13	2.6	0.8
MA 2	6.62	1.8	1.0	3,238	0.26	27	123	102	720	91	868	0.04	0.09	3.7	4.7
MA 3	7.36	0.2	0.1	276	1.13	7	6	5	66	12	37	10.87	0.15	1.5	0.4
MA 4	7.26	0.4	0.2	796	0.83	13	10	6	167	27	177	2.65	0.14	3.3	0.9
MA 5	7.36	0.6	0.3	982	0.47	14	59	28	188	44	208	0.86	0.09	1.6	1.4
MA 6	7.98	1.1	0.5	1,864	1.00	29	59	24	451	67	428	0.87	0.09	3.9	2.5
MA 7	7.77	1.1	0.6	2,100	0.88	30	62	40	514	88	481	0.66	0.04	3.9	3.0
MA 8	7.49	0.2	0.1	540	0.72	13	18	9	89	19	119	3.32	0.10	1.3	0.6
MA 9	6.60	6.7	3.7	12,851	0.37	173	108	293	4,581	436	3,152	0.16	0.10	16.4	23.3
MA 10	6.89	7.4	4.1	13,670	0.48	161	125	322	4,816	377	3,335	0.21	0.39	16.3	24.6
MR 1	8.11	0.3	0.1	458	0.26	12	42	9	40	16	71	0.53	0.03	0.5	0.5
MR 2	7.66	18.6	11.1	42,624	0.46	346	324	1,720	14,981	1,206	5,467	0.02	0.25	23.1	81.9
MR 3	8.58	0.9	0.4	1,946	0.73	28	17	17	554	98	442	0.26	0.00	7.3	2.7
MR 4	7.40	20.8	12.5	46,848	0.39	487	883	1,484	16,600	2,110	5,471	0.05	0.43	25.0	90.1
MR 5	7.86	0.7	0.4	1,340	0.26	29	87	44	247	91	292	0.18	0.01	1.7	1.9
MR 6	7.91	1.8	1.0	3,725	0.32	63	103	81	1,029	344	776	0.03	0.13	5.8	5.8
MR 7	7.77	21.6	13.0	42,752	0.30	370	256	1,445	15,762	778	5,480	0.02	0.35	26.7	82.7
MR 8	7.92	1.5	0.8	3,034	0.21	40	133	72	715	197	677	0.02	0.03	3.9	4.5
MR 9	7.82	18.8	11.2	35,200	0.25	351	564	1,143	12,781	1,233	5,252	0.02	0.12	22.4	68.7
MR 10	8.11	0.4	0.2	708	0.99	21	34	29	239	48	256	5.77	0.03	2.3	1.5
MRN 1	8.37	0.3	0.1	518	0.20	5	68	11	44	11	97	0.02	0.05	0.4	0.6
FR 1	7.90	8.2	4.6	14,451	0.23	172	570	416	4,386	1,101	2,832	0.03	0.09	10.8	25.8
FR 2	7.75	5.7	3.2	13,120	0.24	166	544	362	4,070	1,054	2,706	0.01	0.05	10.5	23.8
FR 3	7.94	4.0	2.2	9,229	0.25	113	393	197	2,753	871	1,812	0.03	0.01	8.9	15.9
FR 4	7.77	1.5	0.8	3,008	0.23	49	185	67	700	470	405	0.03	0.04	3.5	4.7
FR 5	7.47	3.8	2.0	9,062	0.23	115	502	279	2,432	1,024	1,703	0.03	0.04	6.8	15.7
FR 6	7.83	0.4	0.2	730	0.30	16	44	12	134	76	83	0.33	0.01	1.5	0.9
FR 7	7.77	4.7	2.5	12,864	0.31	158	801	395	3,673	1,482	2,365	0.04	0.11	8.4	23.6
FR 8	7.79	5.4	3.0	12,531	0.26	180	771	363	3,682	1,436	2,397	0.02	0.04	8.6	23.3
FR 9	7.98	3.1	1.6	7,002	0.24	102	449	167	1,873	983	1,165	0.08	0.13	6.0	12.0
FR 10	8.16	0.2	0.1	378	0.45	10	19	4	69	16	39	2.56	0.04	1.2	0.5
FR 11	7.54	14.1	8.2	27,008	0.22	310	955	999	8,452	1,676	4,603	0.01	0.13	14.4	50.6
FR 12	7.59	10.8	6.2	24,307	0.23	286	906	788	7,671	1,661	4,286	0.03	0.10	14.2	45.1
FR 13	7.76	1.7	0.9	2,931	0.25	64	272	77	569	408	481	0.24	0.02	2.5	4.6
FR 14	7.78	1.9	1.0	3,776	0.45	66	92	64	1,052	463	630	0.10	0.00	6.5	5.7
FR 15	7.93	5.1	2.8	9,190	0.24	120	355	221	2,760	760	2,012	0.02	0.05	8.9	15.9
FRS 1	7.84	10.7	6.1	20,275	0.40	209	320	554	7,023	743	4,112	0.02	0.09	17.4	37.2
FRS 3	7.80	8.0	4.4	16,282	0.43	210	280	428	5,424	762	3,482	0.02	0.35	15.0	29.1
FRN 2	7.41	19.9	11.9	44,416	0.28	476	834	1,496	15,652	2,016	5,430	0.02	7.66	23.7	85.8
FRN 4	7.75	10.5	6.0	18,176	0.26	220	192	409	6,228	551	3,787	0.02	0.33	18.4	32.0
FRN 7	7.62	7.0	3.9	15,040	0.27	205	823	438	4,503	1,507	2,894	0.01	0.11	10.0	27.8
FRN 13	7.60	8.5	4.8	19,213	0.29	234	523	492	6,432	1,103	3,802	0.04	0.13	15.3	35.2

Appendix Table 10. Soil physical and chemical properties for samples collected in May 2013 (LSU Lab).

Site	pH (1:2)	EC	Salinity	Salts	P	K	Ca	Mg	Na	S	Cl	Fe	Mn	SAR (1)	CEC (2)
		(mS/cm)	(ppt)						(mg/Kg)						(meq/100g)
MA1	7.46	0.4	0.2	558	0.77	19	25	21	88	23	206	11.08	0.41	1.0	0.7
MA2	7.39	0.8	0.4	951	0.43	16	25	21	179	25	167	2.08	0.03	2.0	1.1
MA3	7.30	0.6	0.3	745	1.16	25	34	28	179	68	202	32.23	0.56	1.7	1.2
MA4	7.85	0.3	0.1	332	0.91	15	18	12	56	11	187	22.09	0.51	0.8	0.5
MA5	7.42	0.7	0.4	855	0.42	16	52	33	130	30	235	0.26	0.34	1.1	1.1
MA6	7.51	1.5	0.8	1,908	0.41	20	90	50	392	96	82	0.16	0.03	2.6	2.6
MA7	7.23	1.0	0.5	1,073	1.13	28	51	32	227	42	114	1.53	0.02	1.9	1.6
MA8	7.68	0.3	0.1	357	0.33	13	32	13	36	13	240	3.42	0.08	0.4	0.5
MA9	7.10	6.8	3.7	11,942	0.43	164	104	274	4,523	370	2,131	0.10	0.36	16.7	22.9
MA10	7.00	9.8	5.5	13,197	0.51	161	129	320	5,031	372	2,431	0.13	0.86	17.1	25.6
MR1	7.90	0.3	0.1	322	0.26	15	48	8	14	11	215	0.28	0.01	0.2	0.4
MR2	7.90	27.5	16.9	34,406	0.52	281	242	1,308	14,638	701	5,683	0.02	0.27	26.0	76.4
MR3	8.40	1.3	0.6	2,182	1.25	40	21	26	664	129	273	0.21	0.01	7.2	3.3
MR4	7.59	12.3	7.1	26,061	0.53	320	462	770	10,945	1,026	4,445	0.01	3.88	22.8	57.1
MR5	8.00	0.7	0.3	1,041	0.51	27	30	18	215	38	222	0.20	0.00	2.4	1.3
MR6	7.70	1.6	0.8	2,629	0.36	52	71	49	668	206	120	0.16	0.34	4.7	3.8
MR7	7.75	32.6	20.4	46,080	0.42	389	259	1,428	19,680	635	6,888	0.25	0.75	33.4	99.7
MR8	Sample was contaminated during preparation														
MR9	7.63	34.4	21.6	44,672	0.29	429	835	1,264	19,212	1,484	7,250	0.09	1.04	30.9	99.2
MR10	8.10	0.6	0.3	929	0.30	29	47	27	148	50	147	0.28	0.05	1.3	1.2
MRN1	8.45	0.3	0.1	347	0.20	5	42	8	24	12	265	0.03	0.01	0.3	0.4
FR1	7.78	9.2	5.2	14,413	0.20	174	719	415	5,142	1,237	3,406	0.03	0.01	11.9	29.8
FR2	7.81	3.4	1.8	5,363	0.25	89	331	125	1,477	698	1,015	0.03	0.01	5.5	9.3
FR3	7.72	8.0	4.4	14,374	0.28	186	913	493	4,906	1,649	3,096	0.03	0.00	10.3	30.4
FR4	7.71	1.5	0.7	2,080	0.16	54	272	66	285	467	92	0.03	0.01	1.3	3.3
FR5	7.89	3.8	2.0	4,966	0.39	74	220	127	1,402	535	824	0.03	0.01	5.9	8.4
FR6	7.83	0.7	0.3	777	0.39	29	61	20	109	123	196	0.00	0.01	1.0	1.0
FR7	7.80	6.6	3.6	11,418	0.33	145	428	295	4,124	999	2,547	0.03	0.00	11.9	22.9
FR8	7.78	4.7	2.5	7,002	0.28	112	256	164	2,204	616	1,558	0.03	0.01	8.4	12.5
FR9	7.80	4.8	2.6	8,371	0.24	130	587	270	2,477	1,180	1,531	0.03	0.01	6.7	16.3
FR10	7.71	12.1	7.0	22,630	0.22	275	678	660	9,365	1,485	4,656	0.03	0.05	19.4	50.3
FR11	7.91	10.1	5.7	15,629	0.25	191	668	421	5,674	1,110	3,050	0.03	0.01	13.4	32.0
FR12	7.82	11.4	6.5	15,283	0.25	198	545	425	5,692	1,030	3,206	0.03	0.01	14.0	31.5
FR13	7.81	0.4	0.2	466	0.75	17	35	12	59	25	92	1.22	0.00	0.7	0.6
FR14	7.82	4.3	2.3	7,834	0.33	128	200	159	2,755	763	1,830	0.00	0.01	11.1	14.6
FR15	7.60	3.7	2.0	5,146	6.94	83	223	127	1,402	457	764	0.03	0.00	5.9	8.5
FRS1	8.02	9.2	5.2	16,218	0.28	182	215	445	6,435	502	3,585	0.03	0.01	18.1	33.2
FRS3	7.51	14.2	8.3	23,360	0.35	256	590	751	9,624	1,259	4,371	0.03	0.11	19.6	51.7
FRN2	7.58	13.8	8.0	23,910	0.24	305	540	716	10,040	1,242	4,693	0.00	2.32	21.0	53.0
FRN4	7.90	17.7	10.5	29,658	0.32	346	434	812	12,886	946	5,722	0.15	0.51	26.6	65.8
FRN7	8.00	4.2	2.2	7,155	0.23	108	355	182	2,164	823	1,320	0.01	0.01	7.3	13.0
FRN13	6.42	11.1	6.3	19,597	0.33	241	765	736	7,538	1,964	3,603	0.14	1.21	14.7	43.3
OR1	8.06	0.4	0.2	545	0.38	23	60	19	61	21	239	0.29	0.00	0.6	0.8
OR2	7.80	0.5	0.2	595	0.30	23	66	25	56	38	251	0.26	0.13	0.5	0.8

Appendix Table 11. Soil physical and chemical properties for samples collected in December 2013 (LSU Lab).

Site	pH (1:2)	EC (mS/cm)	Salinity (ppt)	Salts	P	K	Ca	Mg	Na (mg/Kg)	S	Cl	Fe	Mn	SAR	CEC (meq/100g)
MA 1	7.12	0.5	0.2	311	0.70	23	14	19	28	11	136	7.45	0.15	0.4	0.4
MA 2	6.96	0.5	0.3	896	0.30	21	22	26	145	23	994	2.14	0.15	1.6	1.0
MA 3	7.05	0.4	0.2	666	0.33	24	22	24	93	32	564	0.70	0.01	1.0	0.8
MA 4	7.17	0.2	0.1	247	0.48	16	18	13	13	5	115	3.22	0.07	0.2	0.3
MA 5	7.28	0.3	0.1	315	0.50	17	26	23	13	11	75	3.06	0.08	0.1	0.4
MA 6	7.54	0.4	0.2	508	0.34	14	38	22	54	22	168	1.08	0.04	0.5	0.6
MA 7	7.55	0.8	0.4	1,236	0.49	26	34	29	252	66	895	1.16	0.15	2.4	1.6
MA 8	7.34	0.2	0.1	285	0.46	15	22	14	20	6	156	2.72	0.04	0.3	0.3
MA 9	6.72	8.8	4.9	13,402	0.26	230	94	330	4,411	441	762	0.00	0.35	15.2	23.0
MA 10	6.82	8.3	4.7	14,682	0.31	200	91	336	4,878	336	1,306	0.01	0.68	16.7	25.0
MR1	7.60	0.2	0.1	314	0.16	15	32	10	14	9	206	0.72	0.01	0.2	0.3
MR 2	7.61	8.2	5.2	16,038	0.41	176	83	257	3,087	464	5,134	0.03	0.01	11.9	16.4
MR 3	8.29	1.2	0.6	2,086	1.99	45	9	14	572	98	1,748	0.40	0.05	8.7	2.8
MR 4	7.46	13.5	7.7	30,694	0.39	442	508	992	10,218	1,692	21,179	0.04	3.74	19.2	56.3
MR 5	7.72	0.4	0.2	552	0.44	31	21	16	70	14	277	0.56	0.04	0.9	0.6
MR 6	7.54	0.9	0.4	1,422	0.37	44	29	28	285	65	1,287	0.20	0.00	2.9	1.7
MR 7	7.72	21.4	12.9	49,152	0.30	422	199	1,558	15,922	695	55,305	0.03	0.20	26.3	84.2
MR 8	7.70	1.0	0.5	1,411	0.40	42	30	27	262	55	1,345	0.27	0.00	2.6	1.6
MR 9	7.70	25.1	15.2	48,384	0.25	446	537	1,469	15,375	1,300	50,807	0.03	0.28	24.5	82.8
MR 10	7.40	0.4	0.2	554	0.34	25	38	33	37	24	350	0.39	0.02	0.3	0.7
MRN 1	7.82	0.2	0.1	206	0.25	3	29	4	7	4	92	1.07	0.03	0.1	0.2
FR1	7.71	3.9	2.3	8,205	0.23	122	248	101	1,402	979	2,682	0.03	0.07	6.0	8.5
FR 2	7.75	5.3	2.9	9,216	0.24	150	274	233	2,564	736	4,671	0.03	0.00	8.7	14.8
FR 3	7.80	0.4	0.2	594	0.42	26	24	16	79	46	362	1.05	0.02	1.0	0.7
FR 4	7.42	1.1	0.5	1,910	0.17	58	180	79	212	426	313	0.03	0.01	1.0	2.6
FR 5	7.60	4.0	2.2	6,784	0.24	117	266	208	1,671	768	4,363	0.03	0.06	5.9	10.6
FR 6	7.80	0.4	0.2	550	0.38	25	26	12	73	48	190	2.04	0.03	0.9	0.6
FR 7	7.68	3.9	2.1	7,296	0.26	126	227	170	2,063	914	4,354	0.03	0.01	8.0	11.8
FR 8	7.51	3.9	2.1	7,680	0.18	136	370	202	1,898	901	4,579	0.03	0.00	6.2	12.1
FR 9	7.52	0.3	0.2	385	0.41	26	27	14	26	14	187	0.82	0.02	0.3	0.4
FR 10	7.58	11.5	6.6	17,805	0.22	256	415	534	5,727	1,323	1,967	0.02	0.09	13.8	32.0
FR 11	7.33	15.7	9.2	28,493	0.28	340	598	1,040	8,964	1,399	20,627	0.03	0.14	16.2	51.4
FR 12	7.60	10.1	5.7	15,373	0.20	205	445	415	4,614	1,087	580	0.02	0.03	11.9	26.2
FR 13	7.68	0.3	0.2	460	0.26	25	30	13	47	20	246	1.78	0.03	0.6	0.5
FR 14	7.60	0.6	0.3	927	0.49	38	28	18	157	85	514	1.68	0.04	1.8	1.1
FR 15	7.70	3.8	2.0	6,131	0.21	113	217	146	1,563	639	4,303	0.03	0.06	6.3	9.4
FRN 1	7.48	4.5	2.2	7,117	0.32	150	175	205	1,929	826	4,386	0.01	0.26	7.4	11.3
FRN 3	7.71	21.6	13.0	38,784	0.35	421	234	1,134	13,068	886	44,052	0.03	1.07	24.8	68.4
FRN 7	7.52	3.7	2.0	7,194	0.15	122	407	191	1,666	869	4,516	0.04	0.20	5.4	11.2
FRN 13	7.37	8.6	4.8	15,066	0.28	200	264	411	4,748	883	257	0.02	0.46	13.4	25.9
OR 1	7.50	1.1	0.5	1,554	0.22	43	101	44	188	54	1,604	0.01	0.01	1.2	1.8
OR 2	7.62	0.5	0.3	732	0.38	32	50	23	80	25	579	0.12	0.00	0.7	0.9

Appendix Table 12. Soil physical and chemical properties for samples collected in May 2014 (LSU Lab).

Site	pH (1:2)	EC (mS/cm)	Salinity (ppt)	Salts	P	K	Ca	Mg	Na (mg/Kg)	S	Cl	Fe	Mn	SAR	CEC (meq/100g)
MA 1	7.50	0.5	0.3	273	0.31	11	16	11	9	11	39	2.69	0.02	0.1	0.2
MA 2	7.60	0.6	0.3	529	0.52	15	13	9	57	32	114	7.61	0.08	0.9	0.4
MA 3	7.39	0.5	0.3	374	0.69	20	15	12	36	21	48	12.08	0.19	0.5	0.4
MA 4	7.25	0.4	0.2	230	0.37	13	13	10	5	10	59	4.31	0.09	0.1	0.2
MA 5	7.11	0.4	0.2	313	0.28	9	23	12	9	9	47	0.64	0.00	0.1	0.3
MA 6	7.61	0.5	0.3	436	0.26	8	29	9	24	21	76	0.10	0.00	0.3	0.3
MA 7	7.30	0.5	0.3	489	0.45	18	21	12	41	13	52	1.41	0.03	0.6	0.4
MA 8	7.45	0.4	0.2	397	0.27	13	29	9	18	13	51	0.26	0.00	0.2	0.3
MA 9	6.92	6.1	3.8	14,490	0.31	196	79	196	2,717	396	4,845	0.02	0.21	11.8	14.3
MA 10	7.00	6.3	3.9	12,224	0.35	163	68	152	2,361	336	4,562	0.04	0.14	11.5	12.3
MR 1	7.30	0.5	0.3	313	0.24	14	28	7	7	16	48	0.02	0.01	0.1	0.3
MR 2	7.61	22.2	15.1	59,392	0.33	374	166	1,239	10,542	1,196	5,314	0.03	0.91	19.5	57.9
MR 3	8.20	1.0	0.5	1,736	1.10	43	9	13	307	85	508	11.50	0.21	4.8	1.6
MR 4	7.05	10.8	6.9	26,266	0.31	314	292	446	5,201	1,247	5,739	0.02	4.47	14.1	28.6
MR 5	7.50	0.5	0.3	466	0.34	27	26	13	23	13	105	0.58	0.02	0.3	0.4
MR 6	7.59	0.8	0.4	1,230	0.26	36	24	15	140	79	382	0.02	0.00	1.7	0.9
MR 7	7.40	28.7	19.9	73,088	0.38	479	193	1,416	12,819	1,211	4,797	0.03	0.88	22.1	69.6
MR 8	7.88	0.5	0.3	622	1.65	48	17	23	72	19	168	50.40	0.50	0.8	0.7
MR 9	7.45	26.6	18.3	55,936	0.23	420	352	891	10,245	1,195	5,282	0.03	0.71	20.9	54.7
MR 10	7.58	0.8	0.5	1,356	0.27	31	37	22	143	65	473	0.01	0.04	1.5	1.1
FR 1	7.60	4.4	2.7	9,075	0.25	134	254	137	1,510	856	3,113	0.03	0.28	6.0	9.3
FR 2	7.55	4.8	2.9	9,741	0.24	134	269	147	1,609	920	3,310	0.03	0.06	6.2	9.9
FR 3	7.59	1.2	0.7	1,292	0.22	41	68	17	111	241	170	0.02	0.01	1.0	1.1
FR 4	7.70	0.5	0.3	341	0.27	15	22	6	18	26	53	1.12	0.01	0.3	0.3
FR 5	7.41	3.0	1.8	6,426	0.23	108	252	116	915	916	1,874	0.03	0.00	3.8	6.5
FR 6	7.62	0.8	0.5	1,608	0.27	52	79	23	157	331	125	0.02	0.01	1.3	1.4
FR 7	7.23	8.0	5.0	19,162	0.30	213	469	366	3,537	1,660	5,097	0.03	0.03	9.4	21.3
FR 8	7.40	3.1	1.8	6,272	0.27	128	193	86	1,026	1,004	1,640	0.03	0.01	4.9	6.5
FR 9	7.35	3.2	1.9	7,347	0.26	126	320	129	1,060	1,012	2,236	0.03	0.00	4.0	7.6
FR 10	7.65	0.6	0.3	382	0.27	18	23	6	21	28	78	1.42	0.01	0.3	0.3
FR 11	7.72	10.2	6.5	19,840	0.27	234	218	302	3,829	1,156	5,317	0.03	0.01	12.4	20.8
FR 12	7.39	8.0	5.0	18,982	0.25	248	464	285	3,533	1,333	5,155	0.03	0.32	10.0	20.7
FR 13	7.82	1.0	0.5	1,445	0.31	38	23	10	187	156	376	1.19	0.01	2.6	1.1
FR 14	7.55	0.5	0.2	424	0.36	20	20	9	30	26	61	2.02	0.02	0.4	0.4
FR 15	7.69	4.5	2.7	9,869	0.25	140	215	151	1,676	783	3,479	0.03	0.41	6.8	10.0
FRS 1	7.60	5.8	3.6	11,750	0.27	143	95	142	2,212	477	4,226	0.03	0.18	10.6	11.6
FRS 3	7.41	4.9	3.0	11,034	0.26	171	93	136	2,081	536	4,021	0.03	0.85	10.1	11.1
FRN 1	8.09	0.4	0.2	214	0.19	3	24	2	5	5	42	0.00	0.00	0.1	0.2
FRN 2	7.78	7.3	4.5	19,520	0.30	248	305	323	3,770	1,275	5,310	0.03	1.17	11.3	21.2
FRN 4	7.65	13.7	9.0	32,653	0.23	345	128	456	6,709	600	5,819	0.03	0.37	19.7	34.5
FRN 7	7.59	5.0	3.0	9,856	0.24	160	323	152	1,598	1,022	3,208	0.03	0.44	5.8	10.2
FRN 13	7.31	3.7	2.2	7,744	0.29	120	122	96	1,329	741	2,611	0.02	1.02	6.9	7.5
OR 1	7.37	0.4	0.2	300	0.27	17	26	9	7	7	56	1.05	0.01	0.1	0.3
OR 2	7.55	0.4	0.2	402	0.31	21	42	11	7	9	51	0.06	0.01	0.1	0.4

Appendix Table 13. Soil physical and chemical properties for samples collected in October 2014 (LSU Lab).

Site	pH (1:2)	EC	Salinity	Salts	P	K	Ca	Mg	Na	S	Cl	Fe	Mn	SAR	CEC (meq/100g)
		(mS/cm)	(ppt)						(mg/Kg)						
MA 1	6.98	1.0	0.5	768	0.05	17	95	117	59	15	149	0.06	0.42	0.3	1.7
MA 2	6.86	0.8	0.4	635	0.07	19	67	88	92	9	122	0.16	0.21	0.5	1.5
MA 3	6.82	0.9	0.4	837	0.06	24	63	69	244	28	131	1.20	0.46	1.6	2.0
MA 4	6.38	1.3	0.7	1,302	0.01	20	118	163	246	71	183	0.06	0.12	1.1	3.1
MA 5	6.97	0.6	0.3	277	0.13	18	50	46	14	6	83	2.67	0.05	0.1	0.7
MA 6	6.82	1.0	0.5	1,000	0.01	25	89	56	316	35	120	0.70	0.01	2.0	2.3
MA 7	6.81	1.5	0.8	1,798	0.02	24	159	154	514	118	194	0.05	0.13	2.2	4.4
MA 8	7.16	0.7	0.3	645	0.05	21	59	41	201	10	90	1.73	0.03	1.5	1.6
MA 9	6.63	8.9	5.0	14,605	0.06	87	150	597	7,295	224	1,746	0.19	0.76	18.8	37.6
MA 10	6.62	11.2	6.4	18,010	0.03	86	183	782	9,224	248	2,057	0.11	0.82	20.9	47.7
MR 1	7.55	0.8	0.4	447	0.07	19	82	35	51	11	89	0.13	0.13	0.4	1.0
MR 2	6.83	17.8	11.3	29,760	0.04	96	282	1,742	13,567	380	2,615	0.01	1.28	21.0	75.0
MR 3	7.98	1.0	0.5	1,207	1.17	3	20	65	723	21	170	130.18	1.07	5.6	3.8
MR 4	7.06	12.1	6.9	26,432	0.15	88	779	1,502	12,969	943	2,410	0.03	10.65	19.7	72.9
MR 5	7.83	0.7	0.4	572	0.17	24	41	38	182	10	109	0.08	0.11	1.6	1.4
MR 6	7.71	0.8	0.4	740	0.00	31	34	34	278	12	120	3.93	0.07	2.5	1.7
MR 7	6.82	27.3	16.8	46,336	0.04	211	221	2,125	20,628	384	3,040	0.02	1.18	29.4	108.9
MR 8	7.80	1.3	0.7	1,729	0.06	32	73	88	632	18	276	0.18	0.16	3.7	3.9
MR 9	7.26	33.7	23.0	52,864	0.06	188	708	2,330	22,491	667	3,116	0.02	0.89	29.0	121.1
MR 10	7.93	1.1	0.6	1,554	0.04	28	124	121	400	46	226	0.37	0.60	1.9	3.4
MRN 1	7.61	0.6	0.3	324	0.01	19	98	12	13	2	88	0.02	0.01	0.1	0.7
FR 1	7.18	3.1	1.6	5,990	0.06	46	458	257	2,467	417	634	0.03	0.91	7.2	15.3
FR 2	7.30	3.7	2.0	6,195	0.04	46	500	275	2,544	485	615	0.03	0.58	7.2	15.9
FR 3	7.10	11.0	6.2	19,738	0.02	94	917	1,152	8,753	962	1,866	0.00	0.30	14.3	52.4
FR 4	7.92	0.7	0.3	534	0.05	25	91	44	51	10	104	0.22	0.24	0.3	1.1
FR 5	7.41	3.8	2.0	7,206	0.07	47	515	371	2,969	581	672	0.03	0.62	7.7	18.7
FR 6	7.60	1.5	0.8	2,222	0.04	33	150	95	817	163	208	0.02	0.02	4.1	5.2
FR 7	7.39	3.2	1.7	5,709	0.05	46	291	268	2,475	421	551	0.02	0.25	7.9	14.5
FR 8	7.31	5.1	2.7	9,971	0.04	69	498	432	4,631	658	1,011	0.08	0.49	11.6	26.4
FR 9	7.69	0.9	0.5	916	0.05	30	72	54	276	30	126	0.10	0.01	1.9	2.1
FR 10	7.11	7.2	4.0	13,350	0.02	77	395	611	6,614	565	1,498	0.01	0.21	15.4	36.0
FR 11	7.14	11.0	6.3	19,174	0.06	105	650	954	8,704	553	2,016	0.03	0.21	16.0	49.2
FR 12	7.36	9.8	5.5	16,576	0.07	85	528	844	7,646	558	1,775	0.06	0.65	15.2	43.1
FR 13	7.93	0.9	0.4	835	0.05	25	101	68	152	16	135	0.14	0.32	0.9	1.8
FR 14	7.18	7.6	4.2	12,979	0.05	76	566	753	5,850	758	1,294	0.03	0.41	12.0	34.7
FR 15	7.47	4.7	2.5	7,910	0.04	48	164	317	3,855	240	1,062	0.02	0.17	12.8	20.3
FRS 1	7.39	6.8	3.7	13,248	0.04	62	176	590	6,399	252	1,625	0.00	0.33	16.4	33.7
FRS 3	7.56	5.6	3.3	11,430	0.30	71	218	548	5,283	337	1,383	0.03	2.61	13.7	28.8
FRN 2	7.32	7.4	4.1	15,885	0.02	87	481	835	7,493	676	1,665	0.03	1.03	15.1	42.1
FRN 4	7.36	15.8	9.2	28,762	0.05	141	244	1,600	13,747	354	2,621	0.00	0.49	22.2	74.6
FRN 7	7.58	6.4	3.5	11,584	0.03	72	556	524	5,098	507	1,298	0.04	0.11	11.8	29.5
FRN 13	7.73	2.3	1.2	4,915	0.11	49	225	242	2,200	323	527	0.02	0.20	7.7	12.8
OR 1	7.72	0.6	0.3	426	0.05	29	76	44	25	3	98	0.09	0.00	0.2	0.9
OR 2	7.52	0.7	0.3	684	0.05	24	153	72	31	10	95	0.19	0.27	0.2	1.6

1) SAR =Sodium Absorption Ratio
2) Effective Cation Exchange Capacity (sum of cations)

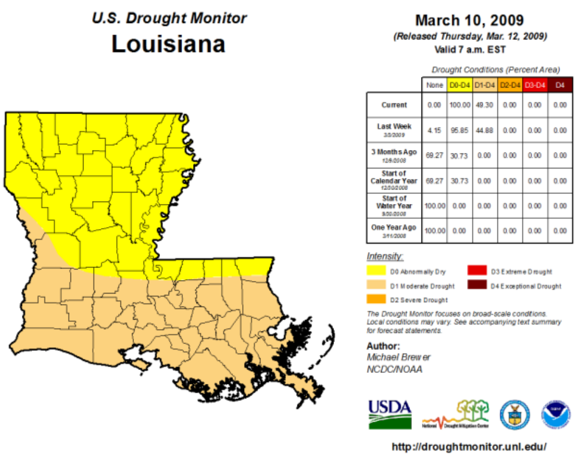
APPENDIX 3

Louisiana Drought Maps 2009-2015

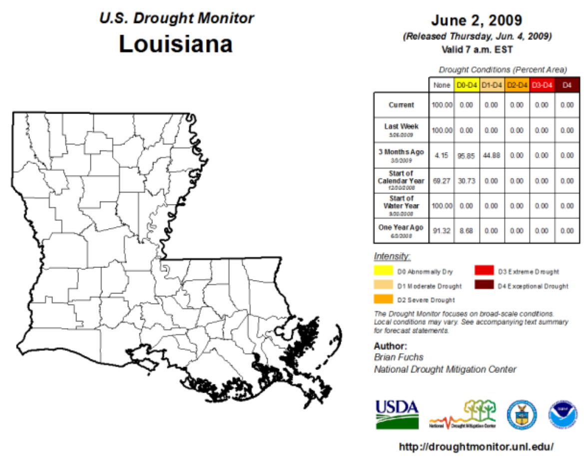
Drought Maps

For each planting year, at least three drought maps are shown: 1) at the time of planting; 2) end of July (the middle of the worst heat); and 3) at the end of the growing season/time of growth data collection around the first week of October. An additional map may be included if it illustrates a substantial change in drought conditions between the three time periods described above. Vegetative plantings implemented during the calendar year are in parenthesis.

