



Seabeach Amaranth Experimental Seed Sowing Report

Sea Girt National Guard Training Center
2019



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Table of Contents

Acronym List	1
Executive Summary	2
Introduction	3
Methods	3
Plot Establishment and Seed Sowing.....	3
Sample Analysis – Grain Size.....	5
Sample Analysis – Moisture Content.....	6
Plot Land-Cover Analysis.....	7
Results & Discussion	7
Plot Establishment Summary.....	7
Survey Complications.....	7
Germination Results.....	8
• Germination Success Rate by Plot Treatment.....	8
• Plant Size and Development.....	8
• Cumulative Success Rate.....	8
• Control Plots Summary.....	8
• Germination Results Conclusion and Discussion.....	9
Grain Size Analysis.....	9
Moisture Content Analysis.....	10
Plot Land-Cover Analysis.....	10
Plot Specific Results.....	11
Recommendations.....	21
References.....	22

Tables

- SG1 – Assigned Seed Sowing Method
- SG2 – Germination Summary 1
- SG3 – Germination Summary 2
- SG4 – Plot Land-Cover Summary

Figures

- SG1 – Seabeach Amaranth Experimental Plot Locations – NPA & SPA
- SG2 – Seabeach Amaranth Locations - NPA
- SG3 – Seabeach Amaranth Locations – SPA

Appendices

- Appendix A – Seed Sowing Data
- Appendix B – Plot Monitoring Data
- Appendix C – Moisture Content Analysis Data
- Appendix D – Plant Measurement Data
- Appendix E – Grain Size Analysis Data
- Appendix F – Blank Datasheets
- Appendix G – Plot Photographs
- Appendix H – Plant Photographs
- Appendix I – Regression Figures

Acronym List

hrs - hours

mm – Millimeter

NGTC – National Guard Training Center

NJDMAVA – New Jersey Department of Military and Veterans Affairs

NJFO – New Jersey Field Office

NPA – Northern Protection Area

QA/QC – Quality Assurance/Quality Control

SA – Seabeach Amaranth (*Amaranthus pumilus*)

SG – Sea Girt

SPA – Southern Protection Area

sq.m – Square Meter

SS – Asiatic Sand Sedge (*Carex kobomugi*)

SUEIP – Stockton University Environmental Internship Program

µm - Micrometer

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

Executive Summary

Seabeach Amaranth (*Amaranthus pumilus*) (SA) is an annual plant endemic to New Jersey's beach and dune habitats. It was listed as a federally threatened species in 1993 as a result of habitat loss due to coastal development and beach grooming for recreational use. The beachfront at the Sea Girt National Guard Training Center (SG NGTC) provides ideal habitat for this species, and supports known populations of naturally occurring SA. Every spring, researchers from the New Jersey Department of Military and Veterans Affairs (NJ DMAVA) Environmental Management Bureau (EMB) and collaborating agencies, install fencing around ideal SA habitat, and conduct surveys to locate and document naturally occurring populations of these plants.

NJDMAVA, with cooperation from the Stockton University Environmental Internship Program (SUEIP) and the United States Fish and Wildlife Service (USFWS), conducted an experimental seed propagation experiment at the SG NGTC in the Summer of 2019, in which the northern and southern protection areas (NPA and SPA) of the beach habitat were used to determine the effectiveness of three different seed sowing methods. In March, 2019, a standardized number of SA seeds, provided by the USFWS, were deposited into standardized sized plots strategically spaced throughout the NPA and SPA. These plots were monitored periodically throughout the spring and summer, with the last survey taking place in October. Photographs and sand samples were collected periodically from each plot in an attempt to account for natural variation between plots, including land cover, moisture content, and grain size.