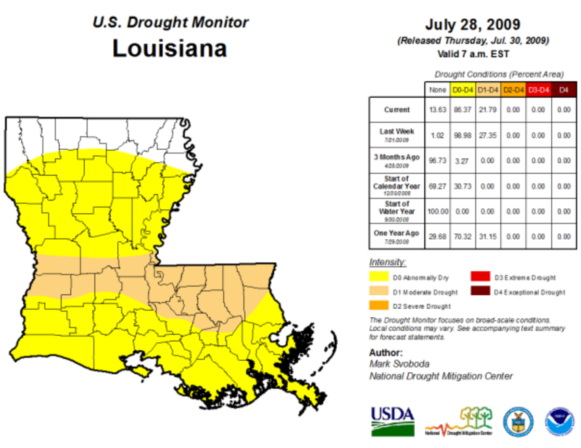
2009 – (Ring Planting & Herbaceous Field Trial Planting)



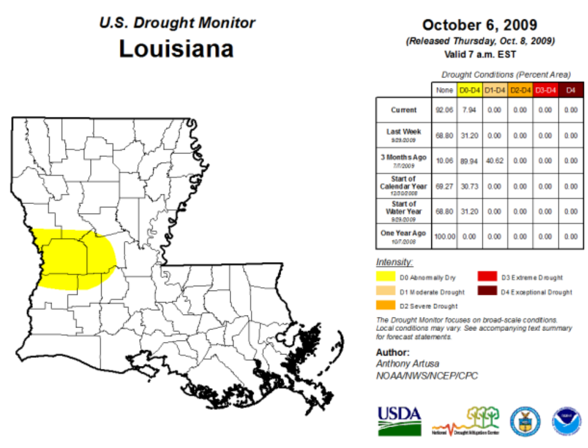
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	49.30	0.00	0.00	0.00
Last Week 3/3/2009	4.15	95.85	44.88	0.00	0.00	0.00
3 Months Ago 12/9/2008	69.27	30.73	0.00	0.00	0.00	0.00
Start of Calendar Year 12/30/2008	69.27	30.73	0.00	0.00	0.00	0.00
Start of Water Year 9/30/2008	100.00	0.00	0.00	0.00	0.00	0.00
One Year Ago 3/11/2008	100.00	0.00	0.00	0.00	0.00	0.00



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	100.00	0.00	0.00	0.00	0.00	0.00
Last Week 5/26/2009	100.00	0.00	0.00	0.00	0.00	0.00
3 Months Ago 3/3/2009	4.15	95.85	44.88	0.00	0.00	0.00
Start of Calendar Year 12/30/2008	69.27	30.73	0.00	0.00	0.00	0.00
Start of Water Year 9/30/2008	100.00	0.00	0.00	0.00	0.00	0.00
One Year Ago 6/3/2008	91.32	8.68	0.00	0.00	0.00	0.00

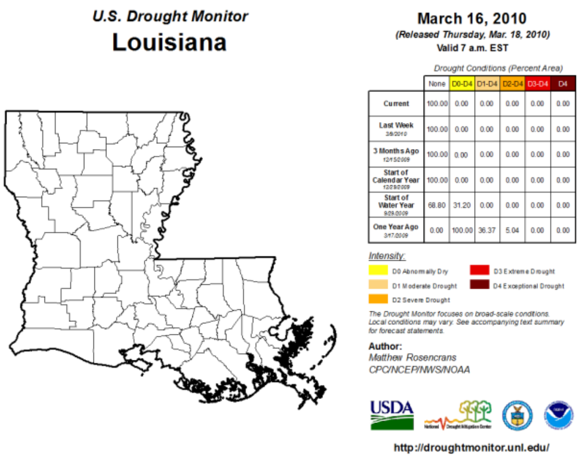


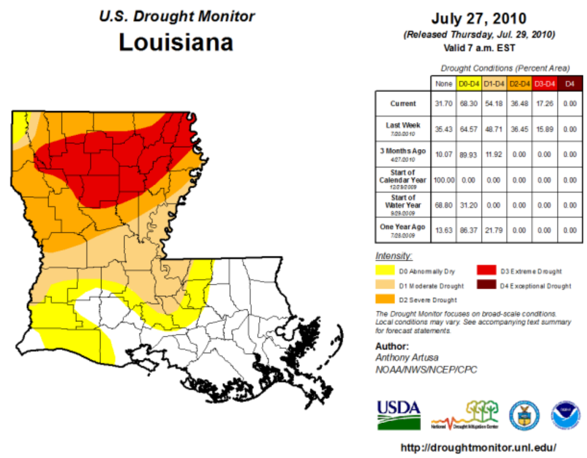
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	13.63	86.37	21.79	0.00	0.00	0.00
Last Week 7/21/2009	1.02	98.98	27.35	0.00	0.00	0.00
3 Months Ago 4/28/2009	96.73	3.27	0.00	0.00	0.00	0.00
Start of Calendar Year 12/30/2008	69.27	30.73	0.00	0.00	0.00	0.00
Start of Water Year 9/30/2008	100.00	0.00	0.00	0.00	0.00	0.00
One Year Ago 7/29/2008	29.68	70.32	31.15	0.00	0.00	0.00

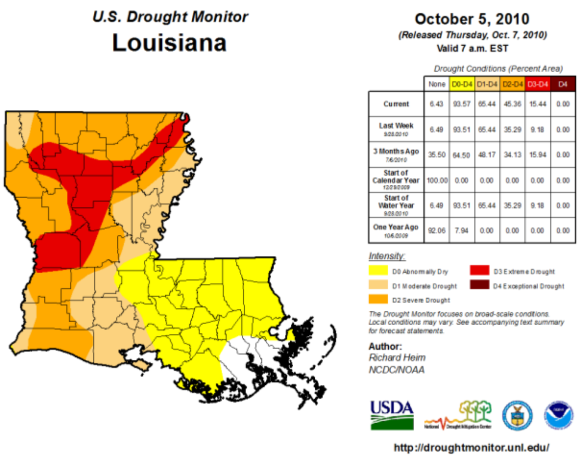


	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	92.06	7.94	0.00	0.00	0.00	0.00
Last Week 9/29/2009	68.80	31.20	0.00	0.00	0.00	0.00
3 Months Ago 7/7/2009	10.06	89.94	40.62	0.00	0.00	0.00
Start of Calendar Year 12/30/2008	69.27	30.73	0.00	0.00	0.00	0.00
Start of Water Year 9/29/2009	68.80	31.20	0.00	0.00	0.00	0.00
One Year Ago 10/7/2008	100.00	0.00	0.00	0.00	0.00	0.00

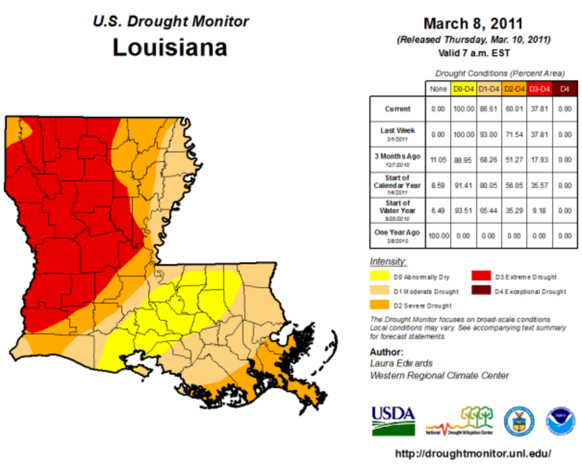
2010 – (2010 Block Planting)

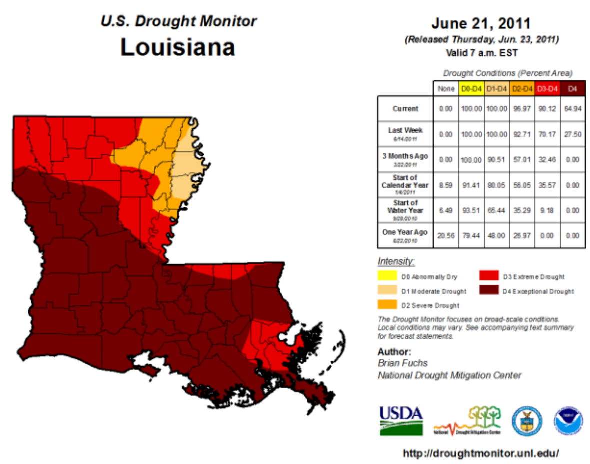




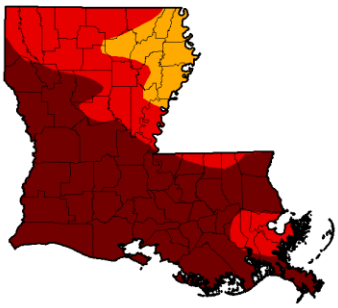


2011 – (2011 Block Planting & Linear Ridge Planting)





U.S. Drought Monitor
Louisiana



July 12, 2011
(Released Thursday, Jul. 14, 2011)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	100.00	100.00	91.02	63.97
Last Week 7/5/2011	0.00	100.00	100.00	96.97	90.12	63.70
3 Months Ago 4/12/2011	0.00	100.00	88.94	57.23	35.96	3.20
Start of Calendar Year 1/4/2011	8.59	91.41	80.05	56.05	35.57	0.00
Start of Water Year 9/28/2010	6.49	93.51	65.44	35.29	9.18	0.00
One Year Ago 7/13/2010	35.50	64.50	48.17	34.13	15.94	0.00

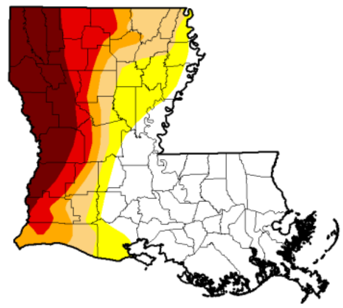
Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
David Miskus
NOAA/NWS/NCEP/CPC

http://droughtmonitor.unl.edu/

U.S. Drought Monitor
Louisiana



October 4, 2011
(Released Thursday, Oct. 6, 2011)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	43.13	56.87	44.57	34.46	27.36	16.60
Last Week 9/27/2011	45.37	54.63	44.43	35.94	27.14	16.37
3 Months Ago 7/5/2011	0.00	100.00	100.00	96.97	90.12	63.70
Start of Calendar Year 1/4/2011	8.59	91.41	80.05	56.05	35.57	0.00
Start of Water Year 9/27/2011	45.37	54.63	44.43	35.94	27.14	16.37
One Year Ago 10/5/2010	6.43	93.57	65.44	45.36	15.44	0.00

Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

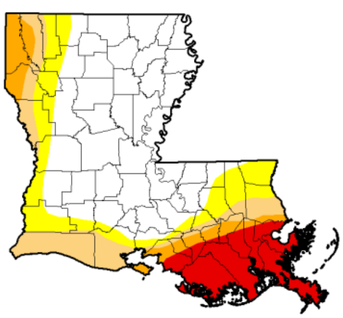
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Richard Tinker
CPC/NOAA/NWS/NCEP

http://droughtmonitor.unl.edu/

2012 – (2012 Block Planting & Mini Block Planting)

U.S. Drought Monitor
Louisiana



February 21, 2012
(Released Thursday, Feb. 23, 2012)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	53.39	46.61	31.32	19.44	12.87	0.00
Last Week 2/14/2012	38.82	61.18	43.73	30.96	16.09	0.00
3 Months Ago 11/22/2011	0.00	100.00	99.11	63.64	50.10	40.67
Start of Calendar Year 1/3/2012	5.57	94.43	83.40	58.92	26.55	4.10
Start of Water Year 9/27/2011	45.37	54.63	44.43	35.94	27.14	16.37
One Year Ago 2/22/2011	0.00	100.00	83.12	47.29	30.13	0.00

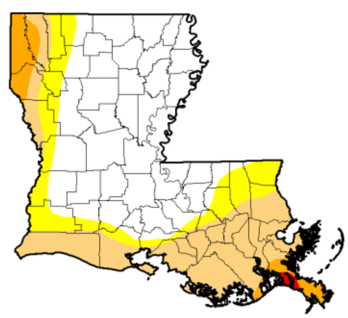
Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Mark Svoboda
National Drought Mitigation Center

http://droughtmonitor.unl.edu/

U.S. Drought Monitor
Louisiana



March 6, 2012
(Released Thursday, Mar. 8, 2012)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	53.39	46.61	31.46	5.93	0.41	0.00
Last Week 2/28/2012	53.39	46.61	31.33	19.44	12.87	0.00
3 Months Ago 12/6/2011	1.71	98.29	90.37	64.80	32.55	7.86
Start of Calendar Year 1/3/2012	5.57	94.43	83.40	58.92	26.55	4.10
Start of Water Year 9/27/2011	45.37	54.63	44.43	35.94	27.14	16.37
One Year Ago 3/8/2011	0.00	100.00	86.61	60.01	37.81	0.00

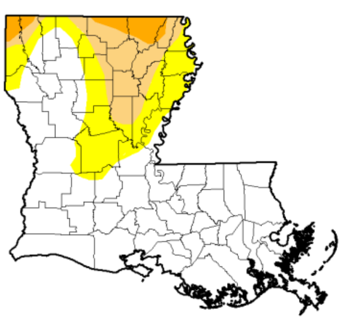
Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Michael Brewer
NCDC/NOAA

http://droughtmonitor.unl.edu/

U.S. Drought Monitor
Louisiana



July 24, 2012
(Released Thursday, Jul. 26, 2012)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	68.65	31.35	13.88	3.23	0.00	0.00
Last Week 7/17/2012	59.97	40.03	15.88	3.23	0.00	0.00
3 Months Ago 4/24/2012	84.98	15.02	0.05	0.00	0.00	0.00
Start of Calendar Year 1/3/2012	5.57	94.43	83.40	58.92	26.55	4.10
Start of Water Year 9/27/2011	45.37	54.63	44.43	35.94	27.14	16.37
One Year Ago 7/26/2011	0.00	100.00	100.00	100.00	82.79	33.41

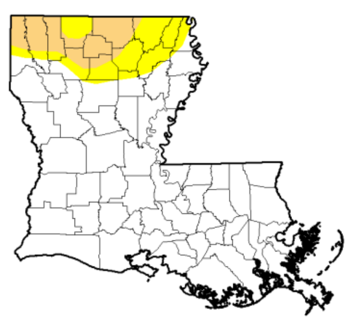
Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Richard Heim
NCDC/NOAA

http://droughtmonitor.unl.edu/

U.S. Drought Monitor
Louisiana



October 2, 2012
(Released Thursday, Oct. 4, 2012)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	82.82	17.18	8.05	0.00	0.00	0.00
Last Week 9/25/2012	81.05	18.95	8.45	0.00	0.00	0.00
3 Months Ago 7/3/2012	33.35	66.65	34.33	3.23	0.00	0.00
Start of Calendar Year 1/3/2012	5.57	94.43	83.40	58.92	26.55	4.10
Start of Water Year 9/25/2012	81.05	18.95	8.45	0.00	0.00	0.00
One Year Ago 10/4/2011	43.13	56.87	44.57	34.46	27.36	16.60

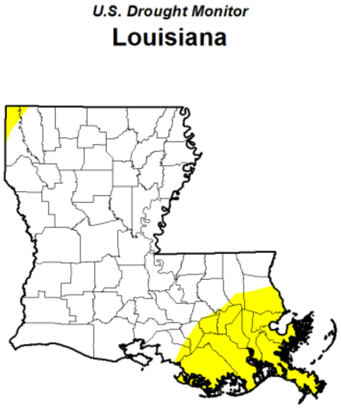
Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Anthony Artusa
NOAA/NWS/NCEP/CPC

http://droughtmonitor.unl.edu/

2013 – (2013 Block Planting)



January 29, 2013
(Released Thursday, Jan. 31, 2013)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

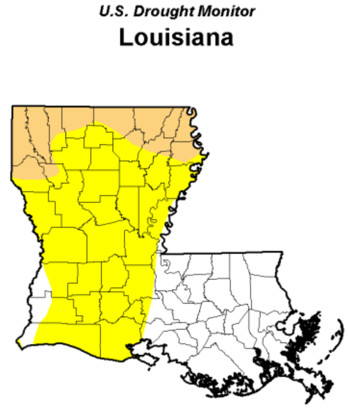
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	83.09	16.91	0.01	0.00	0.00	0.00
Last Week 1/22/2013	83.09	16.91	0.01	0.00	0.00	0.00
3 Months Ago 10/30/2012	93.73	6.27	0.43	0.00	0.00	0.00
Start of Calendar Year 1/1/2013	56.27	43.73	1.20	0.00	0.00	0.00
Start of Water Year 9/25/2012	81.05	18.95	8.45	0.00	0.00	0.00
One Year Ago 1/31/2012	13.92	86.08	61.72	34.21	17.97	0.00

Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Mark Svoboda
National Drought Mitigation Center

http://droughtmonitor.unl.edu/



July 23, 2013
(Released Thursday, Jul. 25, 2013)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

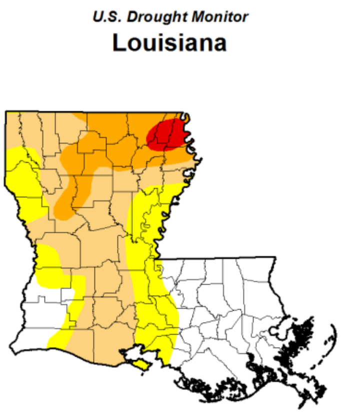
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	35.55	64.45	14.89	0.00	0.00	0.00
Last Week 7/16/2013	68.92	31.08	0.36	0.00	0.00	0.00
3 Months Ago 4/23/2013	93.41	6.59	0.00	0.00	0.00	0.00
Start of Calendar Year 1/1/2013	56.27	43.73	1.20	0.00	0.00	0.00
Start of Water Year 9/25/2012	81.05	18.95	8.45	0.00	0.00	0.00
One Year Ago 7/24/2012	68.65	31.35	13.88	3.23	0.00	0.00

Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Richard Heim
NCDC/NOAA

http://droughtmonitor.unl.edu/



October 1, 2013
(Released Thursday, Oct. 3, 2013)
Valid 7 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	32.46	67.54	46.36	14.33	1.98	0.00
Last Week 9/24/2013	27.34	72.66	54.34	28.67	0.17	0.00
3 Months Ago 7/2/2013	91.32	8.68	0.00	0.00	0.00	0.00
Start of Calendar Year 1/1/2013	56.27	43.73	1.20	0.00	0.00	0.00
Start of Water Year 10/1/2013	32.46	67.54	46.36	14.33	1.98	0.00
One Year Ago 10/2/2012	82.82	17.18	8.05	0.00	0.00	0.00

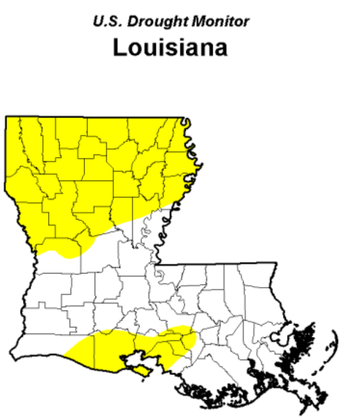
Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
David Miskus
NOAA/NWS/NCEP/CPC

http://droughtmonitor.unl.edu/

2014 – (2014 Block Planting)



March 25, 2014
(Released Thursday, Mar. 27, 2014)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	54.10	45.90	0.00	0.00	0.00	0.00
Last Week 3/18/2014	54.10	45.90	0.00	0.00	0.00	0.00
3 Months Ago 12/24/2013	91.60	8.40	0.00	0.00	0.00	0.00
Start of Calendar Year 12/31/2013	87.36	12.64	0.00	0.00	0.00	0.00
Start of Water Year 10/1/2013	32.46	67.54	46.36	14.33	1.98	0.00
One Year Ago 3/26/2013	71.61	28.39	0.25	0.00	0.00	0.00

Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
David Simeral
Western Regional Climate Center

http://droughtmonitor.unl.edu/

July 29, 2014
(Released Thursday, Jul. 31, 2014)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	99.54	0.46	0.00	0.00	0.00	0.00
Last Week 7/22/2014	99.54	0.46	0.00	0.00	0.00	0.00
3 Months Ago 4/29/2014	68.24	31.76	6.79	0.00	0.00	0.00
Start of Calendar Year 12/31/2013	87.36	12.64	0.00	0.00	0.00	0.00
Start of Water Year 10/1/2013	32.46	67.54	46.36	14.33	1.98	0.00
One Year Ago 7/30/2013	35.06	64.94	20.08	0.00	0.00	0.00

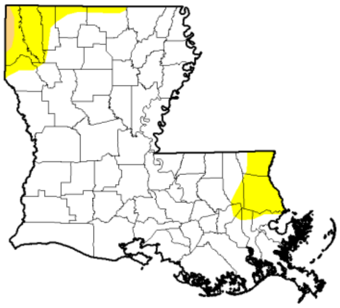
Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Brad Rippey
U.S. Department of Agriculture

http://droughtmonitor.unl.edu/

U.S. Drought Monitor
Louisiana



October 7, 2014
(Released Thursday, Oct. 9, 2014)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	88.92	11.08	0.67	0.00	0.00	0.00
Last Week 9/30/2014	88.99	11.01	0.63	0.00	0.00	0.00
3 Months Ago 7/8/2014	87.55	12.45	0.01	0.00	0.00	0.00
Start of Calendar Year 12/31/2013	87.36	12.64	0.00	0.00	0.00	0.00
Start of Water Year 9/30/2014	88.99	11.01	0.63	0.00	0.00	0.00
One Year Ago 10/8/2013	38.66	61.34	41.68	14.33	0.00	0.00

Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

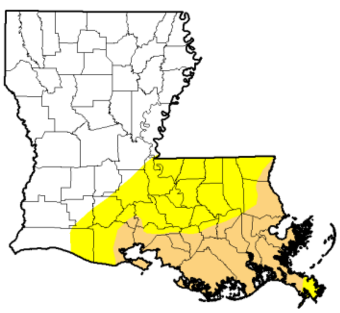
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Mark Svoboda
National Drought Mitigation Center

http://droughtmonitor.unl.edu/

2015 – (No New Plantings/Last Year of Growth Data Collection)

U.S. Drought Monitor
Louisiana



March 24, 2015
(Released Thursday, Mar. 26, 2015)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	59.00	41.00	18.54	0.00	0.00	0.00
Last Week 3/17/2015	59.00	41.00	21.19	0.00	0.00	0.00
3 Months Ago 12/23/2014	15.88	84.12	26.25	11.82	0.00	0.00
Start of Calendar Year 12/30/2014	47.23	52.77	10.88	0.00	0.00	0.00
Start of Water Year 9/30/2014	88.99	11.01	0.63	0.00	0.00	0.00
One Year Ago 3/25/2014	54.10	45.90	0.00	0.00	0.00	0.00

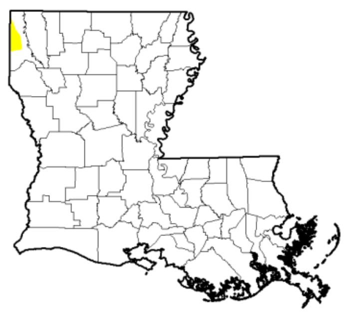
Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Eric Luebehusen
U.S. Department of Agriculture

http://droughtmonitor.unl.edu/

U.S. Drought Monitor
Louisiana



July 21, 2015
(Released Thursday, Jul. 23, 2015)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	99.51	0.49	0.00	0.00	0.00	0.00
Last Week 7/14/2015	100.00	0.00	0.00	0.00	0.00	0.00
3 Months Ago 4/21/2015	100.00	0.00	0.00	0.00	0.00	0.00
Start of Calendar Year 12/30/2014	47.23	52.77	10.88	0.00	0.00	0.00
Start of Water Year 9/30/2014	88.99	11.01	0.63	0.00	0.00	0.00
One Year Ago 7/22/2014	99.54	0.46	0.00	0.00	0.00	0.00

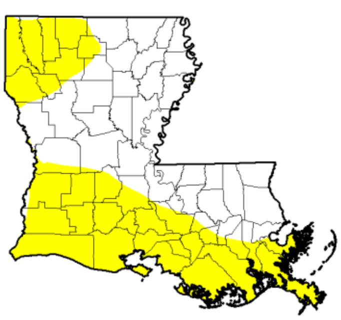
Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
David Simeral
Western Regional Climate Center

http://droughtmonitor.unl.edu/

U.S. Drought Monitor
Louisiana



July 28, 2015
(Released Thursday, Jul. 30, 2015)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	51.06	48.94	0.00	0.00	0.00	0.00
Last Week 7/21/2015	99.51	0.49	0.00	0.00	0.00	0.00
3 Months Ago 4/28/2015	100.00	0.00	0.00	0.00	0.00	0.00
Start of Calendar Year 12/30/2014	47.23	52.77	10.88	0.00	0.00	0.00
Start of Water Year 9/30/2014	88.99	11.01	0.63	0.00	0.00	0.00
One Year Ago 7/29/2014	99.54	0.46	0.00	0.00	0.00	0.00

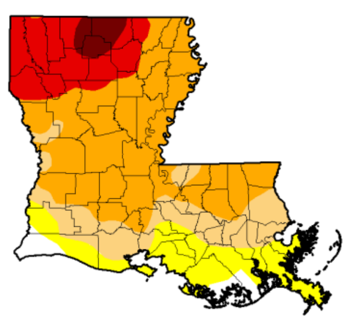
Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Richard Heim
NCEI/NOAA

http://droughtmonitor.unl.edu/

U.S. Drought Monitor
Louisiana



October 6, 2015
(Released Thursday, Oct. 8, 2015)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	3.30	96.70	80.84	63.70	18.36	3.08
Last Week 9/29/2015	6.86	93.14	71.14	45.44	15.22	0.00
3 Months Ago 7/7/2015	100.00	0.00	0.00	0.00	0.00	0.00
Start of Calendar Year 12/30/2014	47.23	52.77	10.88	0.00	0.00	0.00
Start of Water Year 9/29/2015	6.86	93.14	71.14	45.44	15.22	0.00
One Year Ago 10/7/2014	88.92	11.08	0.67	0.00	0.00	0.00

Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
David Miskus
NOAA/NWS/NCEP/CPC

http://droughtmonitor.unl.edu/

APPENDIX 4

Preliminary Report on Growth and Survival of 10 Vegetative Species Planted at the Fourchon Ridge between 2010 – 2014: Effect of Additives

Preliminary Report on Growth and Survival of 10 Vegetative Species Planted at the Fourchon Ridge between 2010 – 2014: Effect of Additives

Quenton Fontenot

Deparment of Biological Sciences

Nicholls State University

Thibodaux, LA

70310

3 December 2015

Executive Summary

This project involved planting multiple species of vegetation on a recently created ridge near Fourchon, Louisiana. The first part of this study evaluated the benefits of adding various forms of supplements to the soil on first year survival and growth. The treatments consisted of a Control (no additives), Bag, Fertilizer, Gypsum, and various combinations of the additives. The additives were added to the hole used to plant the tree at the time of planting. Each planting was conducted in a block, and the mean of each block was used as a replicate. Survival was determined based on the proportion of individuals still alive. Vigor was calculated using an index that ranged from 1 – 9, with 1 being the most vigorous and 9 being dead. Height and Spread were measured in inches and basal stem diameter was measured in mm's.