Results from this experiment were compiled and analyzed by SUEIP. Low germination success was observed for all plot types, regardless of seed sowing method. This low germination success did not provide a robust enough sample size to make any confident determinations regarding the effectiveness or plausibility of the three different seed sowing methods. Additionally, the experimental SA plants were significantly smaller in size compared to naturally occurring SA plants located on-site, raising questions and doubts concerning the viability of the seeds used, and suggests that; A. Seeds may become non-viable if stored at non-optimal conditions for up to 4 years, or B. The use of non-stratified seeds, through chemical or moist pre-chilling methods, is ineffective, and is not a plausible means for seed propagation. Researchers found no correlation between grain size and germination success or between grain size and moisture content, as all samples were nearly identical in composition. A potential relationship between initial moisture content and germination success was identified, however the small sample size does not provide enough evidence to support or confirm this claim. A negative relationship between initial land-cover and germination success may exist, however, as previously stated, a larger sample size is needed to make any determinations with confidence. No relationship between land-cover and moisture content was identified. In summary, although germination success was low, this experiment provided a valuable experimental template, which can be built upon for future seed propagation efforts. This report identifies and addresses potential explanations for low germination success rates, and provides recommended procedural adjustments to be used for larger-scale planting experiments in the future.

Introduction

Seabeach Amaranth (*Amaranthus pumilus*) (SA) is a federally threatened plant species native to New Jersey. It grows in open sandy beachfronts along the Atlantic coast. Habitat destruction and alteration, such as grooming and replenishing beachfronts for recreational use, are the primary threats to this species. SA is also intolerant to overcrowding by other native and non-native plant species, and can be easily displaced by fast growing competitors such as the invasive Asiatic sand sedge (*Carex kobomugi*) (SS) (Seabeach Amaranth, NJFO, 2018).

In the spring, summer, and fall of 2019, the New Jersey Department of Military and Veterans Affairs (NJDMAVA), with cooperation from the Stockton University Environmental Internship Program (SUEIP) and the United States Fish and Wildlife Service (USFWS) conducted an experimental growing season at the Sea Girt National Guard Training Center (SG NGTC). The Northern and Southern Protection Areas (NPA and SPA) of the beachfront served as experimental plots for determining the effectiveness of three different seed sowing methods:

1. Casting – seeds deposited on the surface, not covered
2. Cast and Cover – seeds deposited on the surface, then covered with sand
3. Seed Planting – seeds placed in depressions 1cm deep, then covered with sand

In total, 27 plots were established in early spring 2019, and were monitored for the duration of the growing season. Included in the 27 plots were 9 “Control” plots, which were established as a quality assurance/quality control (QA/QC) method. Detailed methods for this experiment can be found in the protocol titled “Seabeach Amaranth Seed Sowing Protocol, Sea Girt National Guard Training Facility, 2019.” A summary of these methods is included below. This report summarizes the results from this experiment, and identifies which of the three sowing methods, if any, are most effective and practical for future larger-scale propagation efforts. Seeds for this experiment were provided by Wendy Walsh from the USFWS. These seeds were collected from naturally occurring SA populations at National Wildlife Refuge locations in Sandy Hook and Holgate in 2015 and 2016, respectively. Approximately 4,000 of these seeds were used in a seed propagation effort conducted by the USFWS in 2017.

Methods

Plot Establishment and Seed Sowing

1. Use ArcGIS to designate the location of each plot, avoiding historical SA and SS locations.
2. In the field, back-navigate to the designated plot locations, and begin establishing plots:

Establishing a Plot

- A. Place a 2m x 2m square template (constructed from PVC pipes) on the ground at the pre-assigned plot location.
 - B. Using Orange flags, mark the boundaries of the 2m x 2m square.
 - C. Write the plot number on each flag with a permanent marker.
 - D. Record the plot number, coordinates, planting method, and other notes on “Datasheet A: Seabeach Amaranth Experimental Plot - Sowing” (see Appendix F).
3. Fill a sample bag with surface sand from outside the eastern boundary of the plot for grain size and moisture content analysis. Label the bag with the sample ID and date.
 4. Sow the seeds with the assigned planting method according to Table 1: Assigned Sowing Method.

Casting – Gently cast 30 seeds into the plot area, with an attempt to distribute them evenly throughout the plot area. Do not cover.

Cast and Cover - Gently cast 30 seeds into the plot area, with an attempt to distribute them evenly throughout the plot area. Using a gentle kicking motion, kick sand from outside of the plot area to evenly cover (approximately 1cm deep) the sown seeds inside the plot area, being careful not to move the seeds out of the plot area in the process.

Planting – Make 15 depressions in the sand, evenly spaced (at least 10 inches apart) in the established plot area. Place 2 seeds in each depression, then gently fill the depression with sand.

Control – No seeds. This plot will remain unaltered.

5. Continue to establish the remaining plot lines in the NPA and SPA, working north to south, spacing each plot line at least 15m apart.
6. Take a photo of every plot from outside of the eastern boundary, facing west.
7. Monitor each plot approximately twice per month throughout the growing season, collecting and analyzing additional sand samples. Continue to take photos of each plot during every plot-check using the same orientation. Document plot observations on “Datasheet B: Seabeach Amaranth Experimental Plot – Bi-Weekly Monitoring” and “Datasheet D: Seabeach Amaranth Experimental Plot – Plant Measurements”. Examples of these datasheets can be found in Appendix F.

Important parameters:

- Experimental plots were not established near previously documented SA locations to avoid any pre-existing seedbanks that could skew trial results.
- Experimental plots were not established near previously documented SS locations, as uprooting of regenerating SS could disrupt the conditions of the plot.
- Experimental Plots were not established in the vegetation thinning area. This area is shown in Figures SG1 and SG2.
- Wind at this beachfront typically blows in a S, SW, or SE direction. Experimental plots were arranged in an East – West direction to avoid potential seed distribution between experimental plots.
- E-W plots were not located more than 5m from each other.
- N-S plot rows were not located more than 15m from each other.
- Each plot received the same number of seeds, regardless of the sowing method (control plots excluded).
- Plot treatment and arrangement were staggered, as shown in Figure SG1 to minimize any bias in regards to location or conditions.

Sample Analysis – Grain Size

Analyze one sand sample from each plot for grain size using dry sieving and roto-tapping lab methods, using size 10 (2mm), 18 (1mm), 35 (500 μm), 60 (250 μm), 120 (125 μm), and 270 (53 μm) sized sieves.

1. Place the collection tin on the roto-tap shaker.
2. Stack the sieves from smallest to largest on the pan, with the smallest (270) sieve on the bottom and the largest (10) on top.
3. Measure approximately 300g of sand using a lab scale. Record this mass on Datasheet E in the “Initial Sample Mass” column.
4. Add sample to the top (largest) sieve.
5. Secure the lid attachment to the sieve stack.
6. Set the shaker to 5 min and press START.
7. After 5 min, remove the top sieve (10) from the stack, and empty the contents into a clean large plastic bin, being careful not to lose any material. Hold the sieve upside down over the bin and tap the sides and bottom to dislodge any remaining sample.
8. Tare a weigh boat on a scale.
9. Carefully empty the contents of the plastic bin into the weigh boat and place on scale.
10. Record sample mass on Datasheet E.

11. Repeat steps 5-8 for each sieve, as well as the bottom collection pan.
12. Calculate the % sample for each grain size. Note: The sample remaining in a sieve is LARGER than the sieve size.
 - A. Calculate the combined final sample mass. This mass may be lower than the pre-shaking mass due to some sample getting lost during the shaking or weighing process.
 - B. Calculate the % grain size.

Example:

$(\text{Sample Mass (Size 10)} / \text{Initial Sample Mass}) * 100 = \% \text{ Sample Greater Than Size 10 (2mm)}$