Growth and survival were quantified approximately 6 months and one 18 months after planting. Analysis of Variance (ANOVA; alpha = 0.05) was used to evaluate the effect soil treatments had on each variable measured for each sample date. Tukeys post hoc analysis was used to delineate among treatments if ANOVA revealed a treatment effect.

It does not appear that any of the soil additives had a positive effect of survival and growth. The only exception is Fertilizer for Matrimony Vine (Figure's 7, 9, and 10). Although there were a few other statistical differences noted, they do not appear to be relevant. One reason why the additives did not have an affect could by the low level of survival. There were several plantings that resulted in 100% mortality. It appears that survival improved as the ridge became older, which may be an indication of a change in overall soil quality of th ridge (i.e., decrease in soil salinity). Therefore, future analysis will pool each species across soil treatments to increase the robustness of the data set to increase our ability to detect soil quality effects on vegetation survival and growth.

At this time, it does not appear beneficial to use additives when planting the species used for this study on newly created maritime ridges. The remainder of this analysis will focus on soil chemistry and planting location.

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Live Oak 2012 -	34
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Hackberry 2013 -	40
Live Oak 2013 -	43
Sand Oak 2013 -	46
Dogwood 2014 -	49
Live Oak 2014 -	52
Yaupon 2014 -	55

Hackberry – 2010 Planting

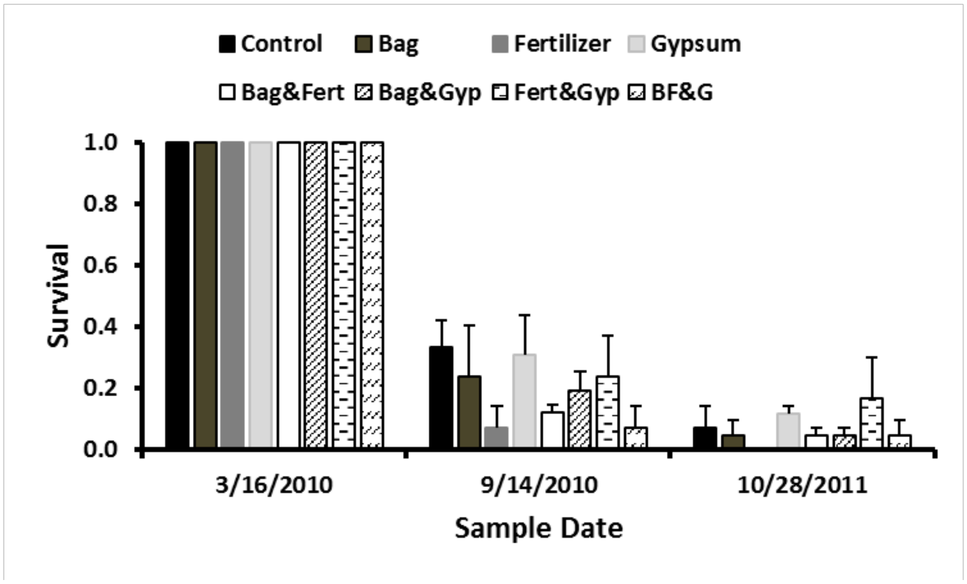

Figure 1. Mean (±SE) survival of Hackberry planted on 16 March 2010 exposed to eight soil treatments. Survival was similar among all treatments for all dates.

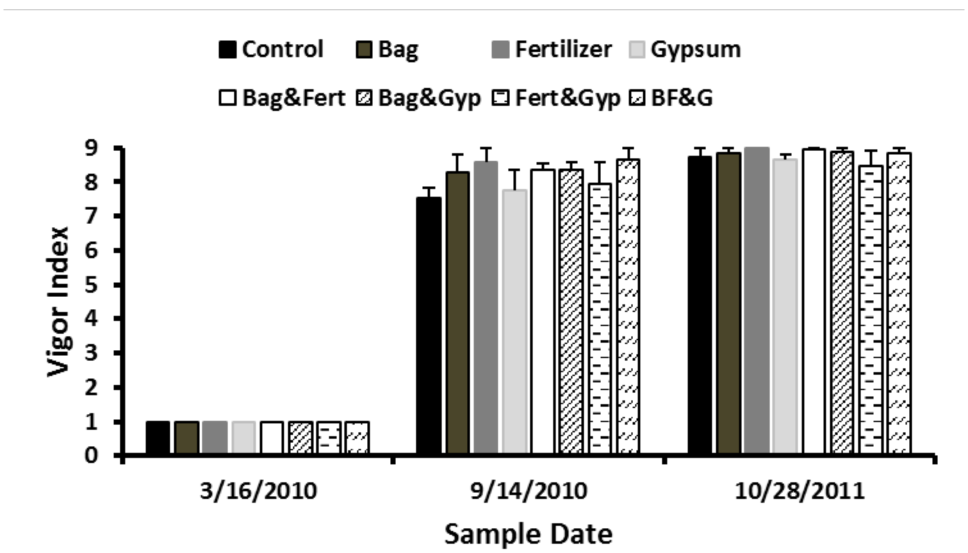

Figure 2. Mean (±SE) vigor of Hackberry planted on 16 March 2010 exposed to eight soil treatments. Vigor was similar among all treatments for all dates.

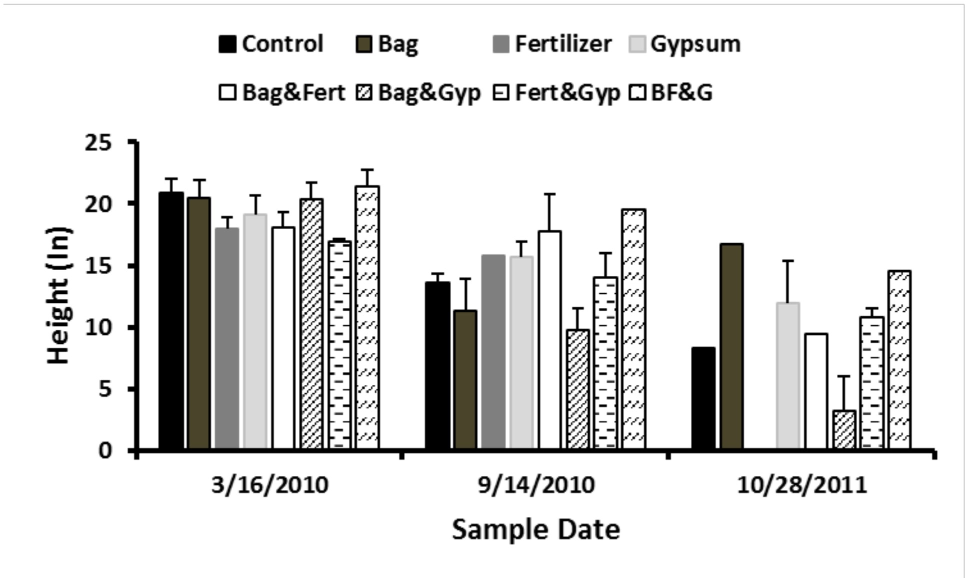

Figure 3. Mean (±SE) height of Hackberry planted on 16 March 2010 exposed to eight soil treatments. Height was similar among all treatments for all dates.

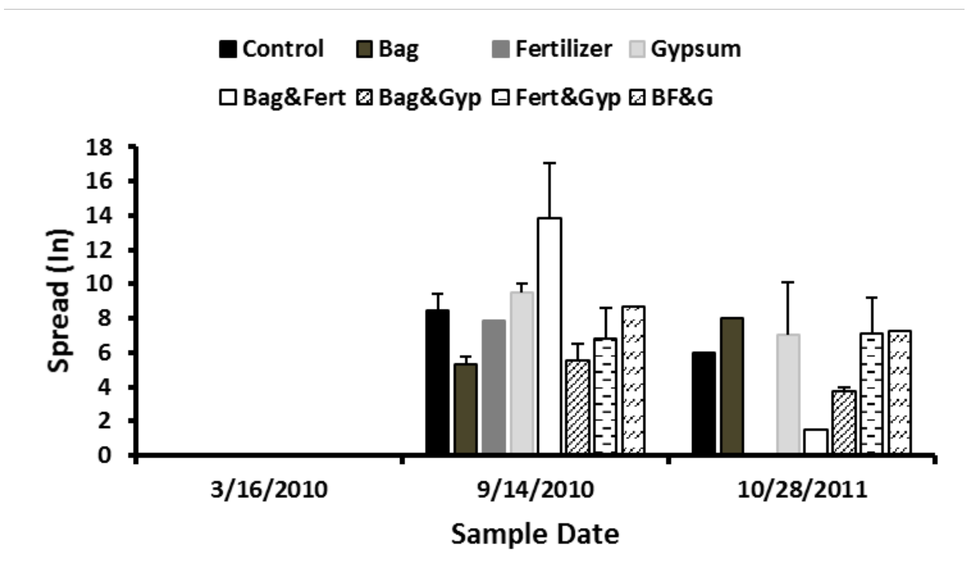

Figure 4. Mean (±SE) spread of Hackberry planted on 16 March 2010 exposed to eight soil treatments. Spread was similar among all treatments for all dates. There was no data available for 16 March 2010.

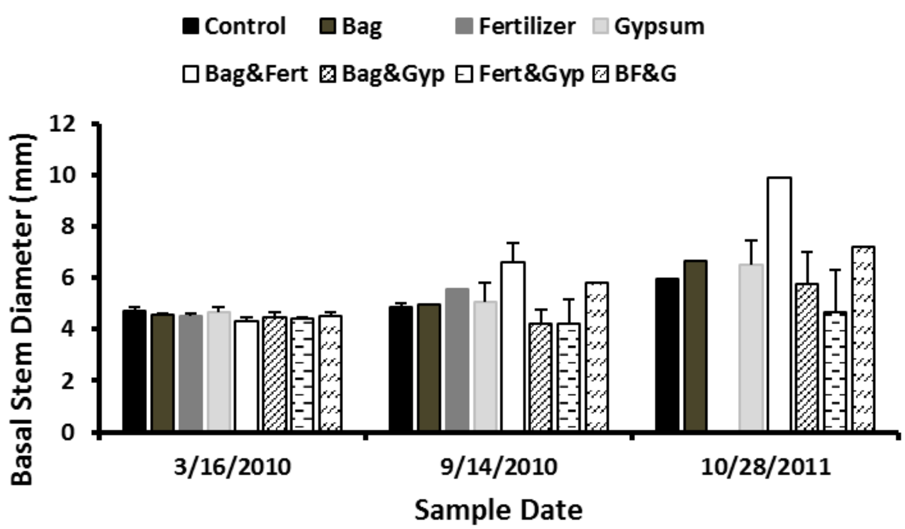

Figure 5. Mean (±SE) basal stem diameter of Hackberry planted on 16 March 2010 exposed to eight soil treatments. Basal stem diameter was similar among all treatments for all dates.

Matrimony Vine – 2010 Planting

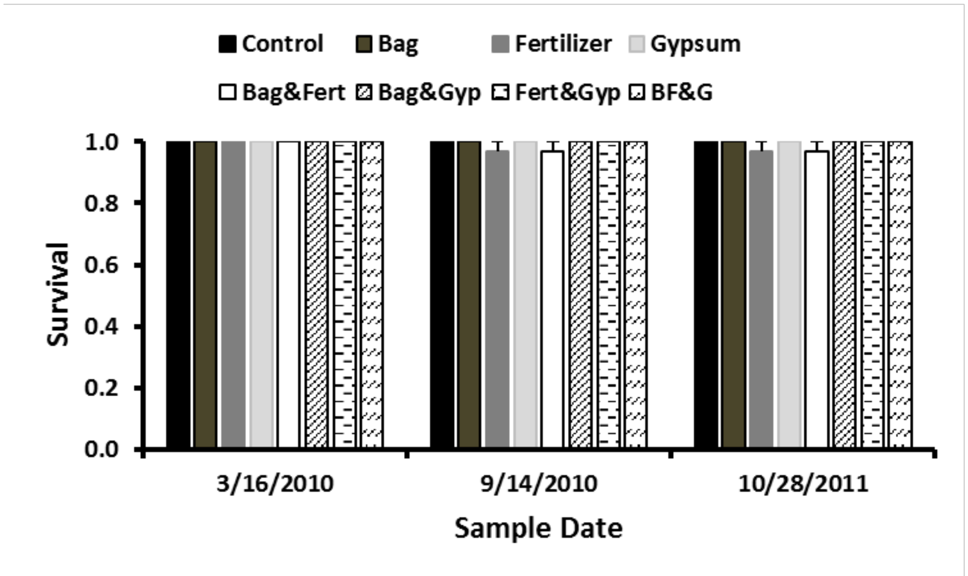

Figure 6. Mean (±SE) survival of Matrimony Vine planted on 16 March 2010 exposed to eight soil treatments. Survival was similar among all treatments for all dates.

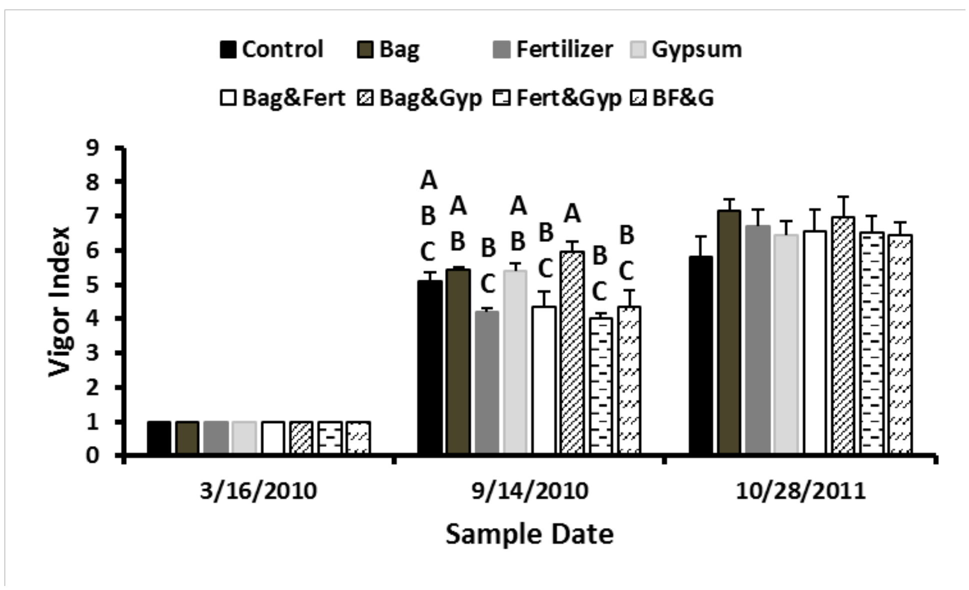

Figure 7. Mean (±SE) vigor of Matrimony Vine planted on 16 March 2010 exposed to eight soil treatments. Vigor varied among treatments on 14 September 2010 but was was similar among all treatments on 28 October 2011. Means with a similar letter are not different.

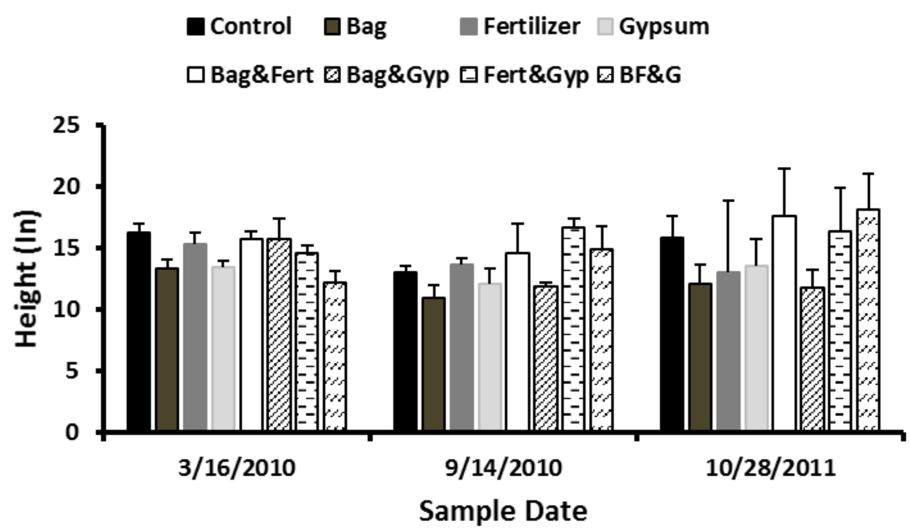

Figure 8. Mean (±SE) height of Matrimony Vine planted on 16 March 2010 exposed to eight soil treatments. Height was similar among all treatments for all dates.

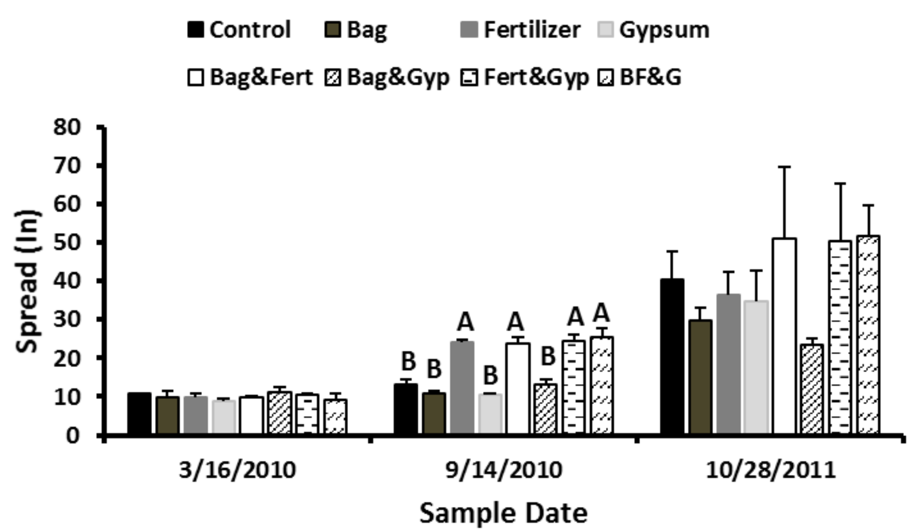

Figure 9. Mean (±SE) spread of Matrimony Vine planted on 16 March 2010 exposed to eight soil treatments. Spread was greater for treatments that contained fertilizer on 14 September 2010 but was was similar among all treatments on 28 October 2011. Means with a similar letter are not different.

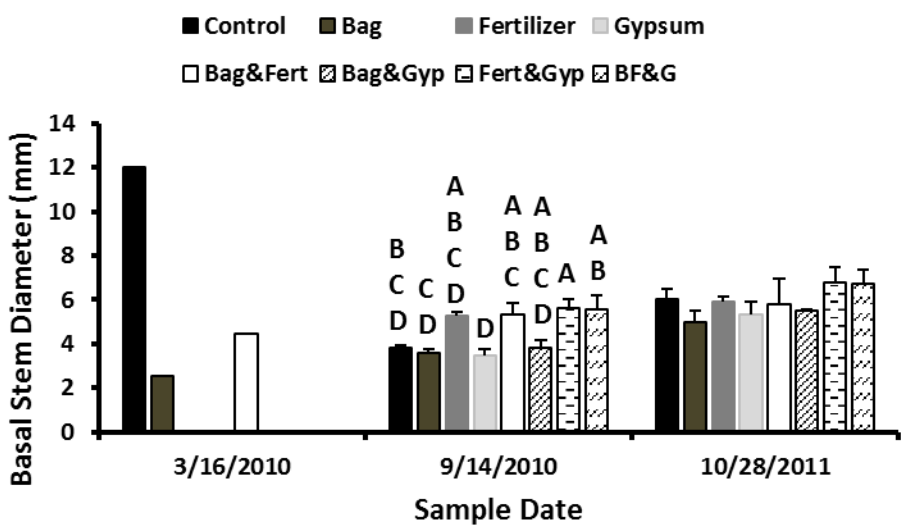

Figure 10. Mean (±SE) basal stem diameter of Matrimony Vine planted on 16 March 2010 exposed to eight soil treatments. Basal stem diameter varied among treatments on 14 September 2010, but fertilizer appears to be beneficial. Basal stem diameter was similar among all treatments on 28 October 2011. Means with a similar letter are not different.

Sand Oak – 2010 Planting

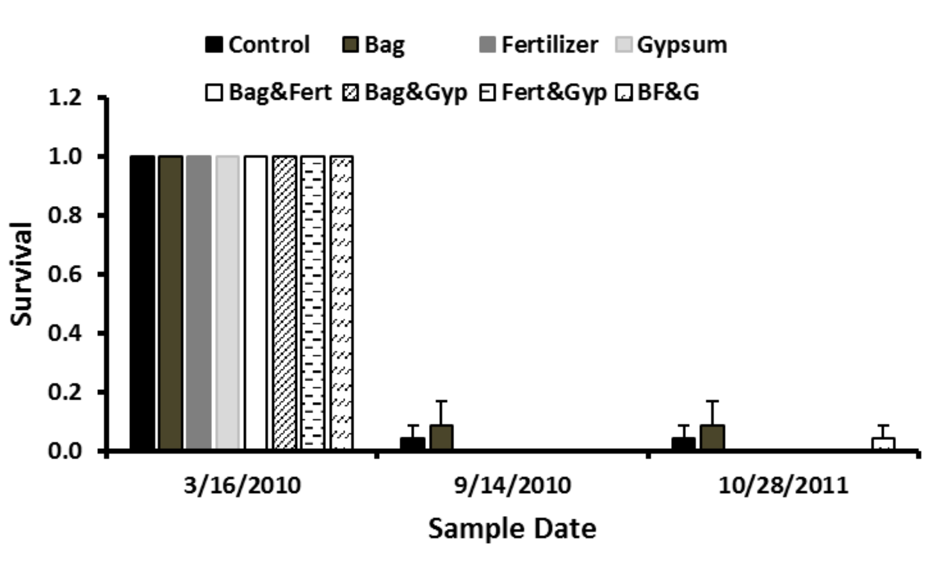

Figure 11. Mean (±SE) survival of Sand Oak planted on 16 March 2010 exposed to eight soil treatments. Survival was very low among treatments, but was similar all dates.

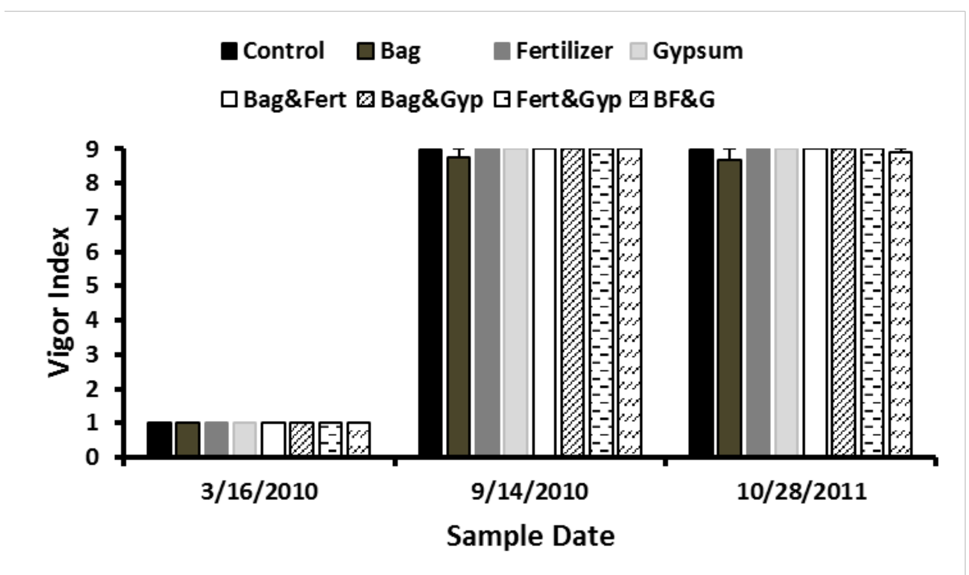

Figure 12. Mean (±SE) vigor of Sand Oak planted on 16 March 2010 exposed to eight soil treatments. Vigor was similar among all treatments for all dates.

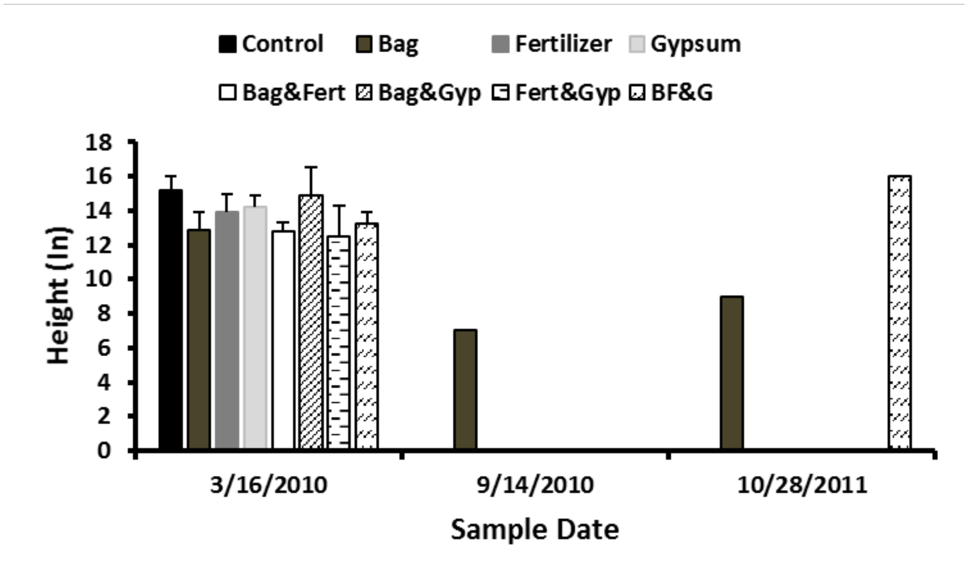

Figure 13. Mean (±SE) Height of Sand Oak planted on 16 March 2010 exposed to eight soil treatments. Height was similar among all treatments for all dates.

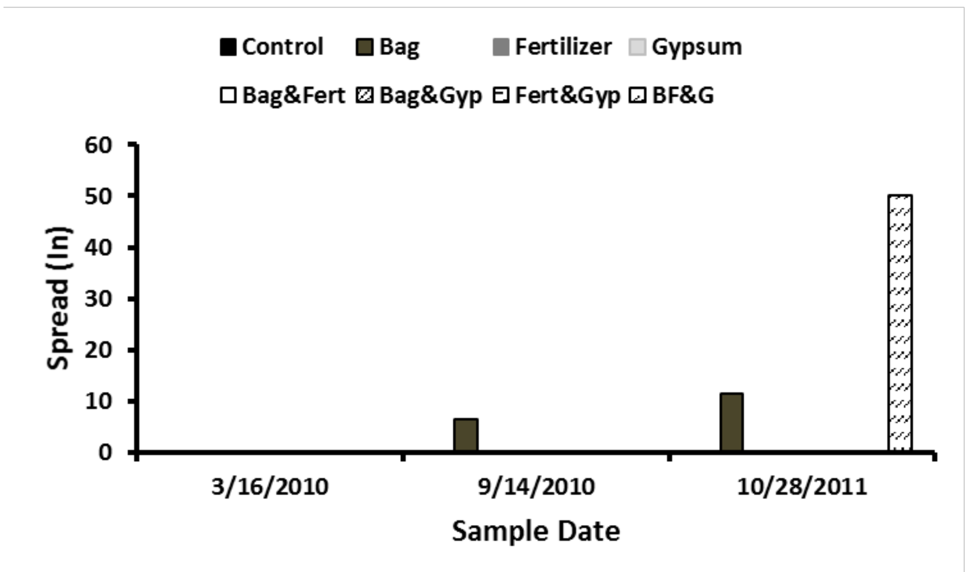

Figure 14. Mean (±SE) Spread of Sand Oak planted on 16 March 2010 exposed to eight soil treatments. There was no data available for 16 March 2010.

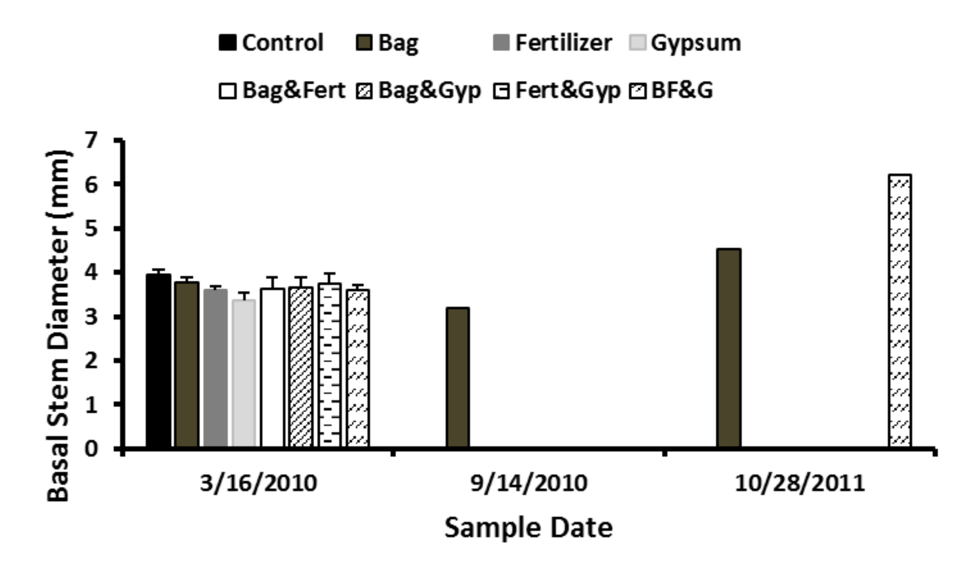

Figure 15. Mean (±SE) Basal Stem Diameter of Sand Oak planted on 16 March 2010 exposed to eight soil treatments. Basal Stem Diameter was similar among all treatments for all dates.

Beautyberry – 2011 Planting

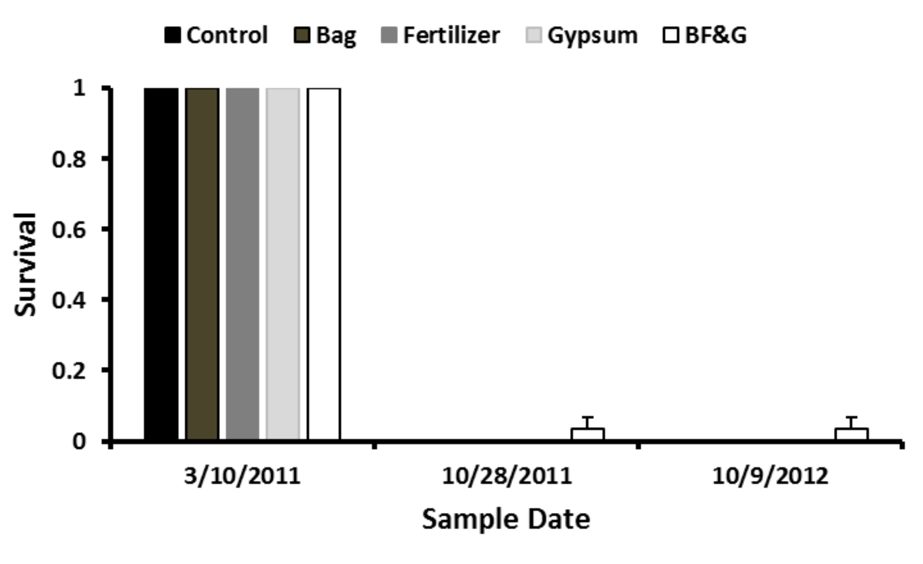

Figure 16. Mean (±SE) survival of Beautyberry planted on 10 March 2011 exposed to five soil treatments. Only the BF&G treatment had survivors post planting.

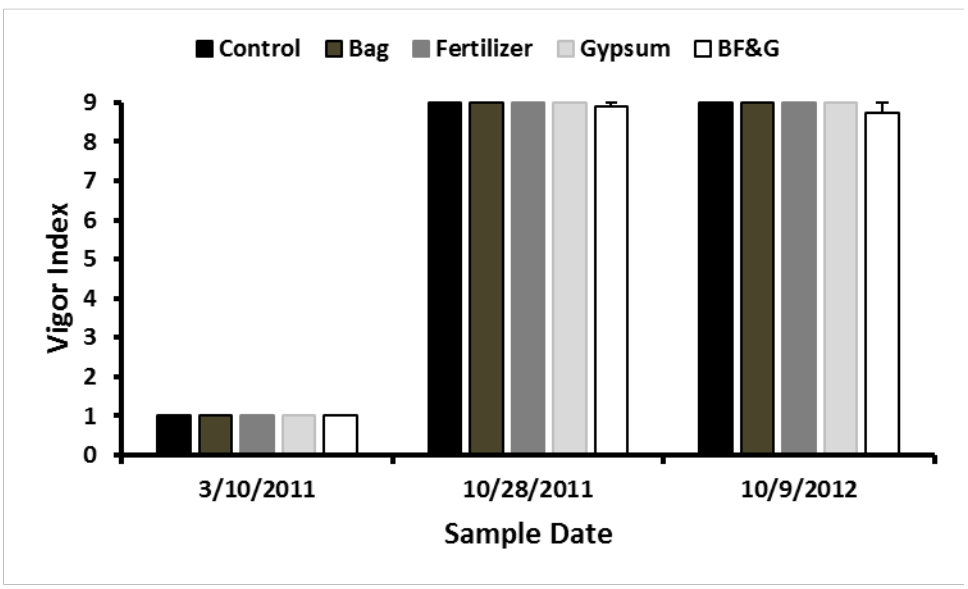

Figure 17. Mean (±SE) vigor of Beautyberry planted on 10 March 2011 exposed to five soil treatments. Only the BF&G treatment had survivors post planting.

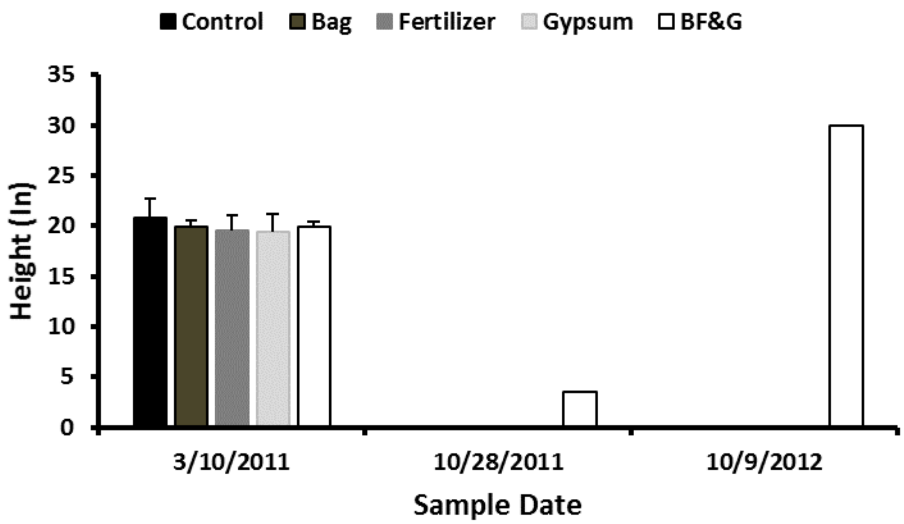

Figure 18. Mean (±SE) height of Beautyberry planted on 10 March 2011 exposed to five soil treatments. Only the BF&G treatment had survivors post planting.

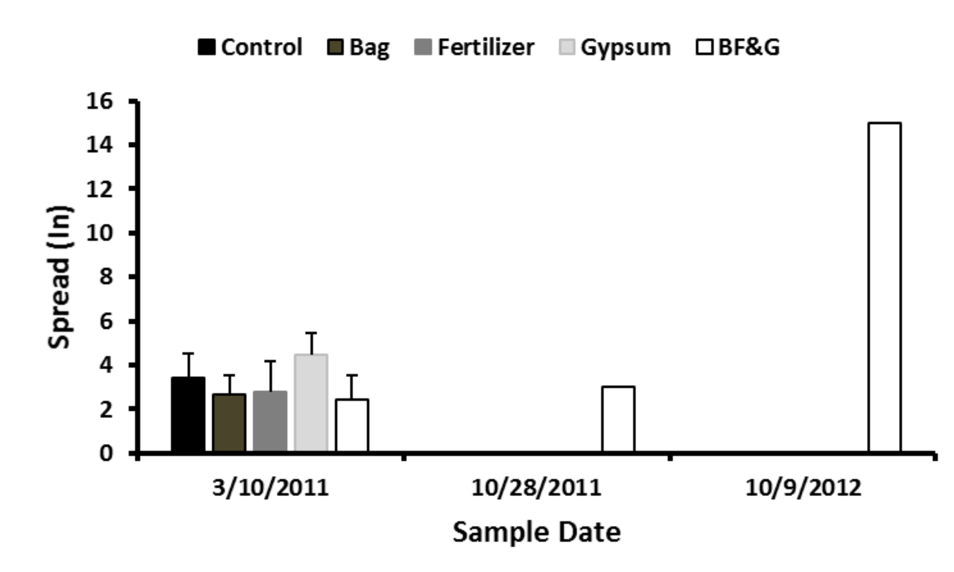

Figure 19. Mean (±SE) spread of Beautyberry planted on 10 March 2011 exposed to five soil treatments. Only the BF&G treatment had survivors post planting.

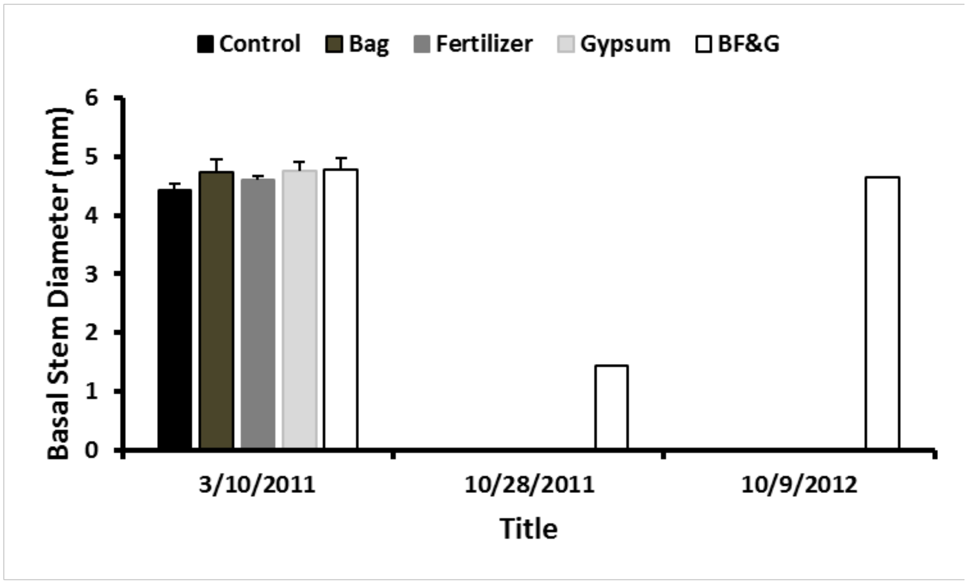

Figure 20. Mean (±SE) basal stem diameter of Beautyberry planted on 10 March 2011 exposed to five soil treatments. Only the BF&G treatment had survivors post planting.

Hackberry – 2011 Planting

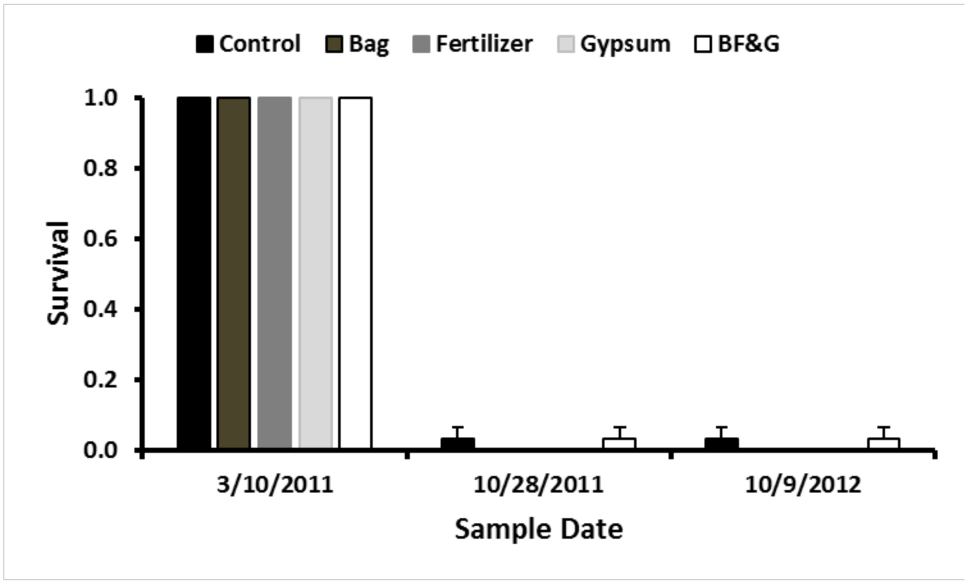

Figure 21. Mean (±SE) Survival of Hackberry planted on 10 March 2011 exposed to five soil treatments. Only the Control and BF&G treatment had survivors post planting.

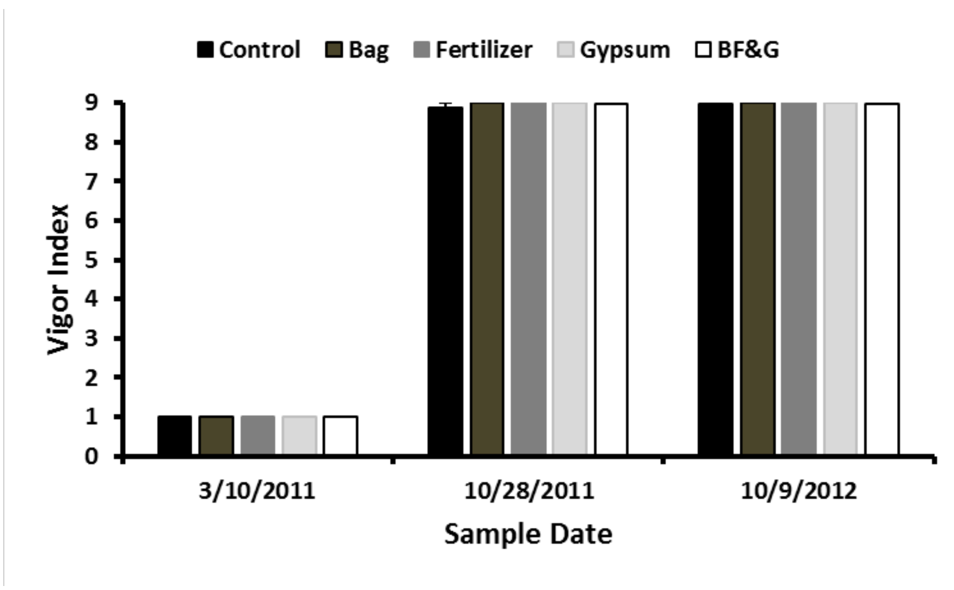

Figure 22. Mean (±SE) Vigor of Hackberry planted on 10 March 2011 exposed to five soil treatments. Only the Control and BF&G treatment had survivors post planting and vigor was similar among all treatments for all dates.

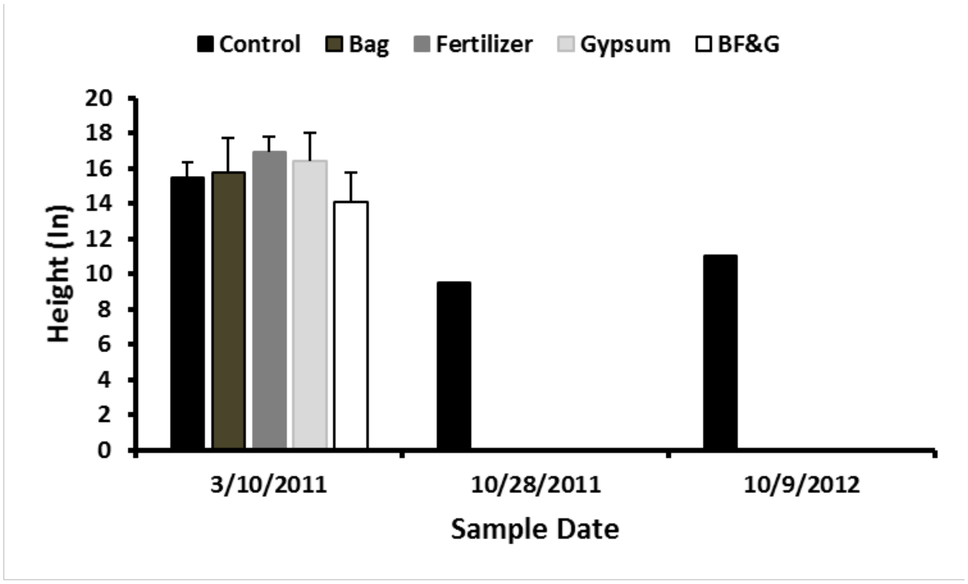

Figure 23. Mean (±SE) Height of Hackberry planted on 10 March 2011 exposed to five soil treatments. Height was similar among all treatments for all dates.

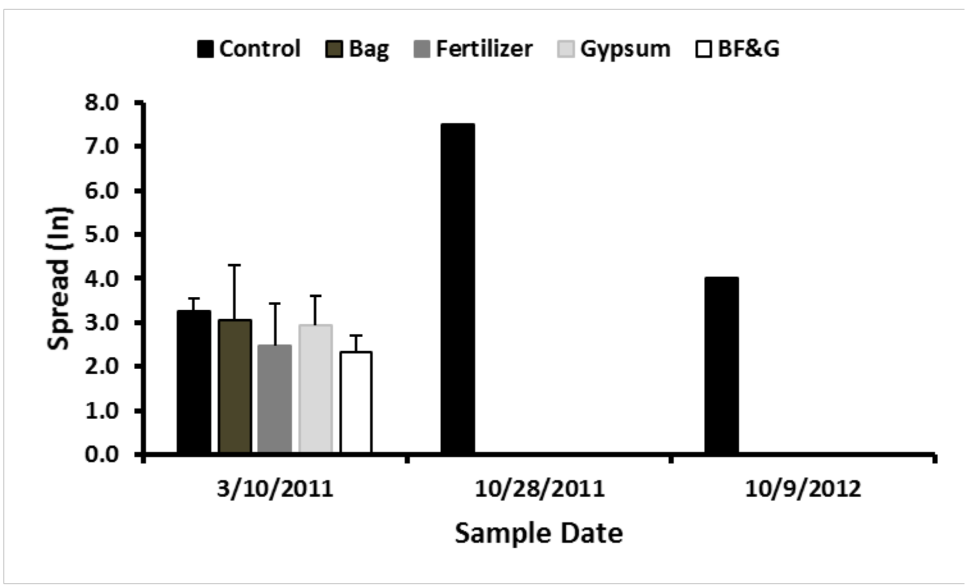

Figure 24. Mean (±SE) Spread of Hackberry planted on 10 March 2011 exposed to five soil treatments. Spread was similar among all treatments for all dates.

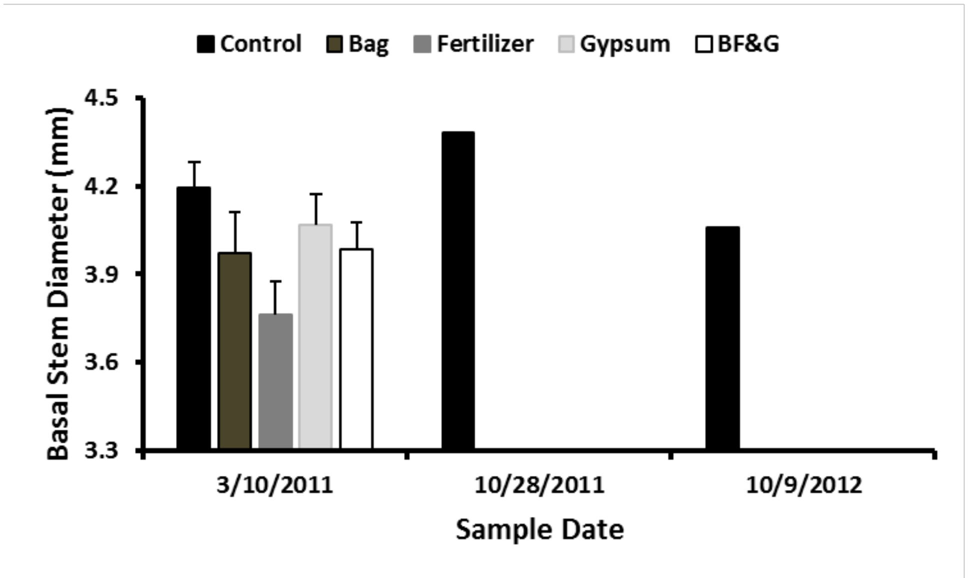

Figure 25. Mean (±SE) Basal Stem Diameter of Hackberry planted on 10 March 2011 exposed to five soil treatments. Basal Stem Diameter was similar among all treatments for all dates.

Honey Locust – 2011 Planting

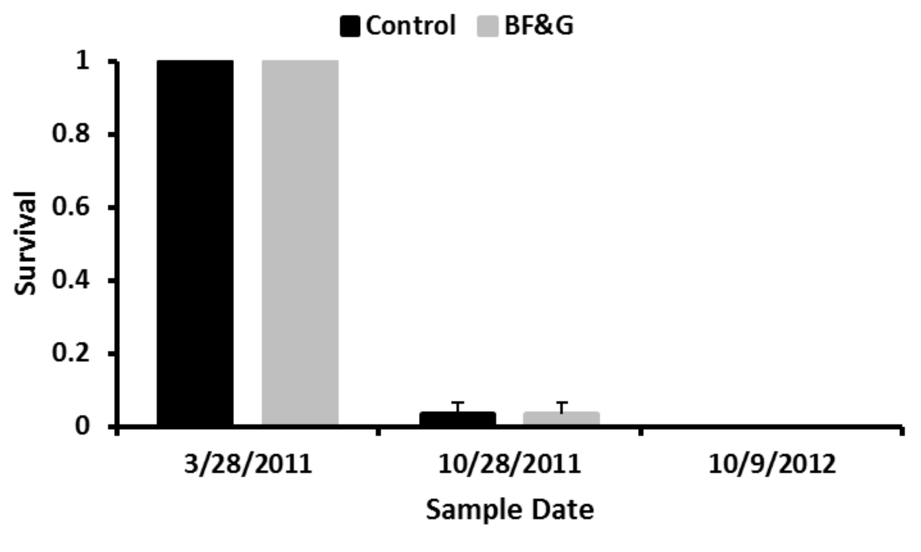

Figure 26. Mean (±SE) Survival of Honey Locust planted on 28 March 2011 exposed to two soil treatments. There were no surviving individuals on 9 October 2012.

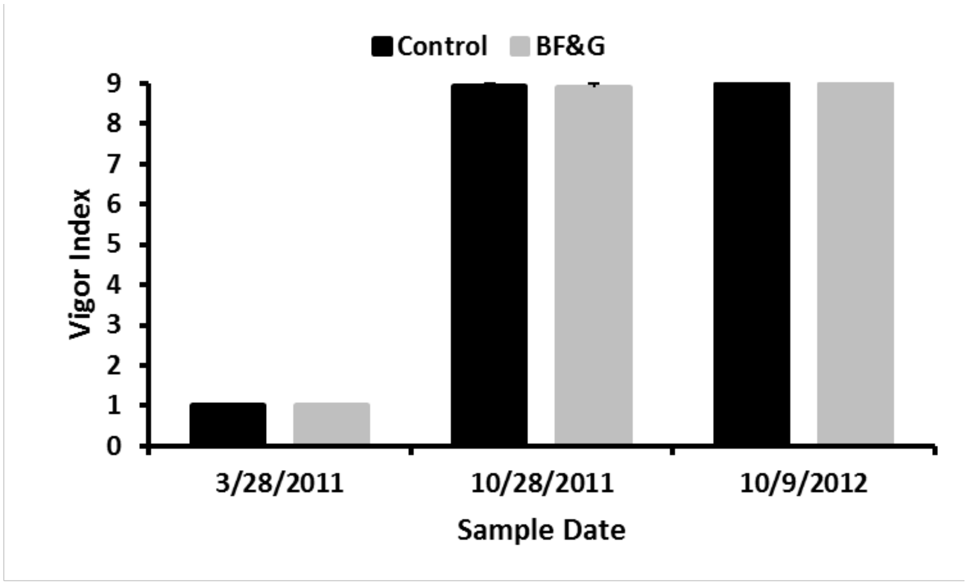

Figure 27. Mean (±SE) Vigor of Honey Locust planted on 28 March 2011 exposed to two soil treatments. There were no surviving individuals on 9 October 2012.

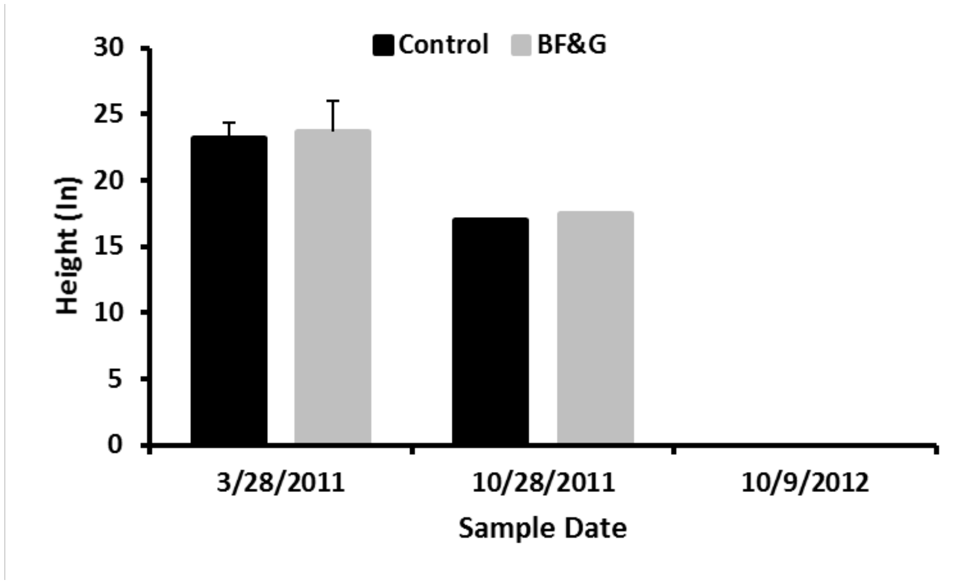

Figure 28. Mean (±SE) Height of Honey Locust planted on 28 March 2011 exposed to two soil treatments. There were no surviving individuals on 9 October 2012.

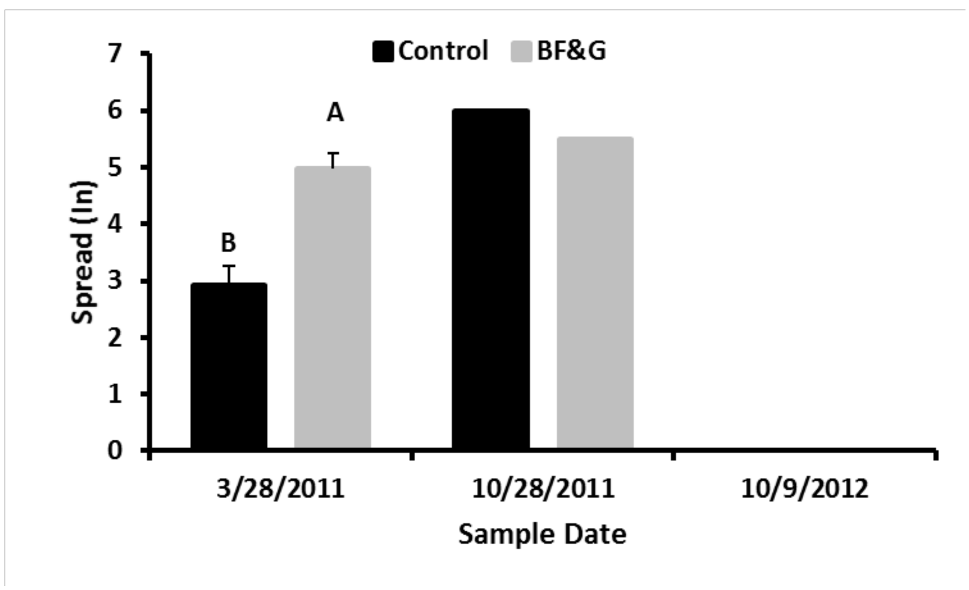

Figure 29. Mean (±SE) Spread of Honey Locust planted on 28 March 2011 exposed to two soil treatments. There were no surviving individuals on 9 October 2012.

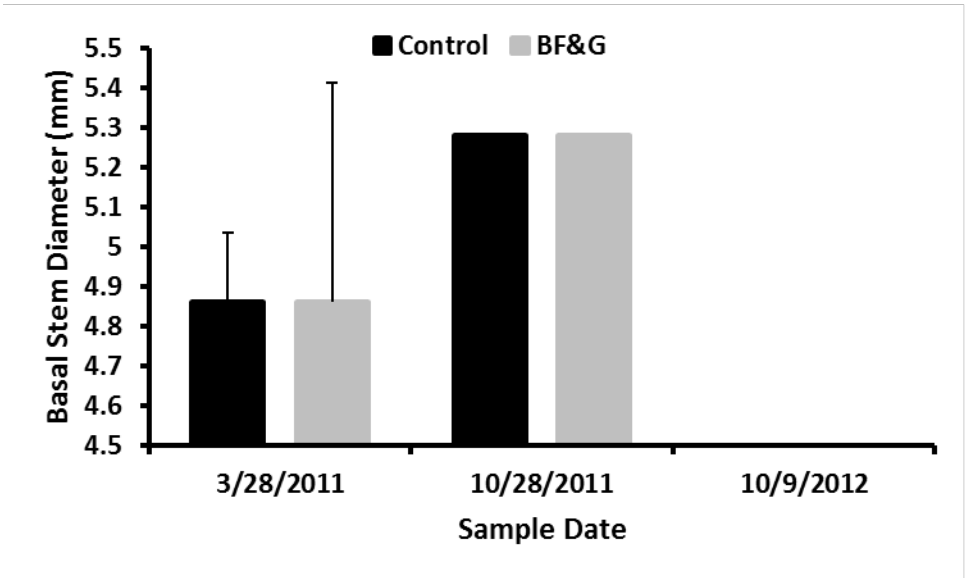

Figure 30. Mean (±SE) Basal Stem Diameter of Honey Locust planted on 28 March 2011 exposed to two soil treatments. There were no surviving individuals on 9 October 2012.

Live Oak – 2011 Planting

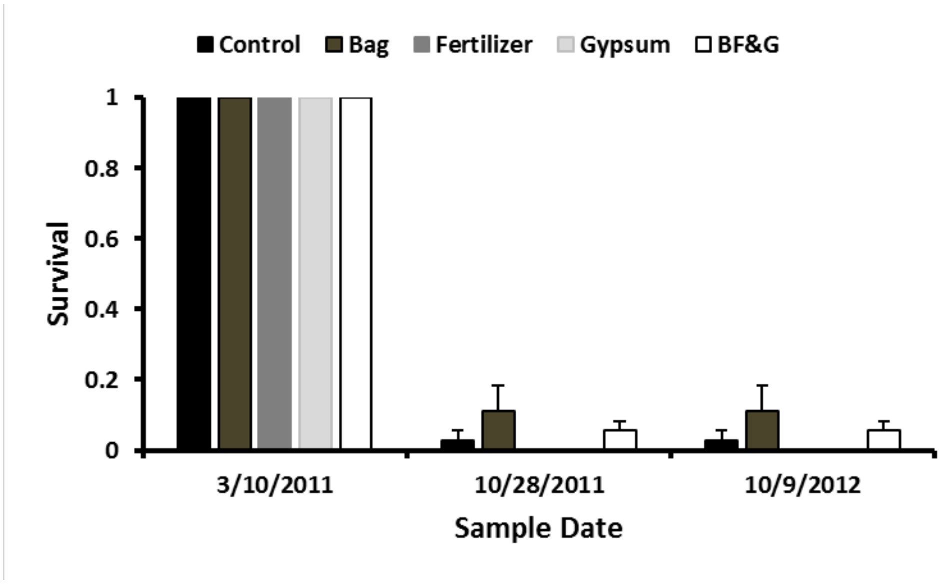

Figure 31. Mean (±SE) Survival of Live Oak planted on 10 March 2011 exposed to five soil treatments. Only the Control, Bag, and BF&G treatment had survivors post planting. Survival was similar among all treatments for all dates.

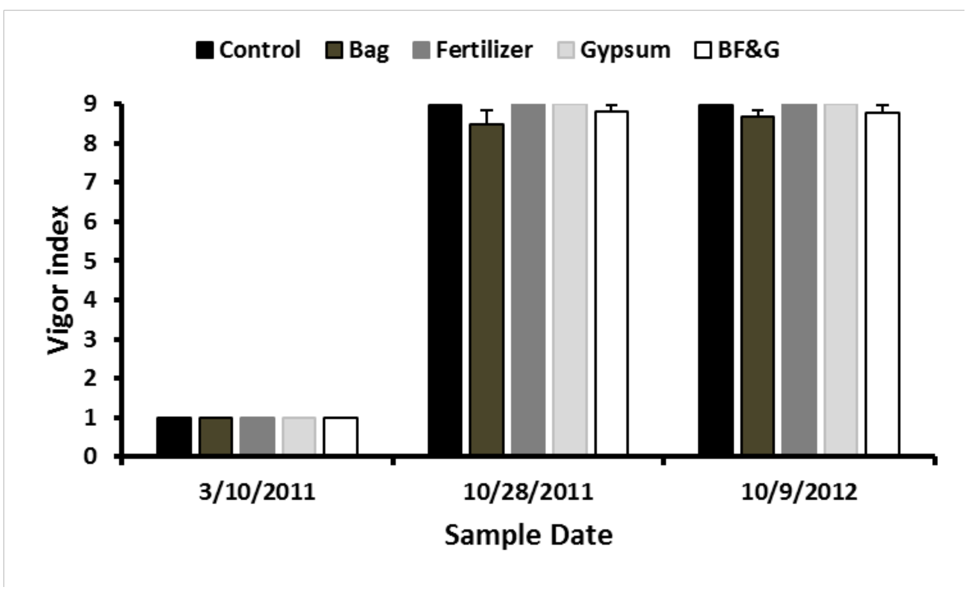

Figure 32. Mean (±SE) Vigor of Live Oak planted on 10 March 2011 exposed to five soil treatments. Vigor was similar among all treatments for all dates.

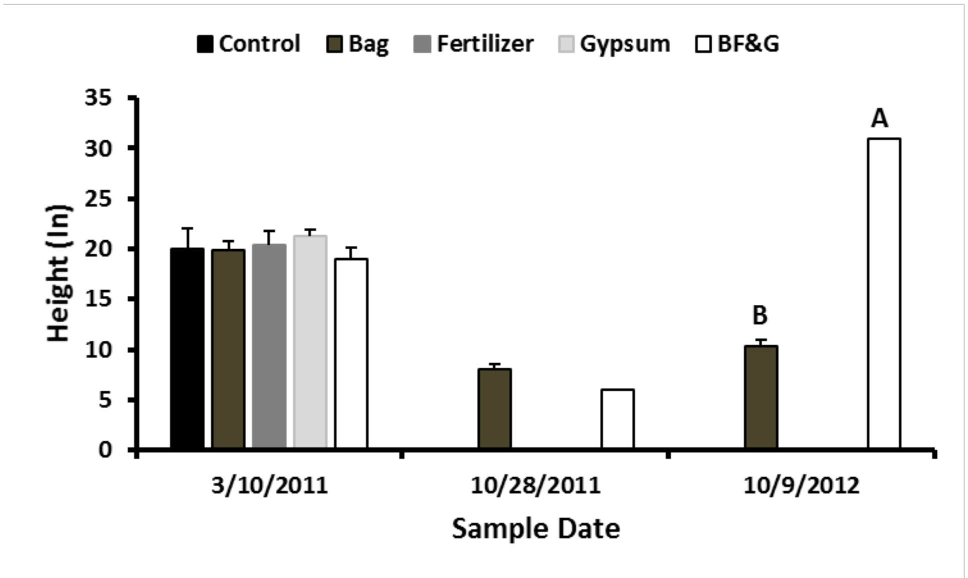

Figure 33. Mean (±SE) Height of Live Oak planted on 10 March 2011 exposed to five soil treatments. Height was similar between the two survivng treatments on 28 October 2011, but the tree in the BF&G treatment was taller than the trees in the Bag treatment on 9 October 2012.

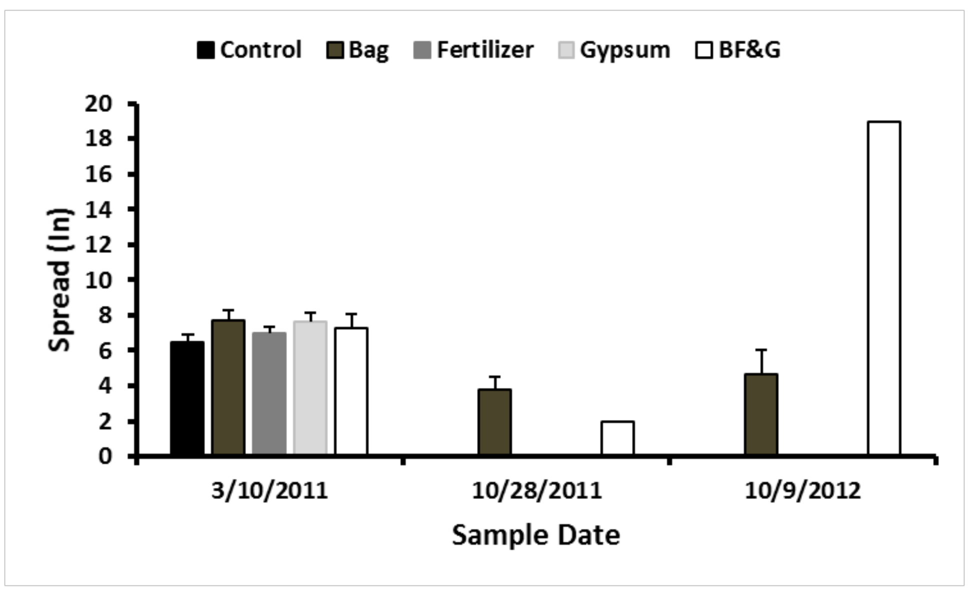

Figure 34. Mean (±SE) Spread of Live Oak planted on 10 March 2011 exposed to five soil treatments. Spread was similar among all treatments for all dates.

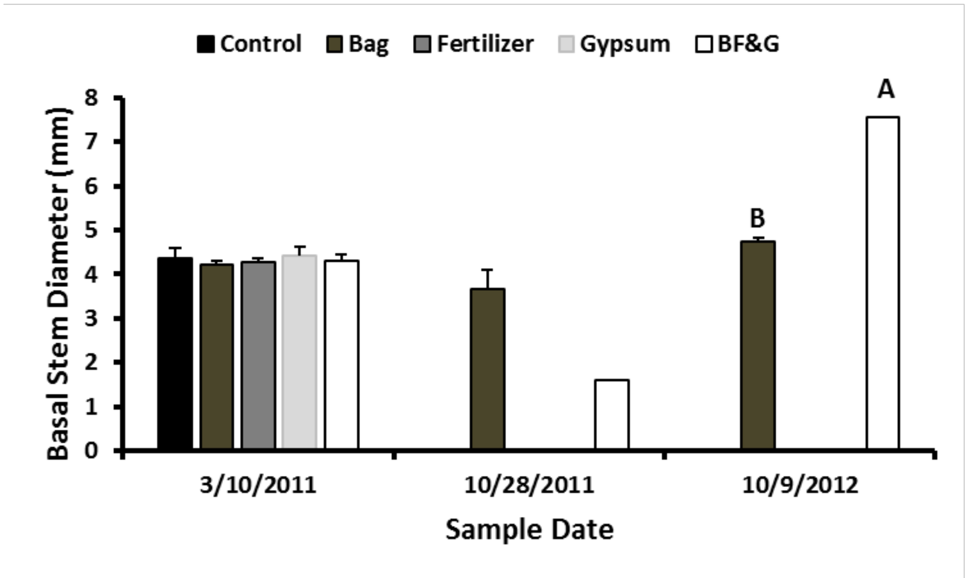

Figure 35. Mean (±SE) Basal Stem Diameter of Live Oak planted on 10 March 2011 exposed to five soil treatments. Basal Stem Diameter was similar among all treatments for all dates.

Persimmon – 2011 Planting

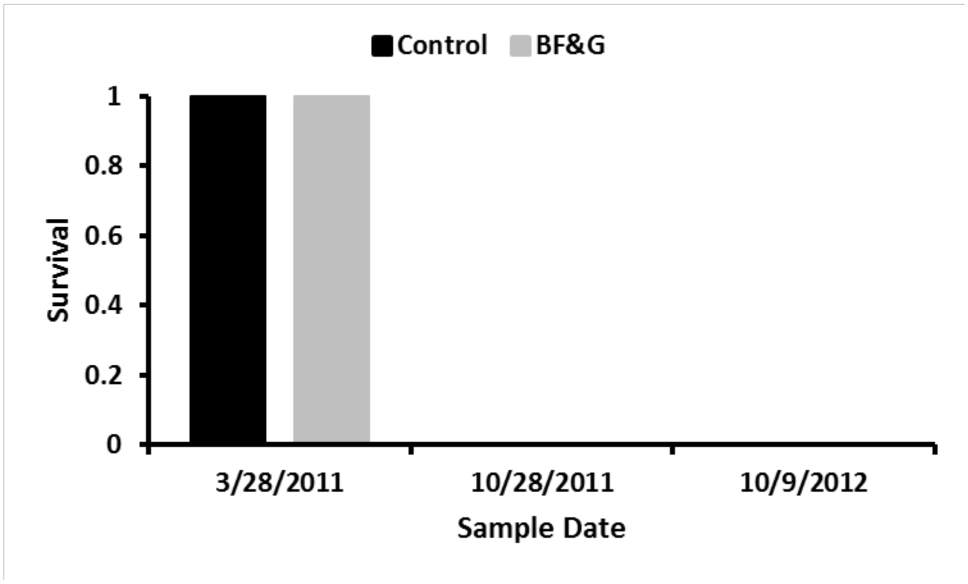

Figure 36. Mean (±SE) Survival of Persimmon planted on 28 March 2011 exposed to two soil treatments. There were no surviving individuals beyond the initital planting.

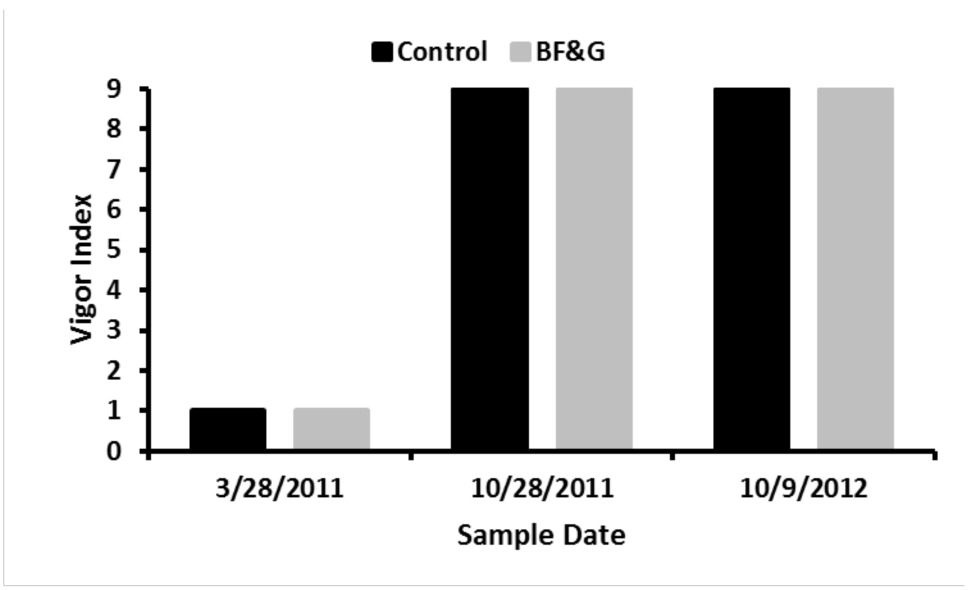

Figure 37. Mean (±SE) Vigor of Persimmon planted on 28 March 2011 exposed to two soil treatments. There were no surviving individuals beyond the initital planting.

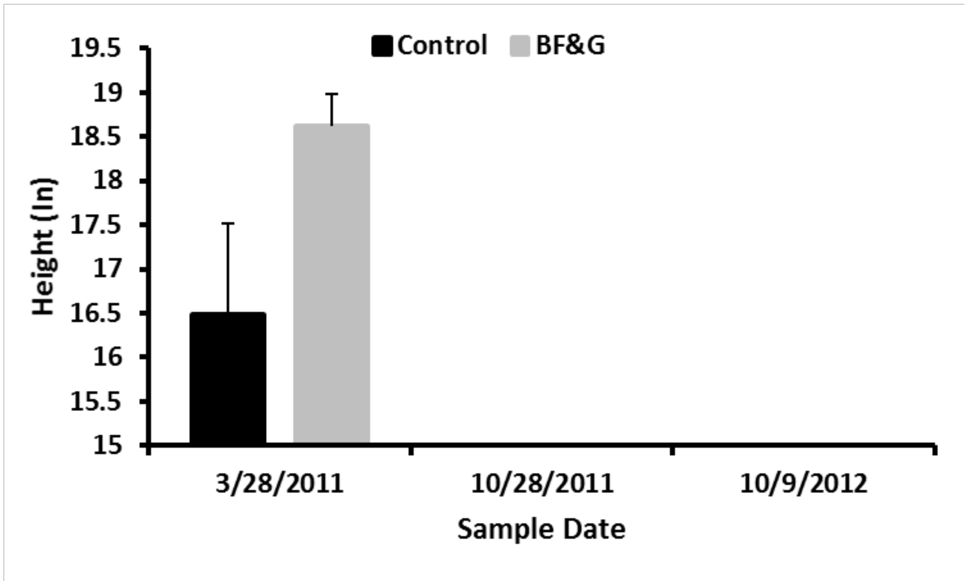

Figure 38. Mean (±SE) Height of Persimmon planted on 28 March 2011 exposed to two soil treatments. There were no surviving individuals beyond the initital planting.

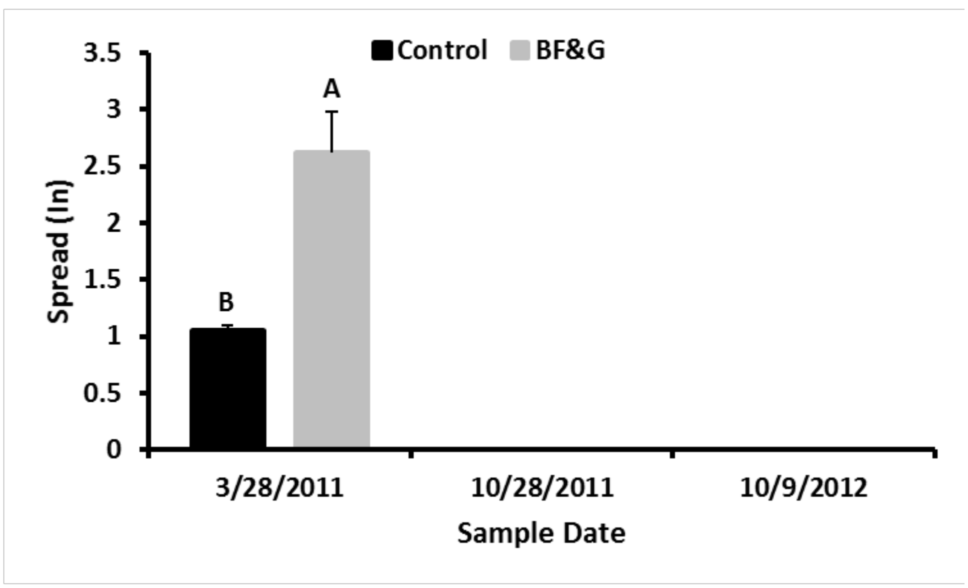

Figure 39. Mean (±SE) Height of Persimmon planted on 28 March 2011 exposed to two soil treatments. The trees planted in the BF&G had a greater spread than the trees planted in the Control treatment. There were no surviving individuals beyond the initial planting.

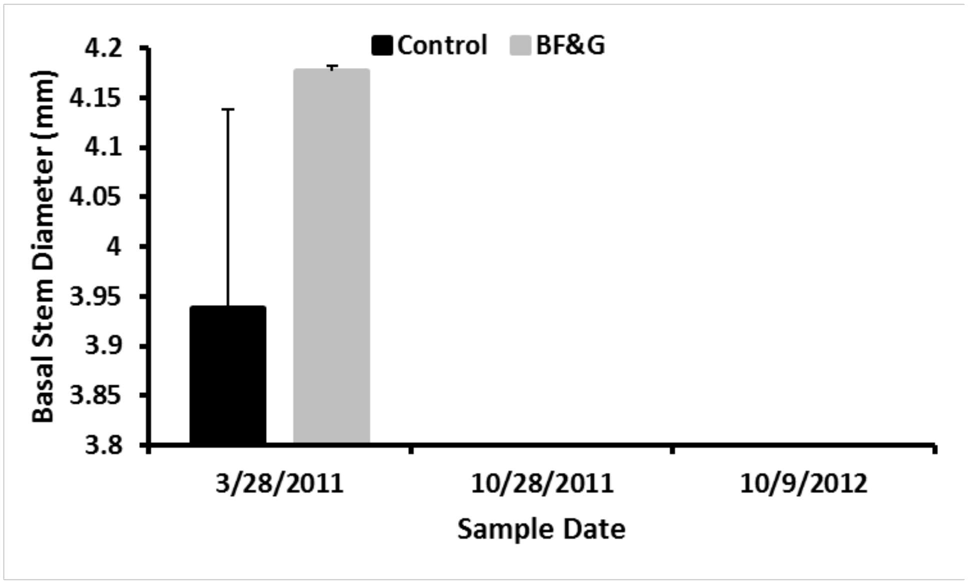

Figure 40. Mean (±SE) Basal Stem Diameter of Persimmon planted on 28 March 2011 exposed to two soil treatments. There were no surviving individuals beyond the initital planting.

Toothache Tree – 2011 Planting

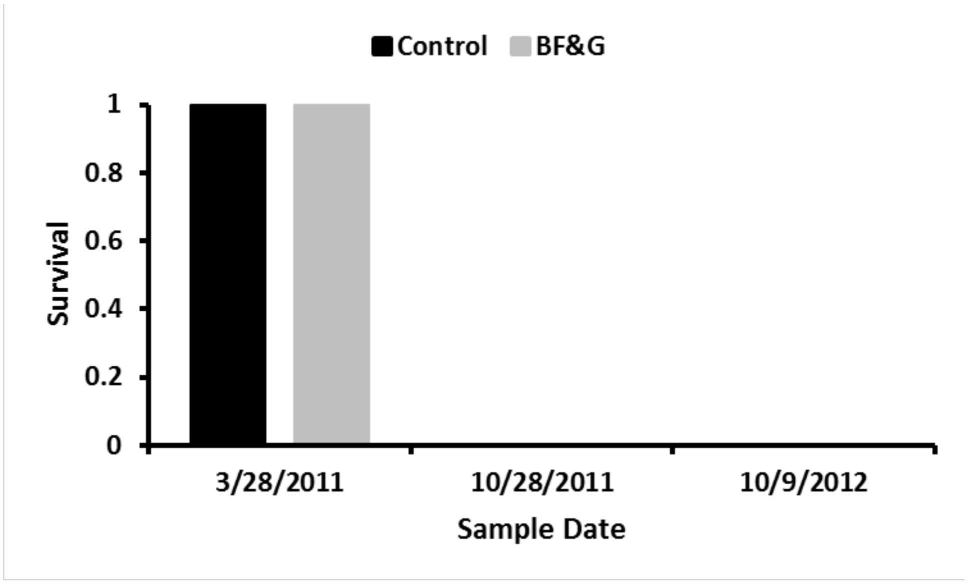

Figure 41. Mean (±SE) Survival of Toothache tree planted on 28 March 2011 exposed to two soil treatments. There were no survivors post planting.

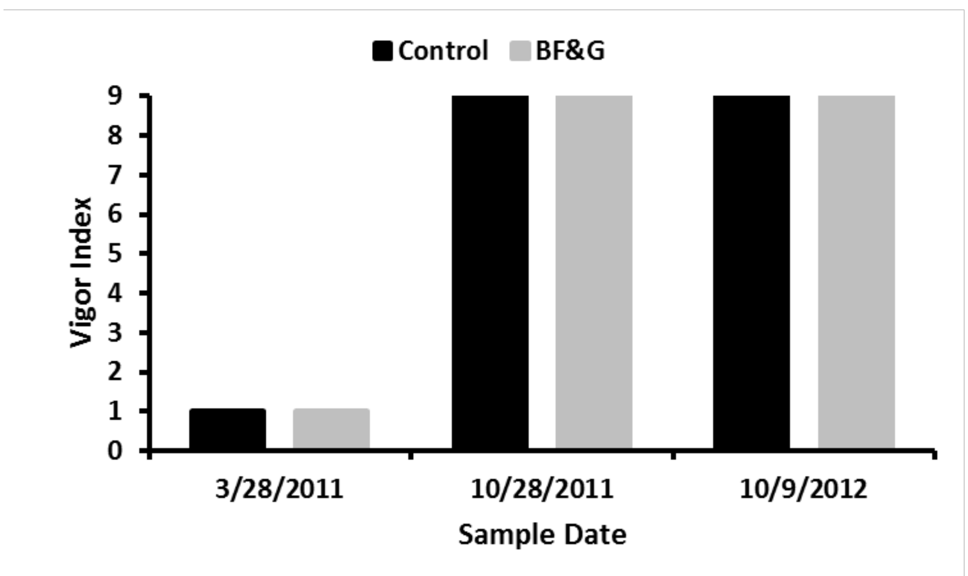

Figure 42. Mean (±SE) Vigor of Toothache tree planted on 28 March 2011 exposed to two soil treatments. There were no survivors post planting.

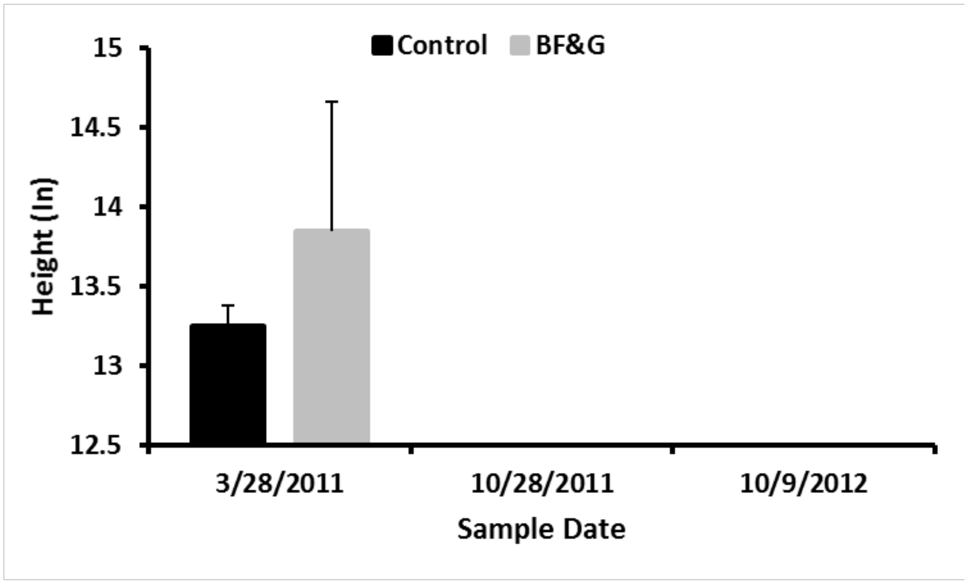

Figure 43. Mean (±SE) Height of Toothache tree planted on 28 March 2011 exposed to two soil treatments. There were no survivors post planting.

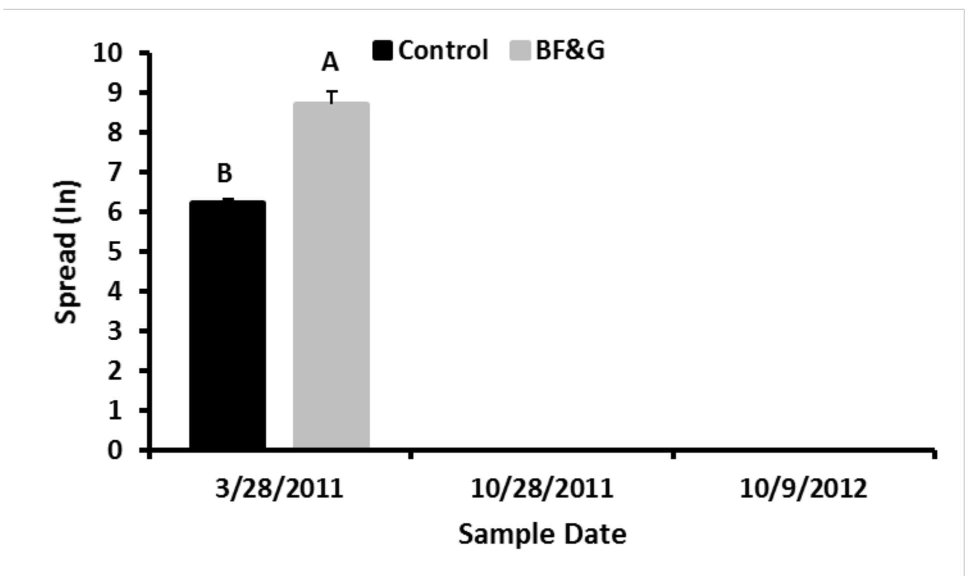

Figure 44. Mean (±SE) Spread of Toothache tree planted on 28 March 2011 exposed to two soil treatments. The plants exposed to the BF&G treatments had a greater spread than those exposed to the control. There were no survivors post planting.

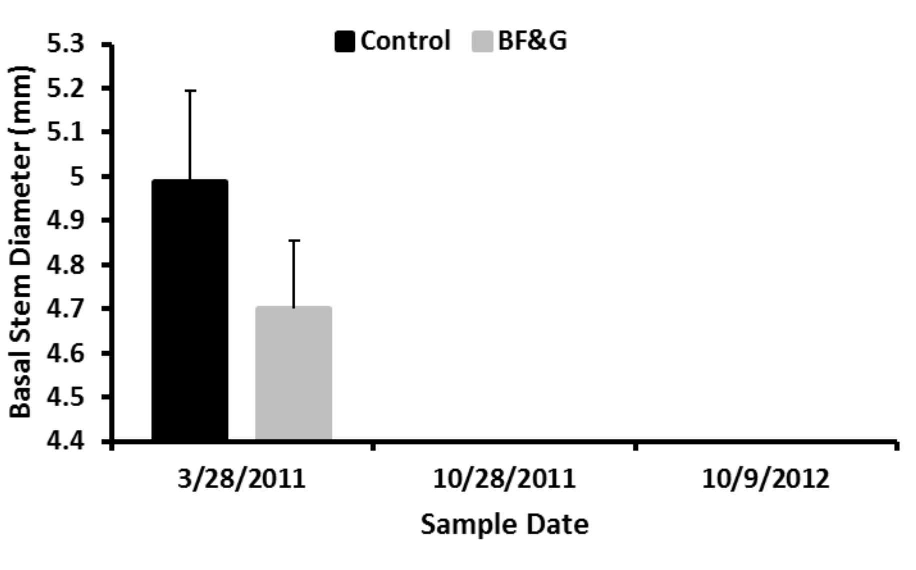

Figure 45. Mean (±SE) Basal Stem Diameter of Toothache tree planted on 28 March 2011 exposed to two soil treatments. There were no survivors post planting.

Hackberry – 2012 Planting

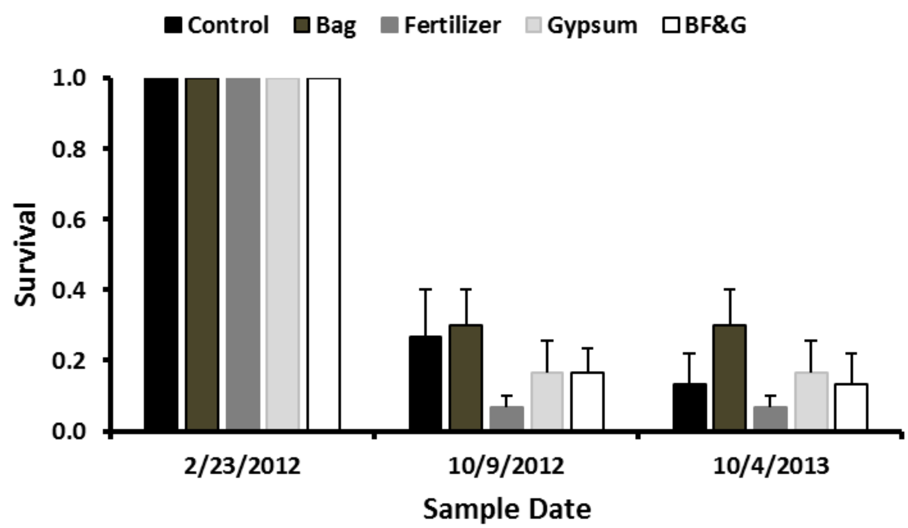

Figure 46. Mean (±SE) Survival of Hackberry planted on 23 February 2012 exposed to five soil treatments. Survival was similar among all treatments for all dates.

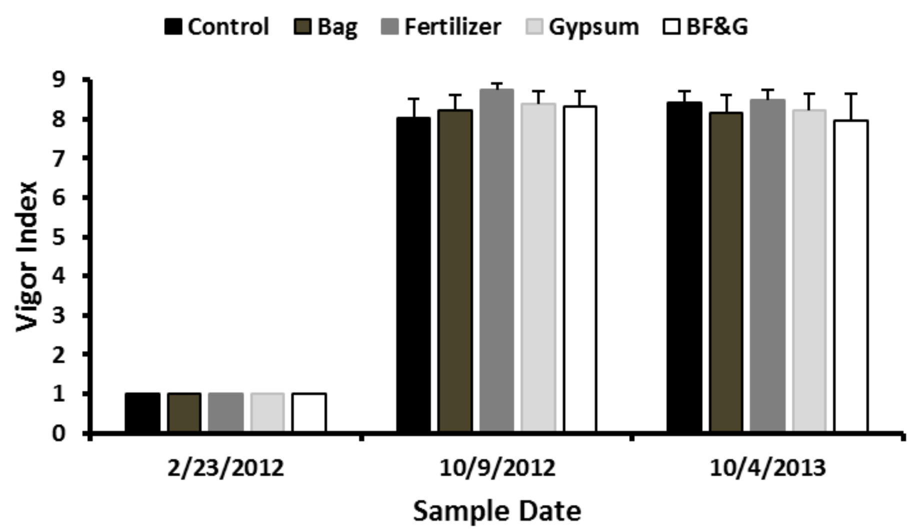

Figure 47. Mean (±SE) Vigor of Hackberry planted on 23 February 2012 exposed to five soil treatments. Vigor was similar among all treatments for all dates.

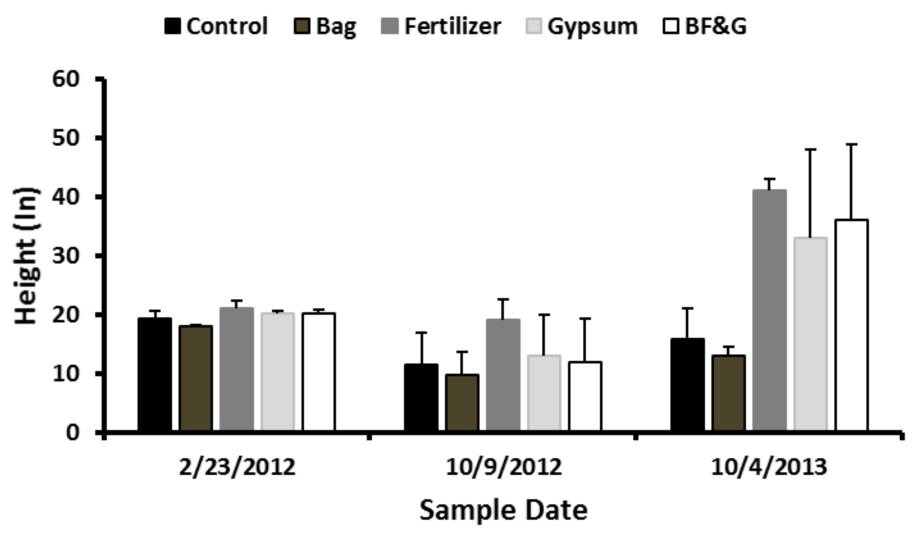

Figure 48. Mean (±SE) Height of Hackberry planted on 23 February 2012 exposed to five soil treatments. Height was similar among all treatments for all dates.

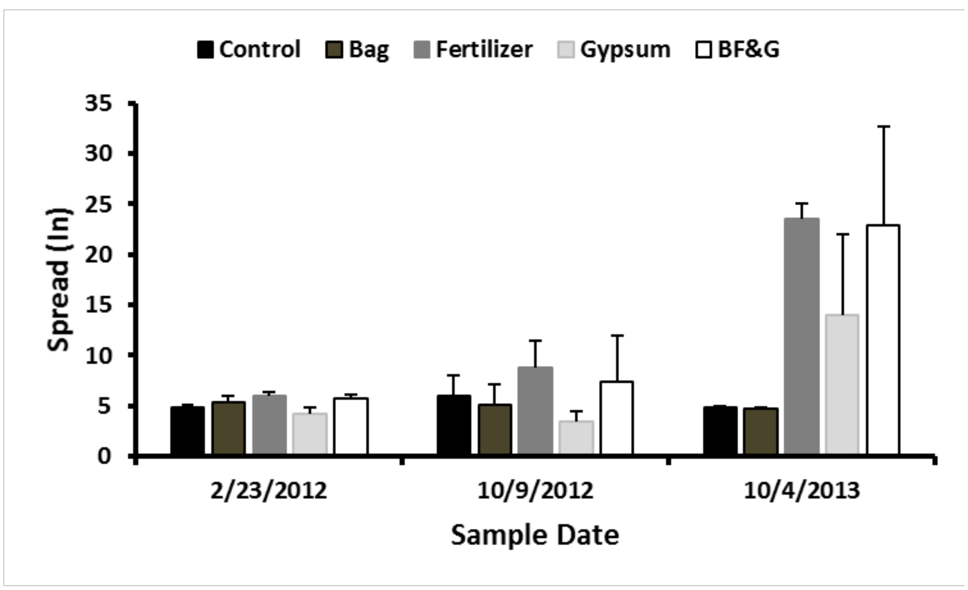

Figure 49. Mean (±SE) Spread of Hackberry planted on 23 February 2012 exposed to five soil treatments. Spread was similar among all treatments for all dates.

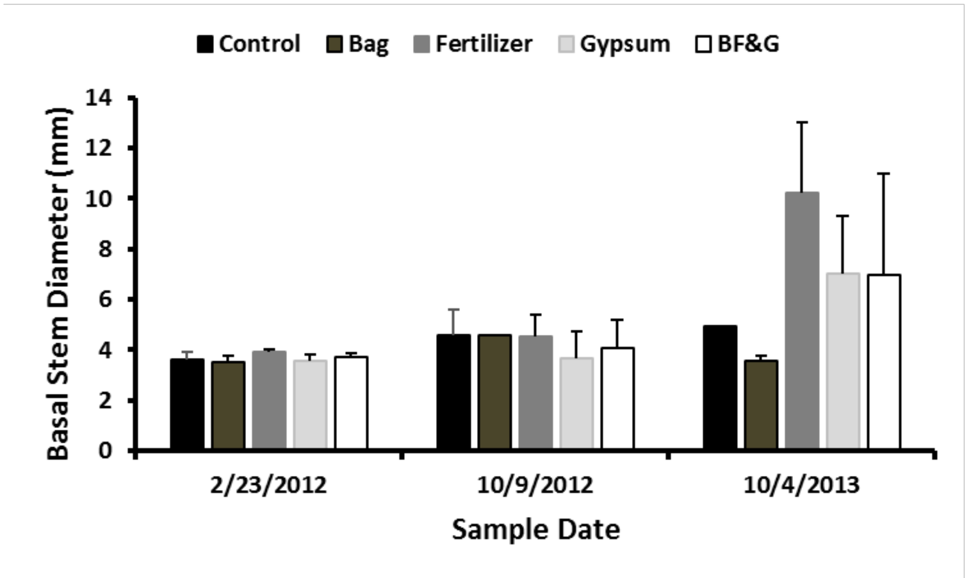

Figure 50. Mean (±SE) Basal Stem Diameter of Hackberry planted on 23 February 2012 exposed to five soil treatments. Basal Stem Diameter was similar among all treatments for all dates.

Live Oak – 2012 Planting

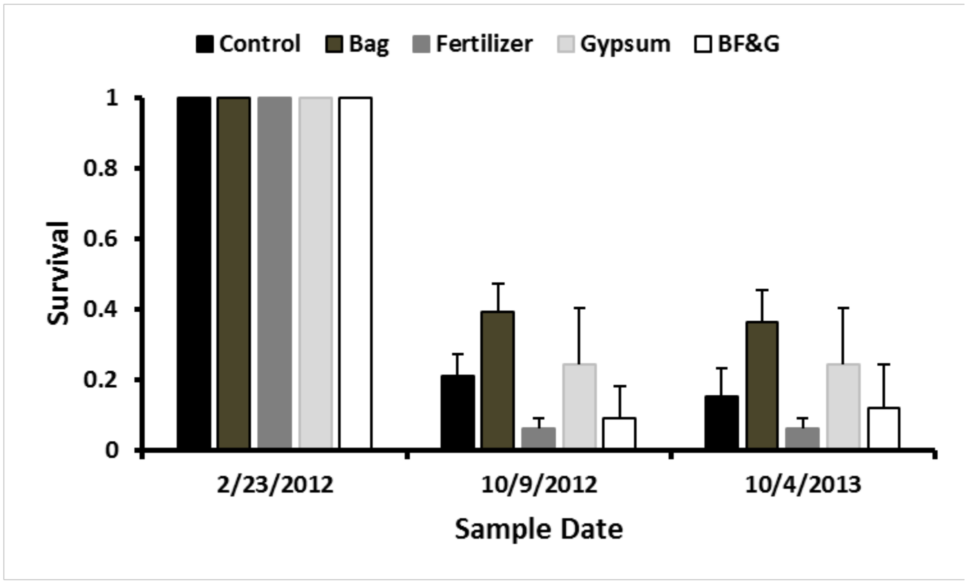

Figure 51. Mean (±SE) Survival of Live Oak planted on 23 February 2012 exposed to five soil treatments. Survival was similar among all treatments for all dates.

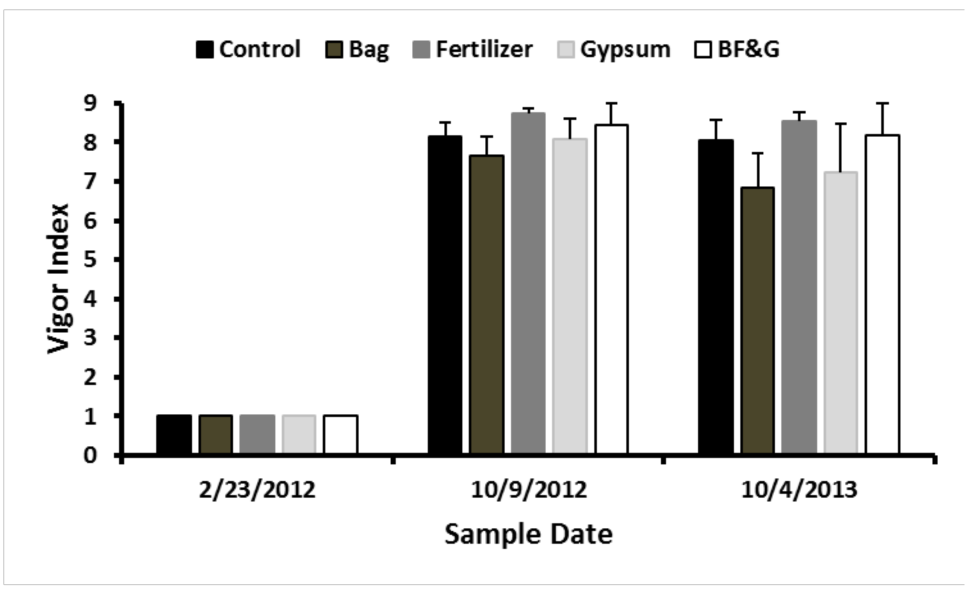

Figure 52. Mean (±SE) Vigor of Live Oak planted on 23 February 2012 exposed to five soil treatments. Vigor was similar among all treatments for all dates.

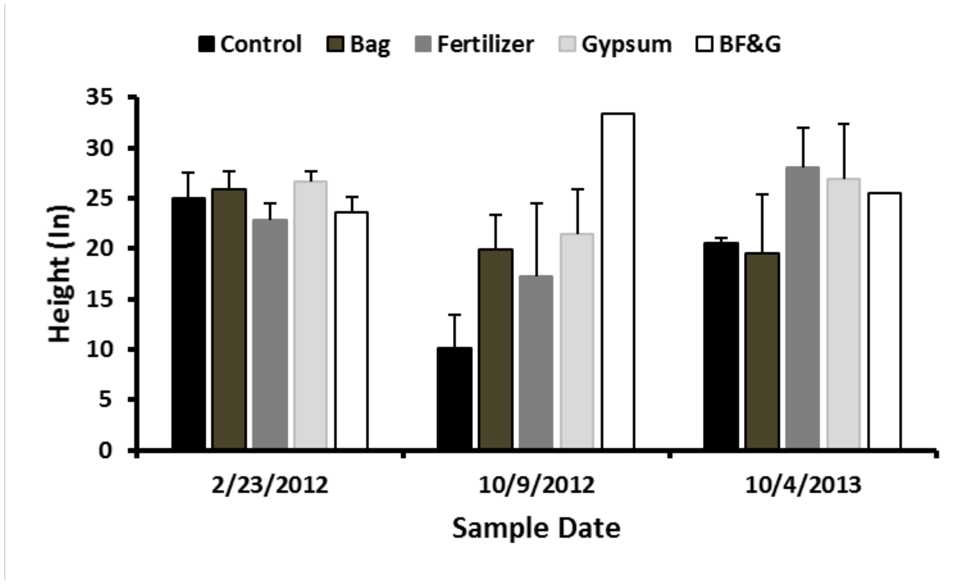

Figure 53. Mean (±SE) Height of Live Oak planted on 23 February 2012 exposed to five soil treatments. Height was similar among all treatments for all dates.

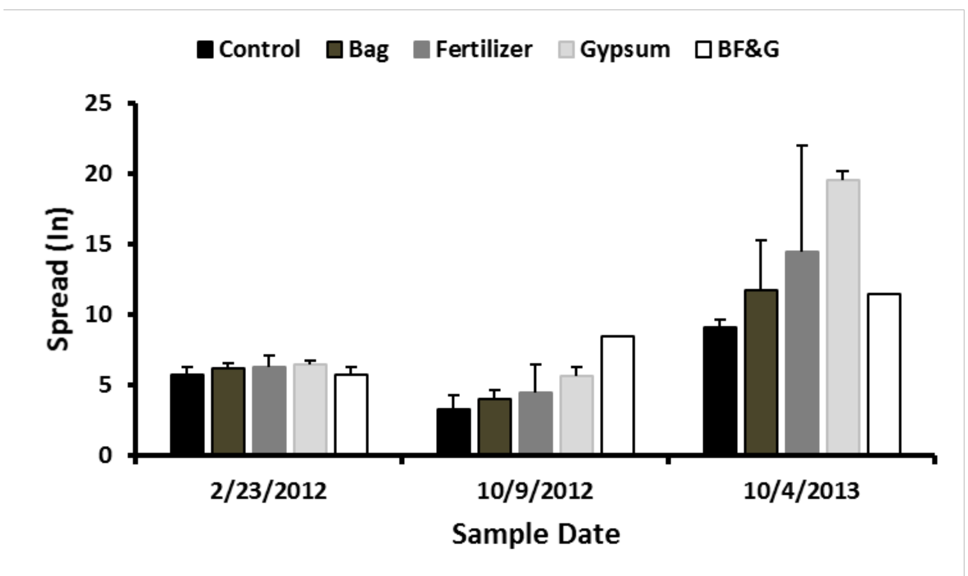

Figure 54. Mean (±SE) Spread of Live Oak planted on 23 February 2012 exposed to five soil treatments. Spread was similar among all treatments for all dates.

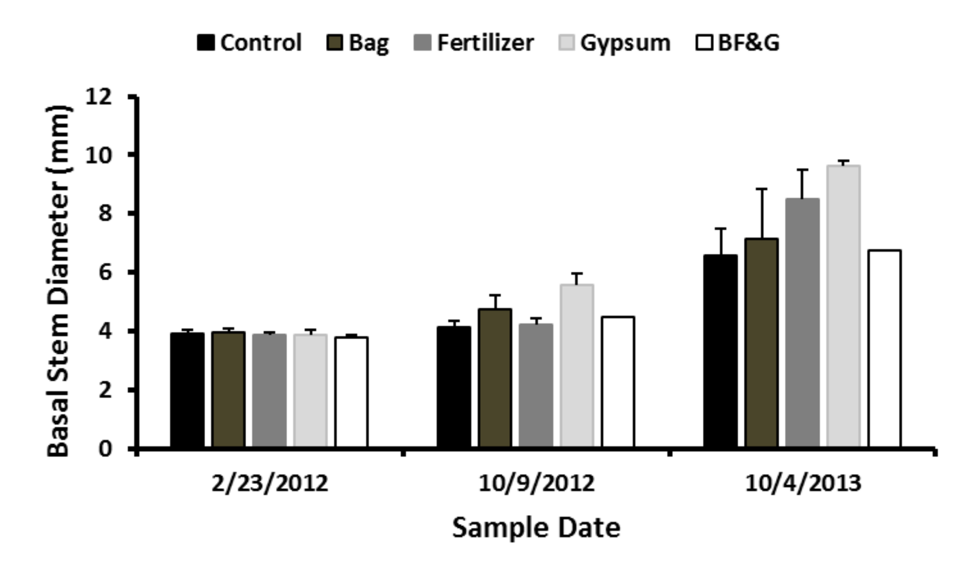

Figure 55. Mean (±SE) Basal Stem Diameter of Live Oak planted on 23 February 2012 exposed to five soil treatments. Basal Stem Diameter was similar among all treatments for all dates.

Sand Oak – 2012 Planting

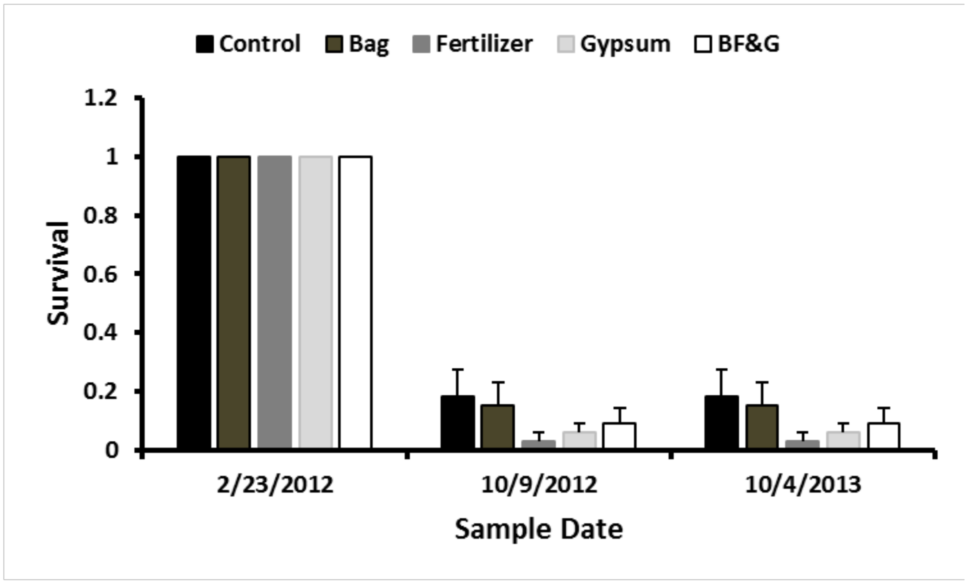

Figure 56. Mean (±SE) Survival of Sand Oak planted on 23 February 2012 exposed to five soil treatments. Survival was similar among all treatments for all dates.

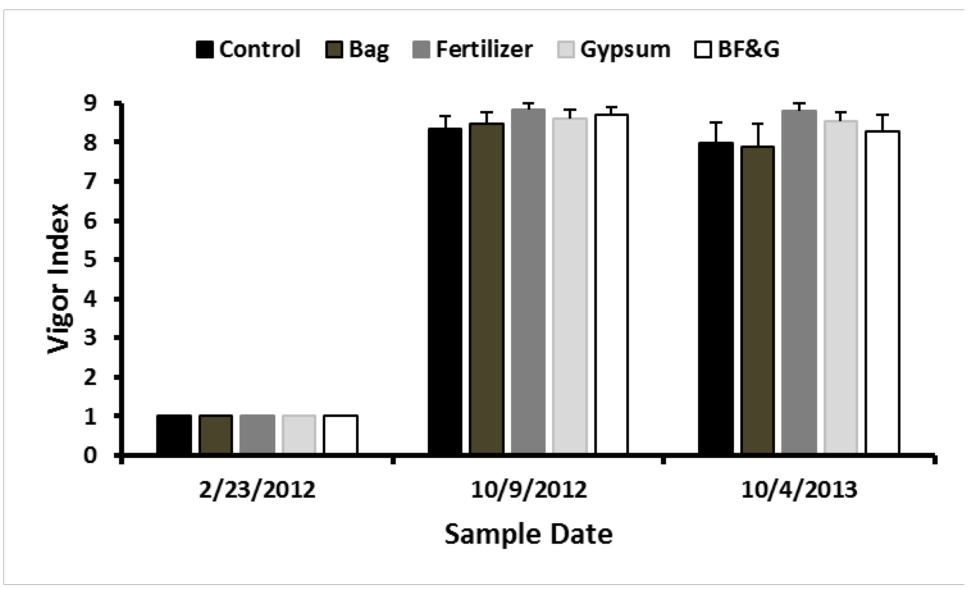

Figure 57. Mean (±SE) Vigor of Sand Oak planted on 23 February 2012 exposed to five soil treatments. Vigor was similar among all treatments for all dates.

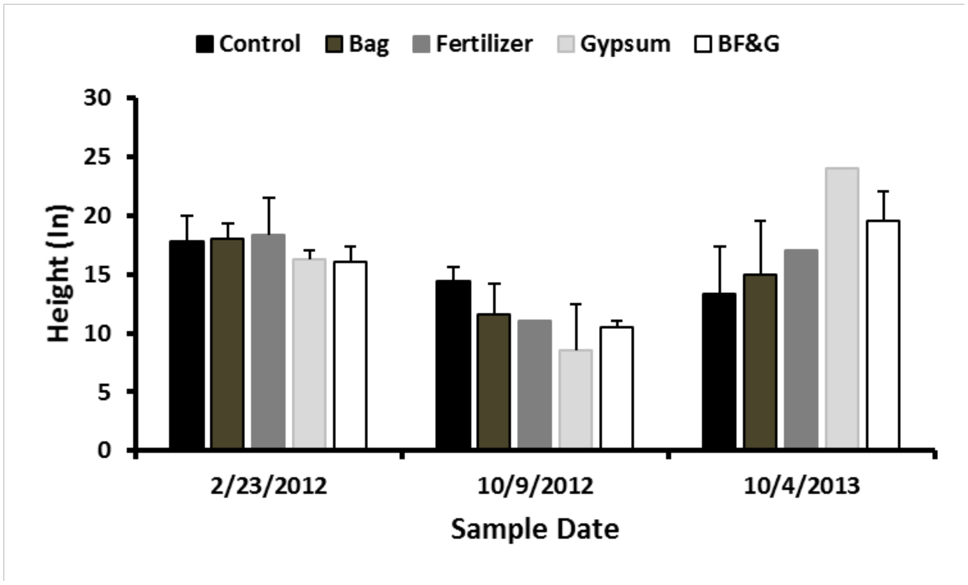

Figure 58. Mean (±SE) Height of Sand Oak planted on 23 February 2012 exposed to five soil treatments. Height was similar among all treatments for all dates.

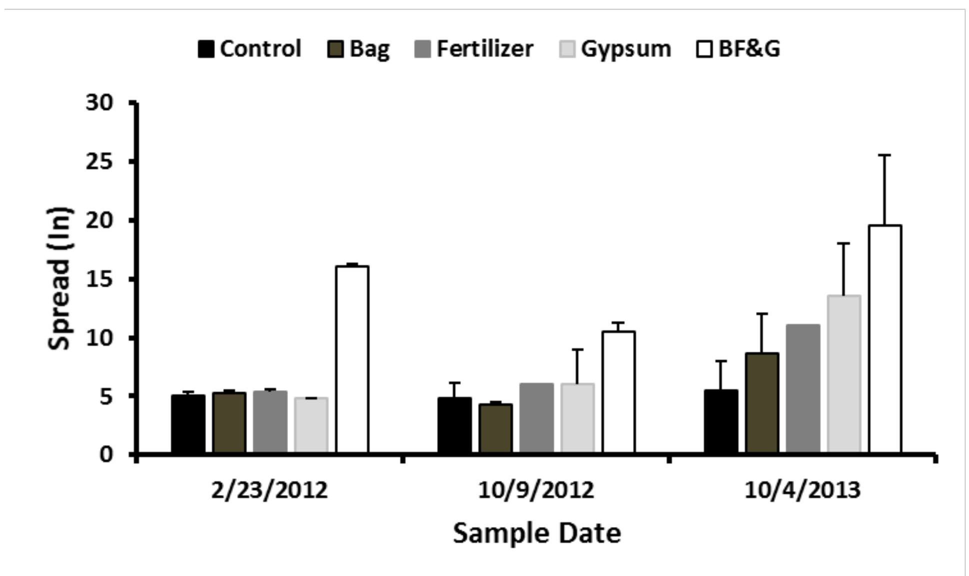

Figure 59. Mean (±SE) Spread of Sand Oak planted on 23 February 2012 exposed to five soil treatments. Spread was similar among all treatments for all dates.

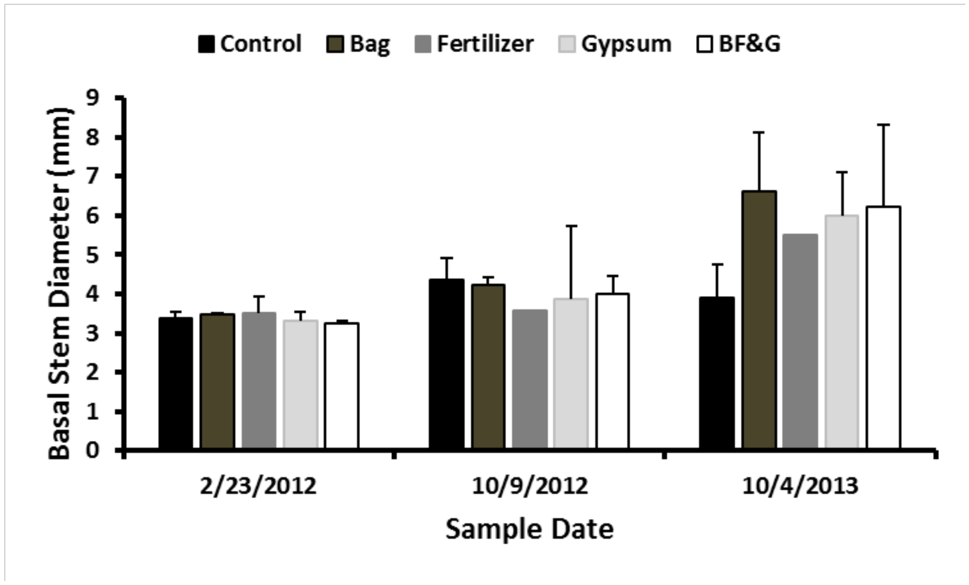

Figure 60. Mean (±SE) Basal Stem Diameter of Sand Oak planted on 23 February 2012 exposed to five soil treatments. Basal Stem Diameter was similar among all treatments for all dates.

Hackberry – 2013 Planting

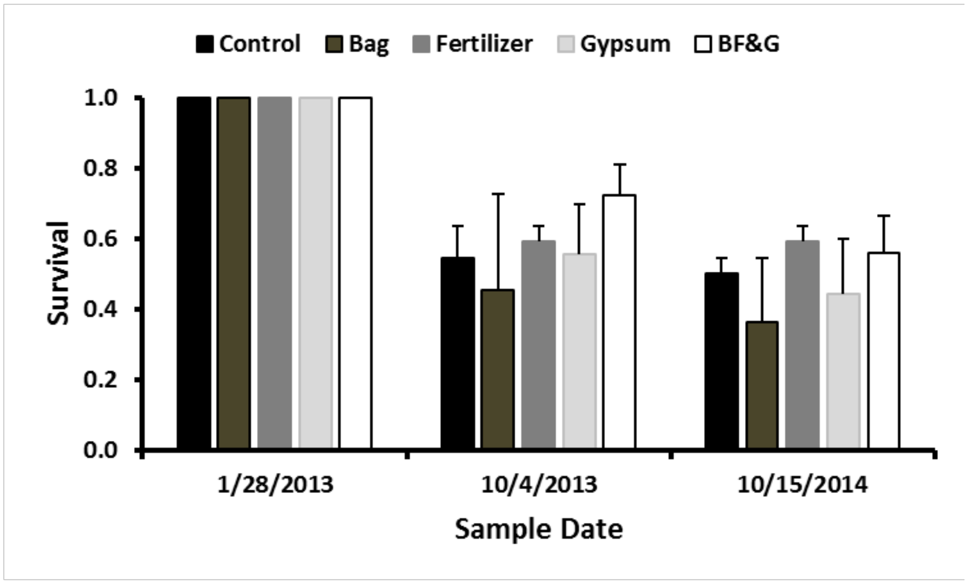

Figure 61. Mean (±SE) Survival of Hackberry planted on 28 January 2013 exposed to five soil treatments. Survival was similar among all treatments for all dates.

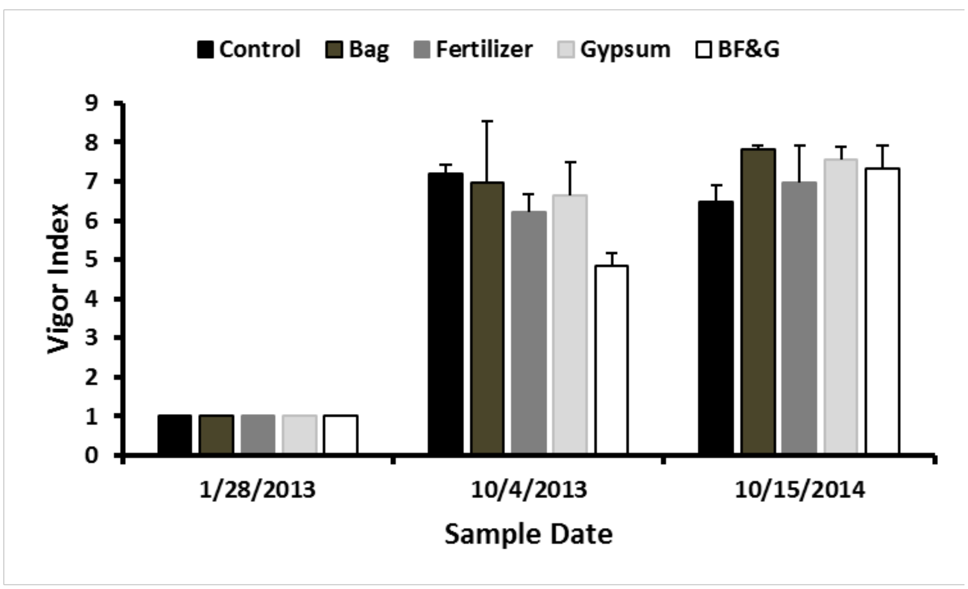

Figure 62. Mean (±SE) Vigor of Hackberry planted on 28 January 2013 exposed to five soil treatments. Vigor was similar among all treatments for all dates.

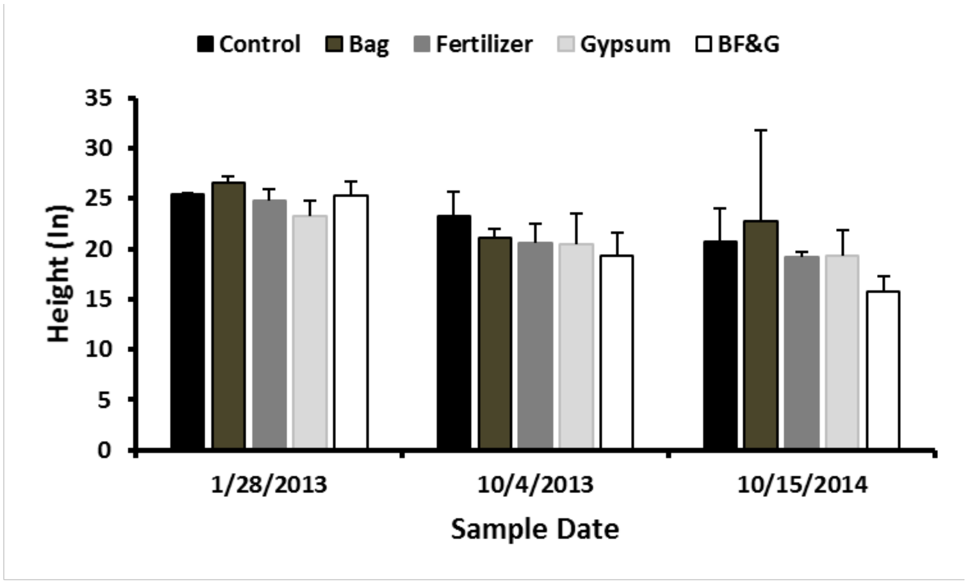

Figure 63. Mean (±SE) Height of Hackberry planted on 28 January 2013 exposed to five soil treatments. Height was similar among all treatments for all dates.

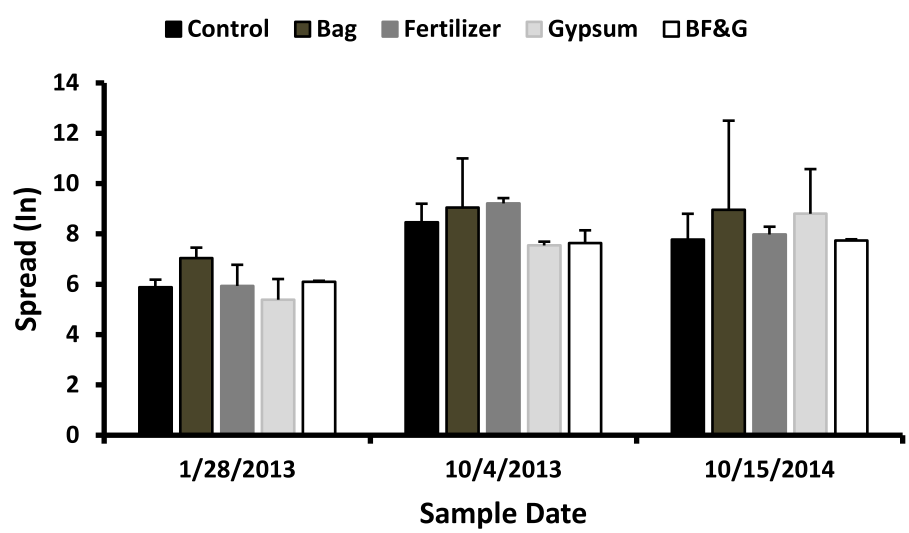

Figure 64. Mean (±SE) Spread of Hackberry planted on 28 January 2013 exposed to five soil treatments. Spread was similar among all treatments for all dates.

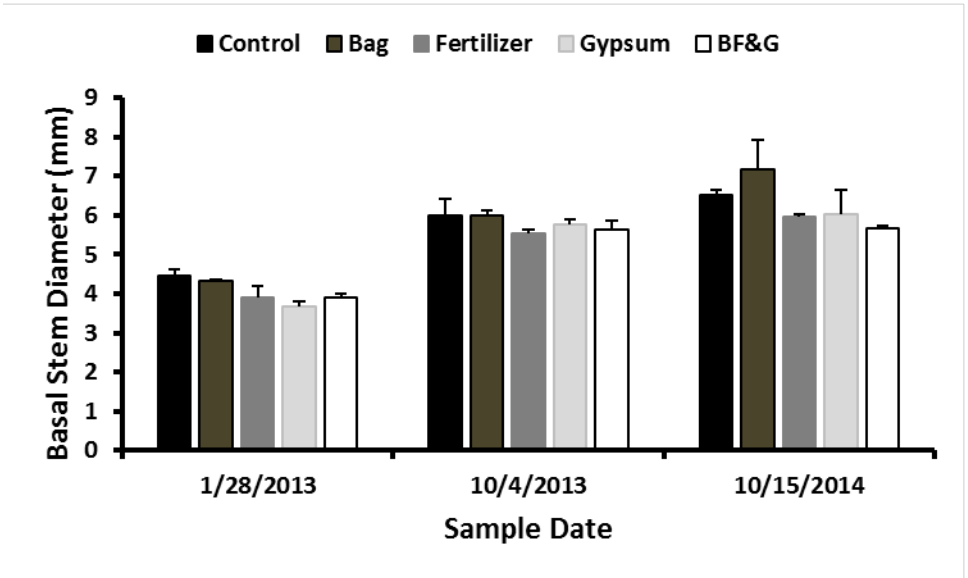

Figure 65. Mean (±SE) Basal Stem Diameter of Hackberry planted on 28 January 2013 exposed to five soil treatments. Basal Stem Diameter was similar among all treatments for all dates.

Live Oak – 2013 Planting

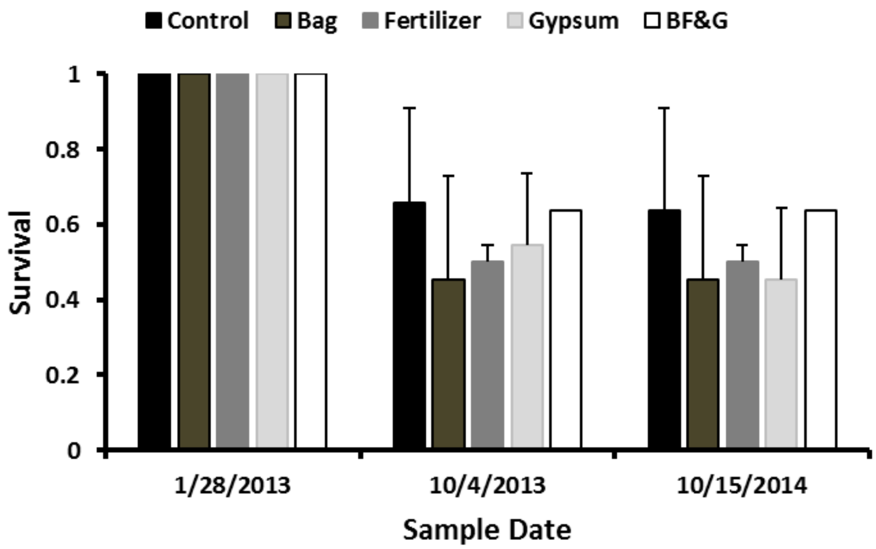

Figure 66. Mean (±SE) Survival of Live Oak planted on 28 January 2013 exposed to five soil treatments. Survival was similar among all treatments for all dates.

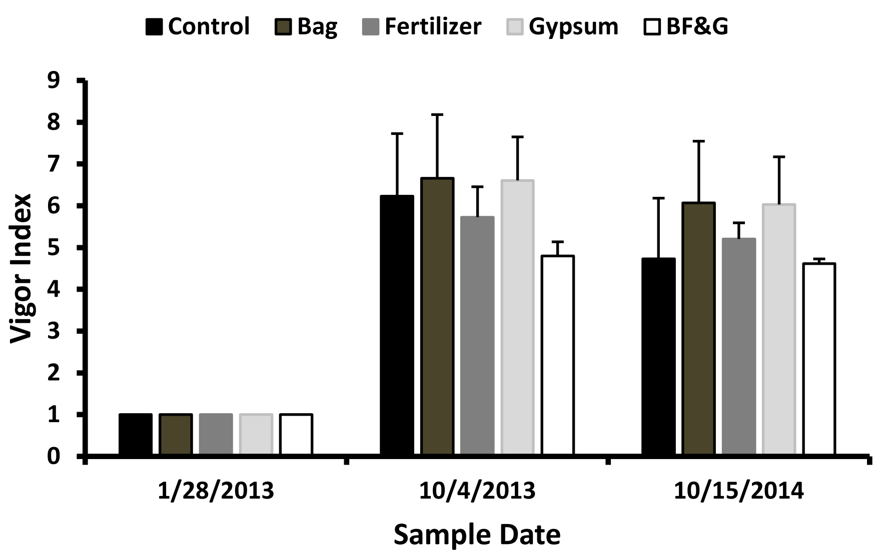

Figure 67. Mean (±SE) Vigor of Live Oak planted on 28 January 2013 exposed to five soil treatments. Vigor was similar among all treatments for all dates.

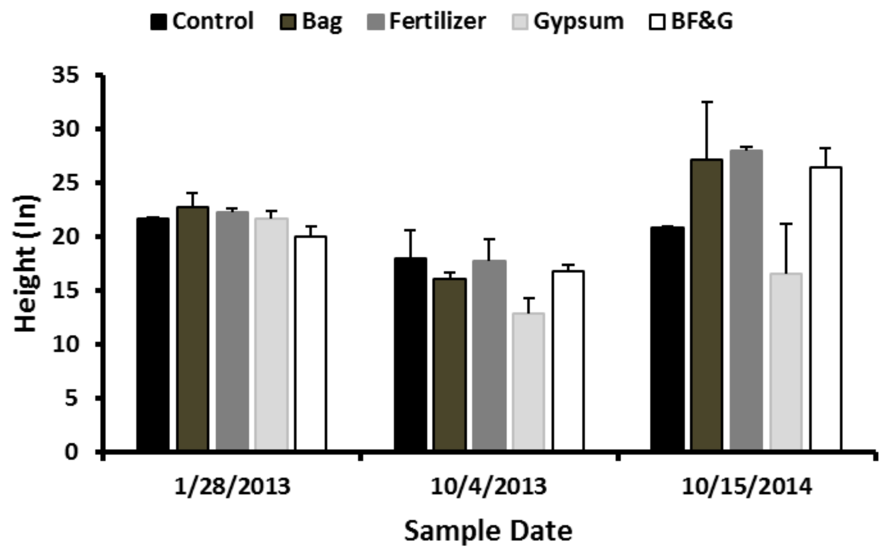

Figure 68. Mean (±SE) Height of Live Oak planted on 28 January 2013 exposed to five soil treatments. Height was similar among all treatments for all dates.

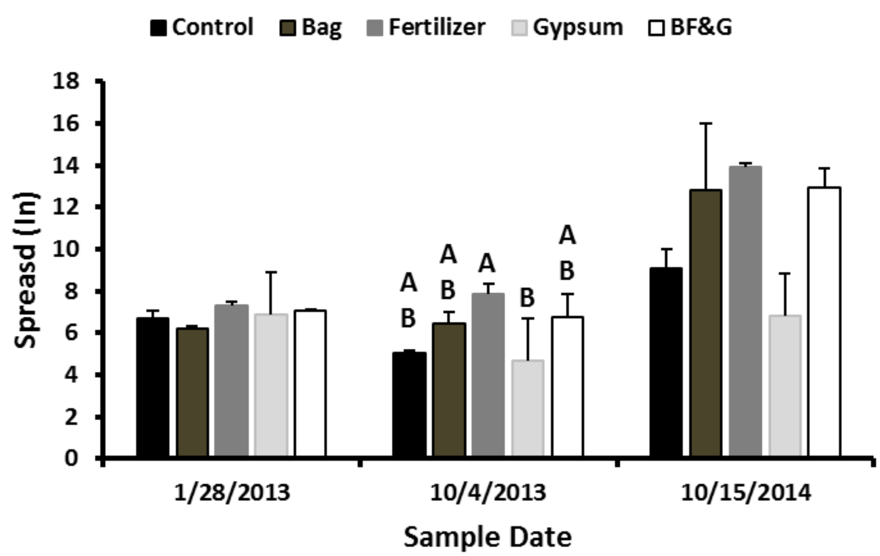

Figure 69. Mean (±SE) Spread of Live Oak planted on 28 January 2013 exposed to five soil treatments. Spread varied among treatments on 4 October 2013 but was similar among all treatments on 15 October 2014.

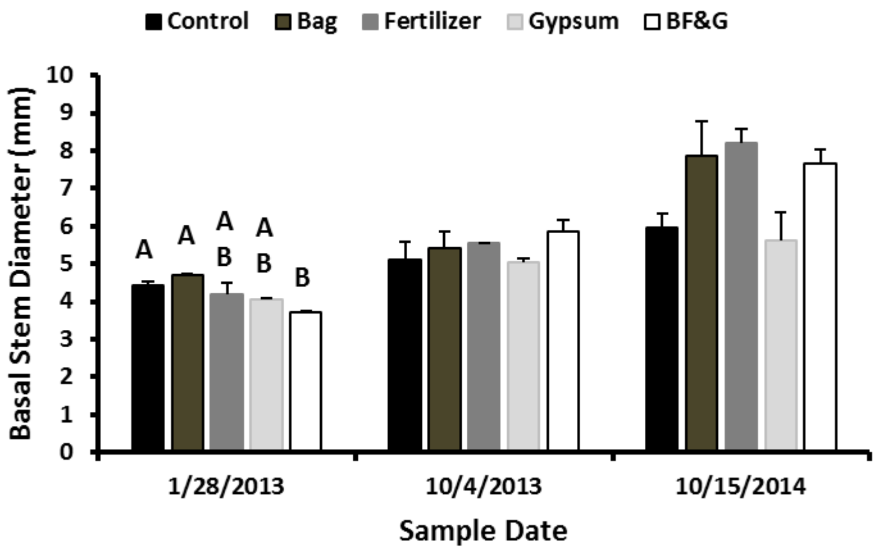

Figure 70. Mean (±SE) Basal Stem Diameter of Live Oak planted on 28 January 2013 exposed to five soil treatments. Although Basal Stem diameter varied among treatments when planted, Basal Stem Diameter was similar among all treatments on both subsequent sample dates. Means with a similar letter are not different.

Sand Oak – 2013 Planting

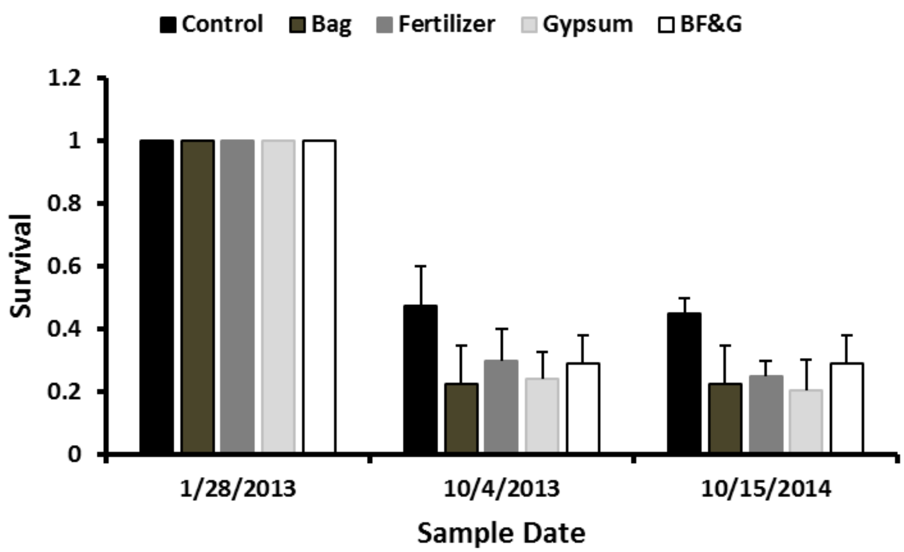

Figure 71. Mean (±SE) Survival of Sand Oak planted on 28 January 2013 exposed to five soil treatments. Survival was similar among all treatments for all dates.

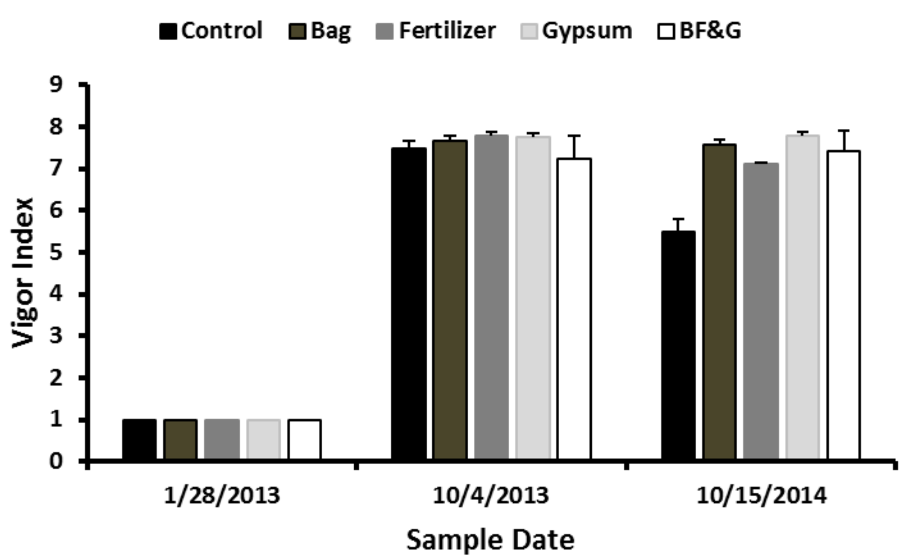

Figure 72. Mean (±SE) Vigor of Sand Oak planted on 28 January 2013 exposed to five soil treatments. Vigor was similar among all treatments for all dates.

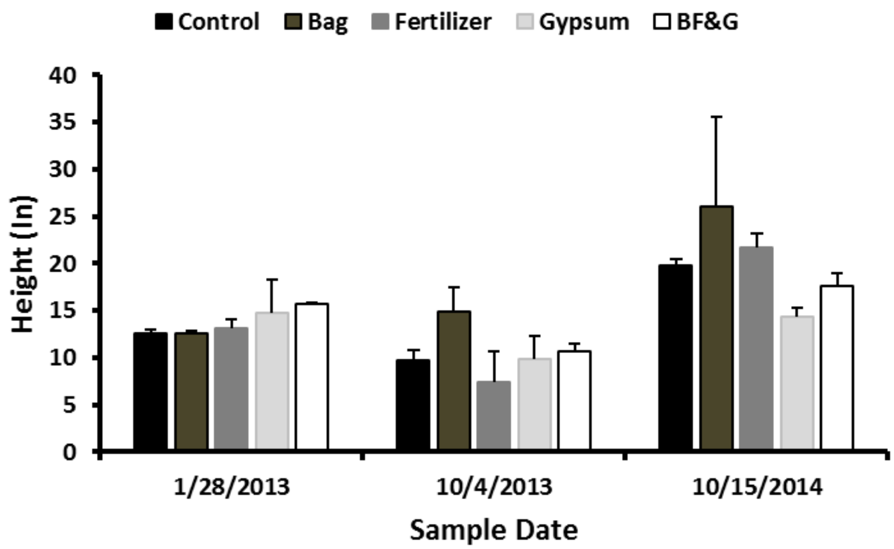

Figure 73. Mean (±SE) Height of Sand Oak planted on 28 January 2013 exposed to five soil treatments. Height was similar among all treatments for all dates.

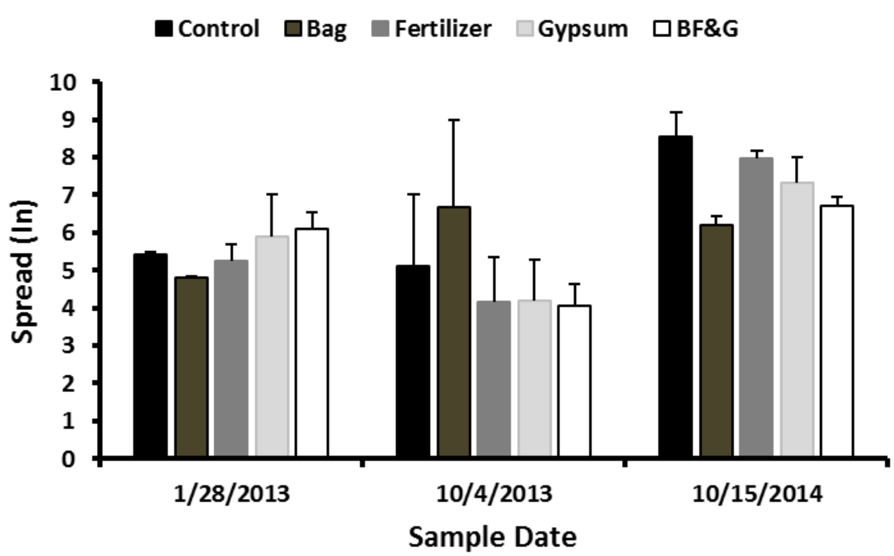

Figure 74. Mean (±SE) Spread of Sand Oak planted on 28 January 2013 exposed to five soil treatments. Height was similar among all treatments for all dates.

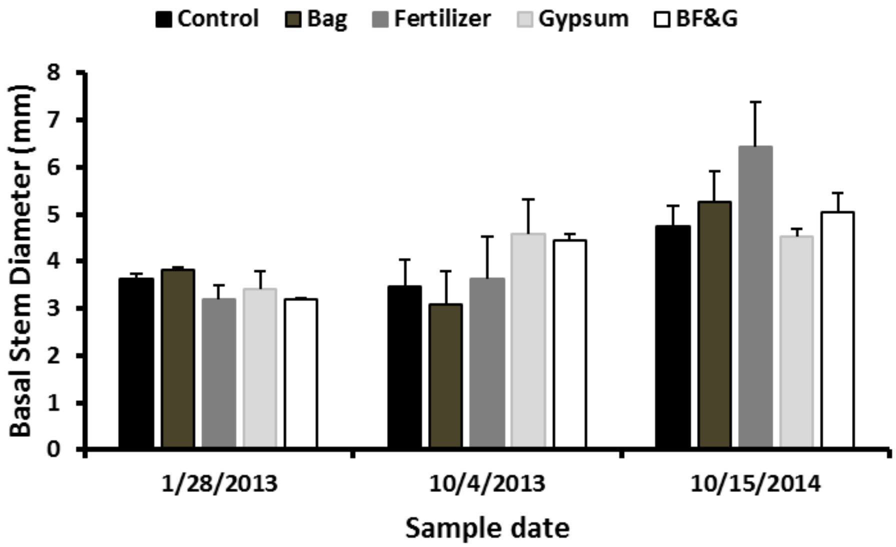

Figure 75. Mean (±SE) Basal Stem Diameter of Sand Oak planted on 28 January 2013 exposed to five soil treatments. Basal Stem Diameter was similar among all treatments for all dates.

Dogwood – 2014 Planting

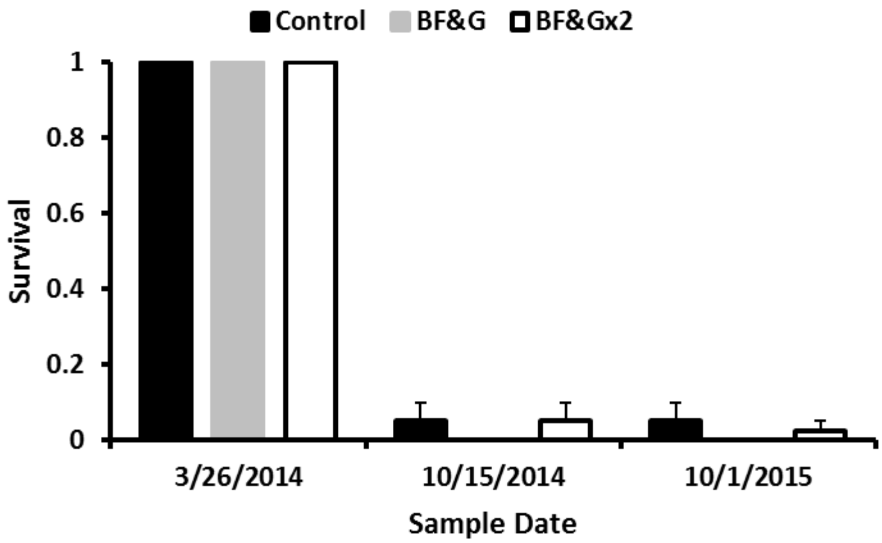

Figure 76. Mean (±SE) Survival of Dogwood planted on 26 March 2014 exposed to three soil treatments. There were no survivors in the BF&G treatment and the number of survivors did not differ between the Control and the BF&Gx2 treatments after planting.

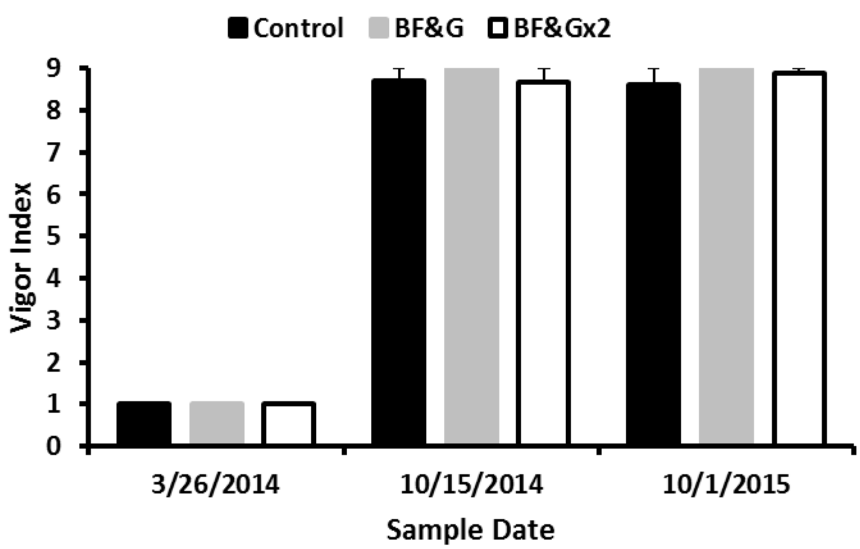

Figure 77. Mean (±SE) Vigor of Dogwood planted on 26 March 2014 exposed to three soil treatments. There were no survivors in the BF&G treatment and vigor did not differ between the Control and the BF&Gx2 treatments after planting.

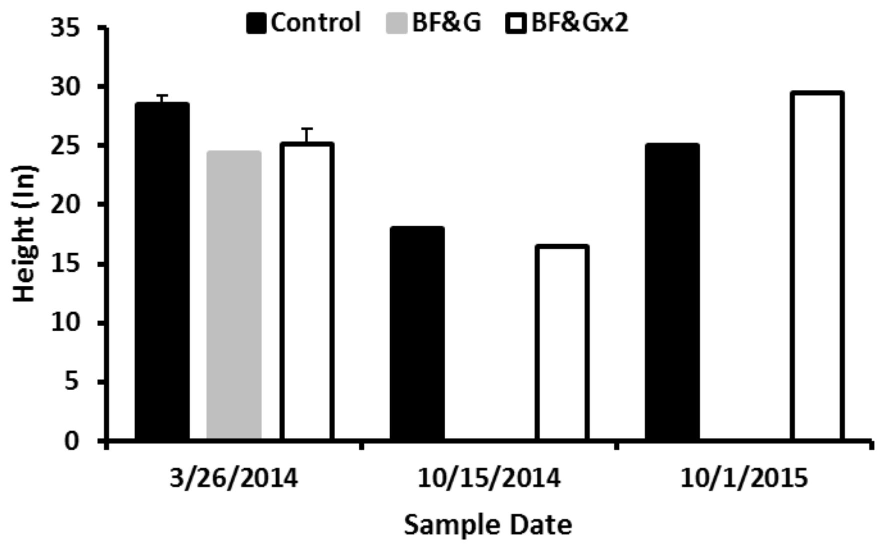

Figure 78. Mean (±SE) Height of Dogwood planted on 26 March 2014 exposed to three soil treatments. Height did not differ among treatments.

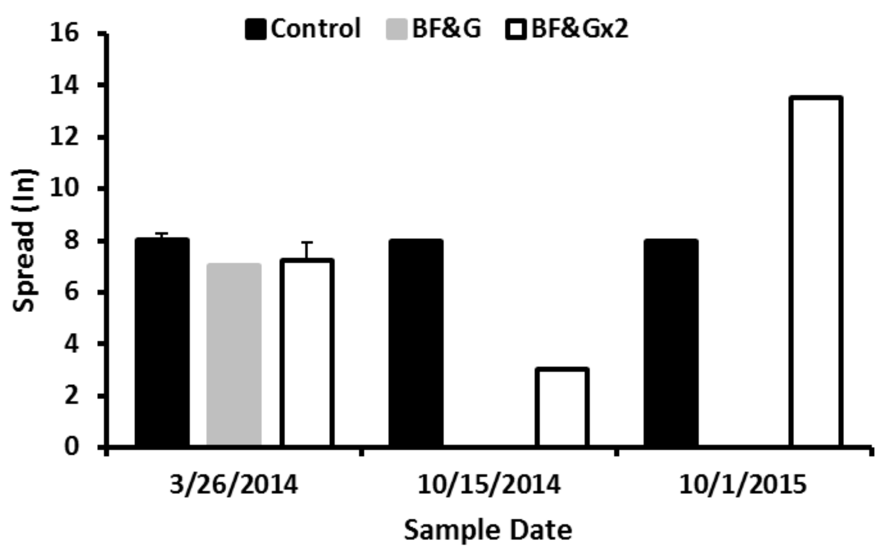

Figure 79. Mean (±SE) Spread of Dogwood planted on 26 March 2014 exposed to three soil treatments. Height did not differ among treatments.

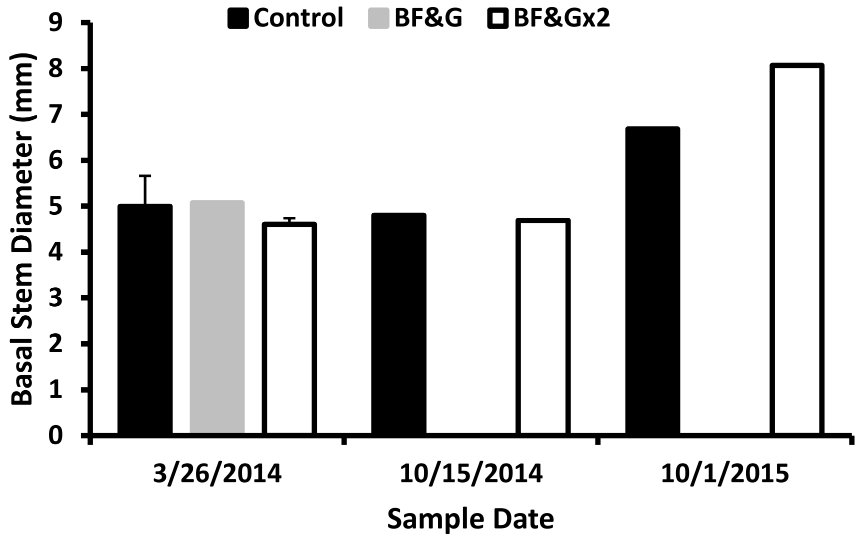

Figure 80. Mean (±SE) Basal Stem Diameter of Dogwood planted on 26 March 2014 exposed to three soil treatments. Basal Stem Diameter did not differ among treatments.

Live Oak – 2014 Planting

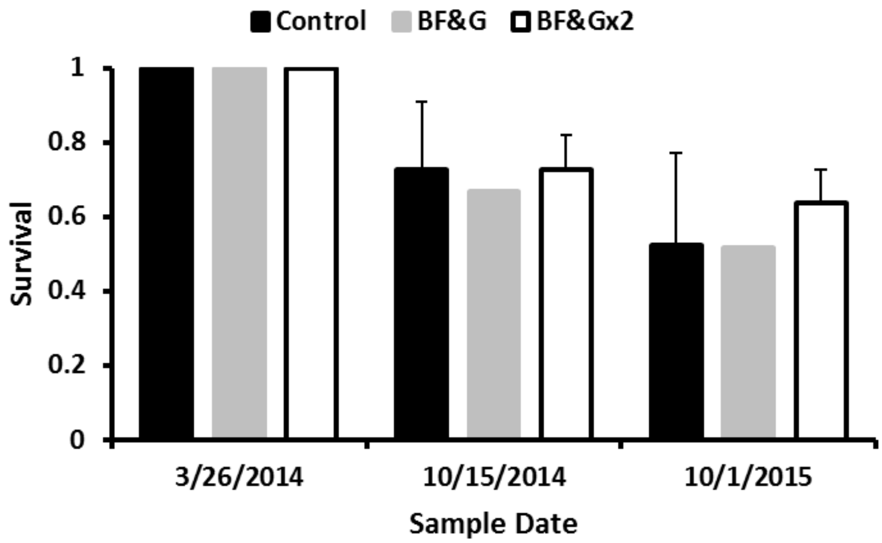

Figure 81. Mean (±SE) Survival of Live Oak planted on 26 March 2014 exposed to three soil treatments. Survival was similar among all treatments for all dates.

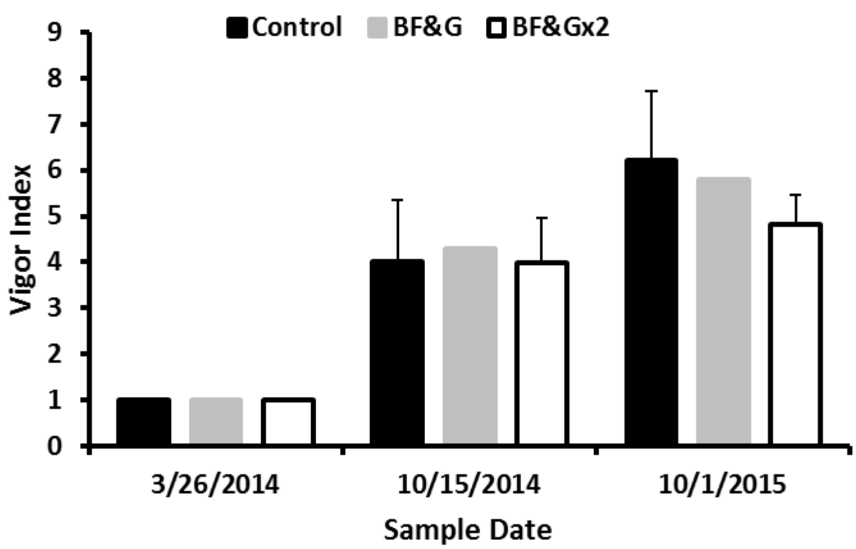

Figure 82. Mean (±SE) Vigor of Live Oak planted on 26 March 2014 exposed to three soil treatments. Vigor was similar among all treatments for all dates.

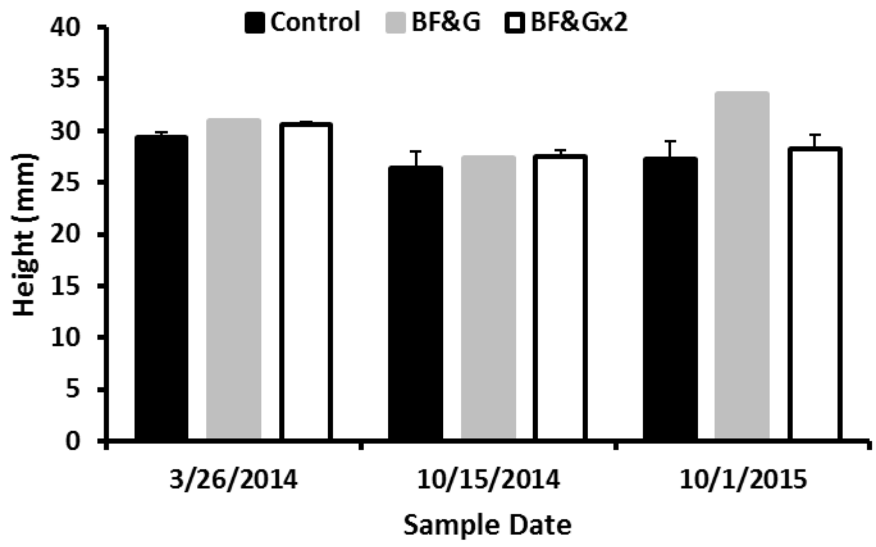

Figure 83. Mean (±SE) Height of Live Oak planted on 26 March 2014 exposed to three soil treatments. Height was similar among all treatments for all dates.

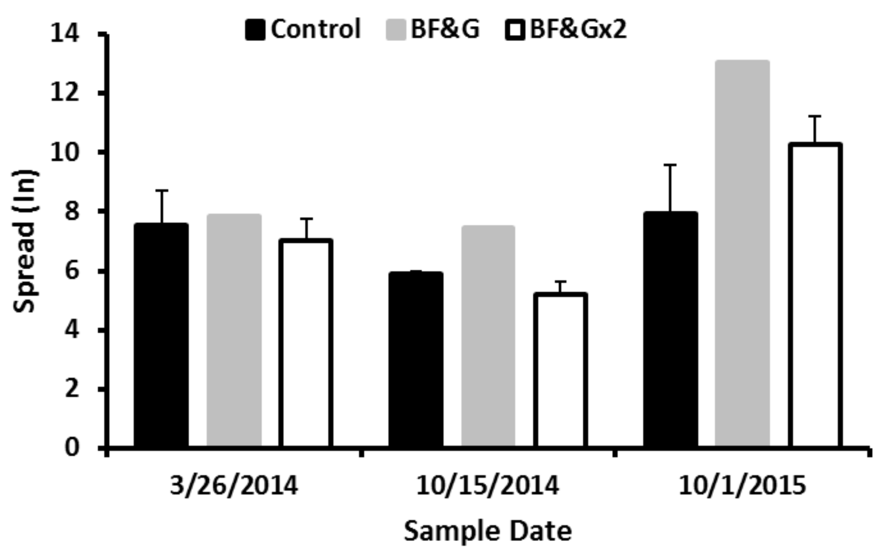

Figure 84. Mean (±SE) Spread of Live Oak planted on 26 March 2014 exposed to three soil treatments. Spread was similar among all treatments for all dates.

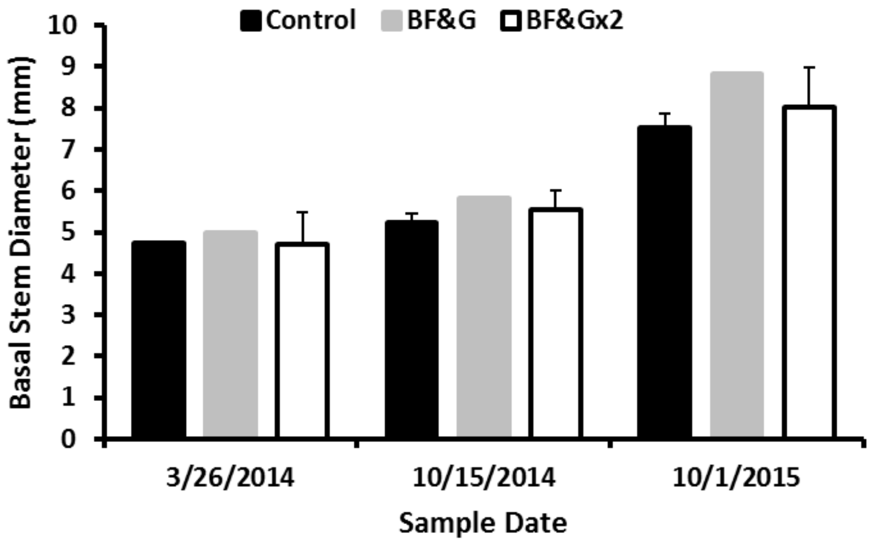

Figure 85. Mean (±SE) Basal Stem Diameter of Live Oak planted on 26 March 2014 exposed to three soil treatments. Basal Stem Diameter was similar among all treatments for all dates.

Yaupon – 2014 Planting

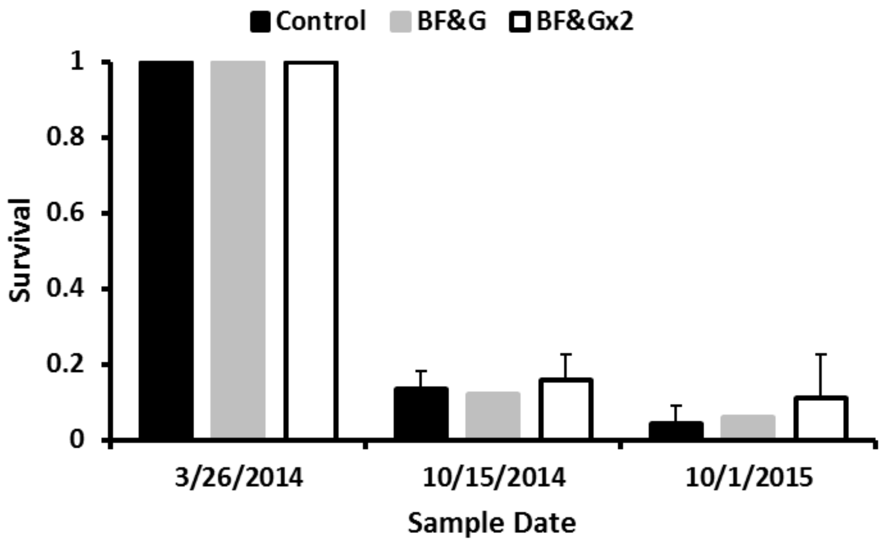

Figure 86. Mean (±SE) Survival of Yaupon planted on 26 March 2014 exposed to three soil treatments. Survival was similar among all treatments for all dates.

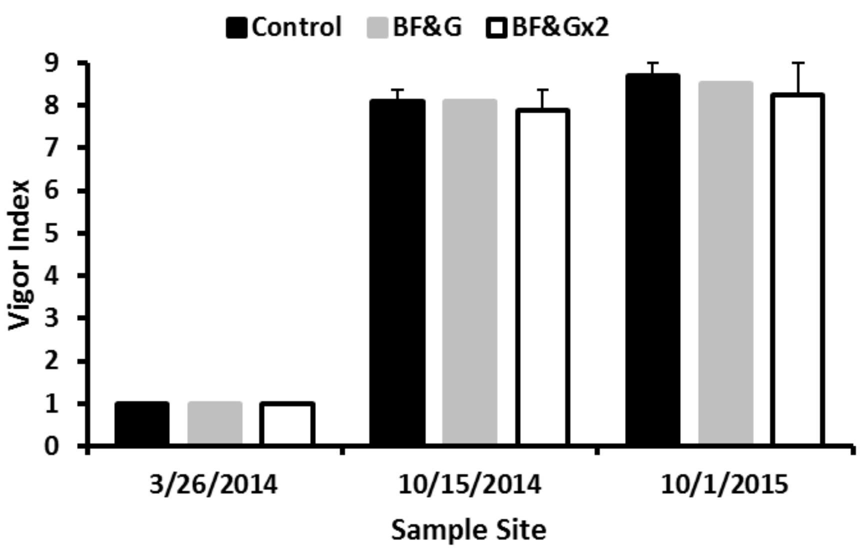

Figure 87. Mean (±SE) Vigor of Yaupon planted on 26 March 2014 exposed to three soil treatments. Vigor was similar among all treatments for all dates.

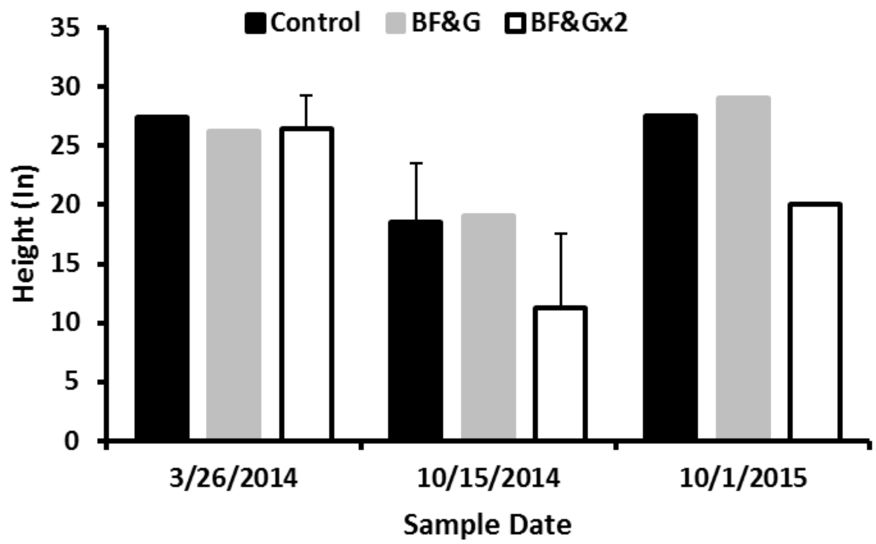

Figure 88. Mean (±SE) Height of Yaupon planted on 26 March 2014 exposed to three soil treatments. Height was similar among all treatments for all dates.

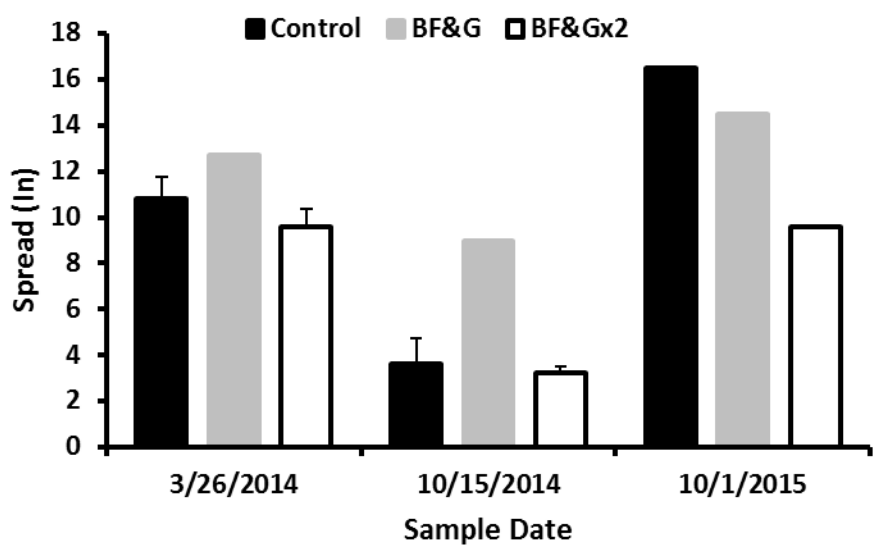

Figure 89. Mean (±SE) Spread of Yaupon planted on 26 March 2014 exposed to three soil treatments. Spread was similar among all treatments for all dates.

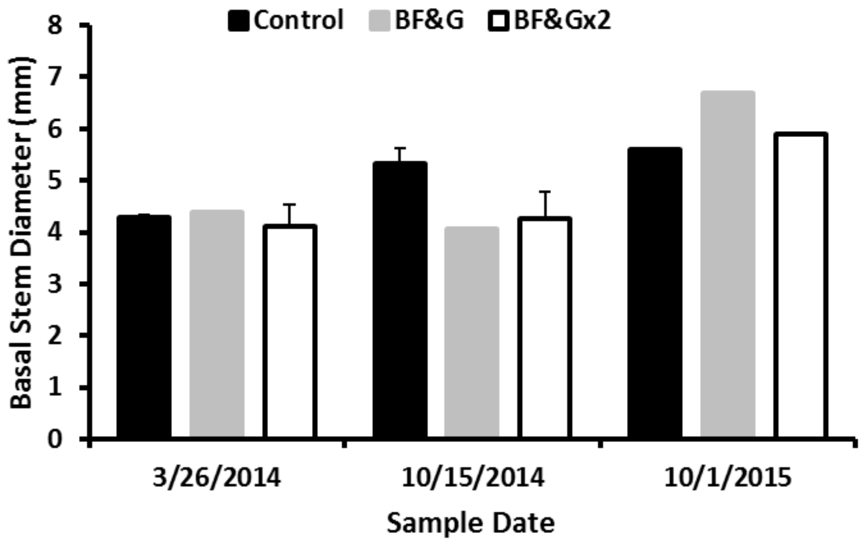

Figure 90. Mean (±SE) Basal Stem Diameter of Yaupon planted on 26 March 2014 exposed to three soil treatments. Basal Stem Diametert was similar among all treatments for all dates.

APPENDIX 5

EC and SAR Results Used in the Fourchon Maritime Forest Ridge and Marsh Restoration: Vegetative Efforts Report

EC and SAR Results used in the Fourchon Maritime Forest Ridge and Marsh Restoration: Vegetative Efforts Report

Electrical Conductivity (EC) and Sodium Adsorption Ratio results for soil samples collected off the top of the Far Ridge in Fourchon, Louisiana, between October 2011 and October 2015. All results are from the LSU Agricultural Center's Soil Testing and Wetland Soil Characterization Laboratories, Baton Rouge, Louisiana, (not Manoch Kongchum's results used in his report in Appendix 2) and used for statistical analysis in the Fourchon Maritime Forest Ridge and Marsh Restoration: Vegetative Efforts report.

Sample Date	Sample Site	EC (dS/m)	SAR
Oct-11	FR1	21.12	32.75
Oct-11	FR2	25.12	35.45
Oct-11	FR3	7.08	19.55
Oct-11	FR4	9.70	17.05
Oct-11	FR5	28.26	33.36
Oct-11	FR6	6.50	15.69
Oct-11	FR7	31.44	38.75
Oct-11	FR8	29.80	42.78
Oct-11	FR9	3.19	8.12
Oct-11	FR10	16.16	29.55
Oct-11	FR11	34.46	45.86
Oct-11	FR12	42.00	51.38
Oct-11	FR13	15.60	28.47
Oct-11	FR14	9.76	20.89
Oct-11	FR15	29.28	37.37
Oct-11	**Average of all 15**	**20.63**	**30.47**

Sample Date	Sample Site	EC (dS/m)	SAR
Oct-12	FR1	22.58	34.07
Oct-12	FR2	20.50	33.17
Oct-12	FR3	14.42	28.29
Oct-12	FR4	4.70	11.21
Oct-12	FR5	14.16	21.59
Oct-12	FR6	1.14	4.61
Oct-12	FR7	20.10	26.54
Oct-12	FR8	19.58	27.39
Oct-12	FR9	10.94	19.16
Oct-12	FR10	0.59	3.82
Oct-12	FR11	42.20	45.61
Oct-12	FR12	37.98	44.96
Oct-12	FR13	4.58	7.84
Oct-12	FR14	5.90	20.62
Oct-12	FR15	14.36	28.33
Oct-12	**Average of all 15**	**15.58**	**23.81**
May-13	FR1	22.52	37.79
May-13	FR2	8.38	17.55
May-13	FR3	22.46	32.51
May-13	FR4	3.25	4.02
May-13	FR5	7.76	18.63
May-13	FR6	1.21	3.08
May-13	FR7	17.84	37.55
May-13	FR8	10.94	26.45
May-13	FR9	13.08	21.21
May-13	FR10	35.36	61.34
May-13	FR11	24.42	42.32
May-13	FR12	23.88	44.40
May-13	FR13	0.73	2.17
May-13	FR14	12.24	35.26
May-13	FR15	8.04	18.57
May-13	**Average of all 15**	**14.14**	**26.86**

Sample Date	Sample Site	EC (dS/m)	SAR
Dec-13	FR1	12.82	18.97
Dec-13	FR2	14.40	27.50
Dec-13	FR3	0.93	3.09
Dec-13	FR4	2.98	3.32
Dec-13	FR5	10.60	18.63
Dec-13	FR6	0.86	2.96
Dec-13	FR7	11.40	25.21
Dec-13	FR8	12.00	19.69
Dec-13	FR9	0.60	1.03
Dec-13	FR10	27.82	43.81
Dec-13	FR11	44.52	51.31
Dec-13	FR12	24.02	37.78
Dec-13	FR13	0.72	1.82
Dec-13	FR14	1.45	5.68
Dec-13	FR15	9.58	20.09
Dec-13	**Average of all 15**	**11.65**	**18.73**
May-14	FR1	14.18	18.96
May-14	FR2	15.22	19.59
May-14	FR3	2.02	3.11
May-14	FR4	0.53	0.87
May-14	FR5	10.04	11.94
May-14	FR6	2.51	3.99
May-14	FR7	29.94	29.72
May-14	FR8	9.80	15.44
May-14	FR9	11.48	12.63
May-14	FR10	0.60	1.01
May-14	FR11	31.00	39.38
May-14	FR12	29.66	31.82
May-14	FR13	2.26	8.11
May-14	FR14	0.66	1.38
May-14	FR15	15.42	21.42
May-14	**Average of all 15**	**11.69**	**14.63**

Sample Date	Sample Site	EC (dS/m)	SAR
Oct-14	FR1	9.36	22.87
Oct-14	FR2	9.68	22.68
Oct-14	FR3	30.84	45.40
Oct-14	FR4	0.83	1.09
Oct-14	FR5	11.26	24.35
Oct-14	FR6	3.47	12.86
Oct-14	FR7	8.92	25.17
Oct-14	FR8	15.58	36.63
Oct-14	FR9	1.43	5.99
Oct-14	FR10	20.86	48.64
Oct-14	FR11	29.96	50.81
Oct-14	FR12	25.90	48.03
Oct-14	FR13	1.30	2.87
Oct-14	FR14	20.28	37.88
Oct-14	FR15	12.36	40.51
Oct-14	**Average of all 15**	**13.47**	**28.39**
Oct-15	FR1	8.50	16.90
Oct-15	FR2	5.60	9.40
Oct-15	FR3	23.30	37.40
Oct-15	FR4	2.10	1.70
Oct-15	FR5	8.40	17.20
Oct-15	FR6	0.70	1.20
Oct-15	FR7	14.50	23.00
Oct-15	FR8	7.00	13.20
Oct-15	FR9	6.30	13.00
Oct-15	FR10	12.70	23.70
Oct-15	FR11	36.70	55.70
Oct-15	FR12	17.30	37.30
Oct-15	FR13	0.50	0.90
Oct-15	FR14	11.20	20.20
Oct-15	FR15	5.00	16.50
Oct-15	**Average of all 15**	**10.65**	**19.15**