13. Use the Wentworth Grade Scale to determine % sand, % silt, and % clay. Record these percentages on Datasheet E.

Sample Analysis – Moisture Content

1. Record the sample ID and collection date on “Datasheet C: Seabeach Amaranth Experimental Plot – Moisture Content Analysis”.
2. Using a permanent marker, label a drying oven tin with the Sample ID.
3. Weigh the tin, and record the tin mass on Datasheet C.
4. Empty the contents of the sample bag into a plastic bin.
5. Using a plastic spatula, mix the sand thoroughly.
6. Tare the drying tin.
7. Add 160-200g of sand to the tin and weigh immediately. Record the mass on Datasheet C.
8. Place the tin in the drying oven. Repeat steps 1-7 for each sample.
9. Record the Drying Date 1 and Drying Time 1 on Datasheet C.
10. Dry the samples at 105°C, periodically checking to make sure the temperature is still 105°C.
11. After a minimum of 24 hrs, re-weigh each sample, recording the weight on Datasheet C (Drying Weight 2), and place the sample back in the drying oven.
12. After another 5 hrs in the oven, re-weigh each sample, recording the weight on Datasheet C (Drying Weight 3). If Drying Weight 3 is the same as Drying Weight 2, the sample is dry. If Drying Weight 3 is less than Drying Weight 2, continue to dry the sample until there is no change in mass.
13. Calculate Moisture Content:

$$(\text{Wet Mass} - \text{Dry Mass} / \text{Dry Mass}) * 100 = \% \text{ Moisture}$$

Plot Land-Cover Analysis

1. Add a plot photo in JPEG format as a layer in ArcMap
2. Using the drawing tool, draw a polygon around the area of the plot occupied by vegetation.
3. Record the combined area of all polygons in a plot on a notepad. Area will be in unknown units because no spatial data exists for the file.
4. Draw a polygon around the plot border.
5. Record the area of the plot on a notepad.
6. Calculate land-cover percent:

$$\text{Area of land cover (unknown units)}/\text{Area of plot (unknown units)}*100 = \text{Land-cover \%}$$

7. Calculate actual land-cover area:

$$(\text{Land-Cover \%} / 100) * \text{Actual plot area (4 sp.m)} = \text{Actual land-cover area (sq.m)}$$

8. Repeat steps 1-7 for each plot for A. Plot photo from plot establishment, and B. Plot photo from final plot check. Calculated land-cover percent and land-cover area can be found in Table SG4.

Results & Discussion

Plot Establishment Summary

On 3/28/2019, 6 plot lines containing 18 plots were successfully established using the methods described above. Of these 18 plots, 6 were treated using the “Cast” method, 6 were treated using the “Cast & Cover” method, and 6 were treated using the “Planting” method. Thirty seeds were deposited in each of the 18 plots, for a total of 540 seeds. Treatments were split evenly between the NPA and SPA. In addition, 3 control plot lines (2 in the NPA and 1 in the SPA) containing 9 plots were established on 4/17/2019. No seeds were planted within the 9 control plots, and like the 18 treatment plots, historical SA locations were avoided when assigning control plot locations. Figures SG1, SG2, and SG3 show the location of each plot. Assigned plot treatments can be found in Table SG1.

Survey Complications

On 4/16/2019, piping plovers were observed on-site, and began prospecting for nesting locations in the NPA on 4/25/2019. In accordance with section 6.3.10.2 of the 2018 Integrated Natural Resources Management Plan (INRMP), all SA surveying in the NPA was immediately suspended to avoid any potential disturbance to nesting pairs. Surveying of the SPA was also limited during this time, and was only permitted under the supervision of trained Conserve

Wildlife employees. For that reason, the NPA and SPA were only surveyed 4 and 6 times, respectively, over the duration of this experiment.

High water events were documented on June 12-14, August 1, and October 14-15. Surveyors confirmed that the August surge entered the NPA, and the October surge flooded portions of the NPA to the base of the dunes. Tides were not observed entering the SPA at any time over the course of the season. It is possible that SA plants that germinated between the April 17 and August 14 NPA plot checks could have been impacted by the August 1 surge. Germination success in the NPA was 1% lower than in the SPA.

Germination Results

Germination Success Rate by Plot Treatment

In total, 0 SA plants germinated in Control plots, 8 SA plants germinated in Cast plots, 5 SA plants germinated in Cast & Cover plots, and 8 SA plants germinated in Plant plots. Germination of at least 1 plant was observed in 0% of the Control plots, 33% of the Cast plots, 33% of the Cast & Cover plots, and 83% of the Plant plots.

Plant Size and Development

SA plant sizes ranged from 0.3 cm to 3.2 cm in diameter, with an average of 1.16 cm. According to the USFWS, naturally occurring SA plants typically reach 10 cm in diameter (Seabeach Amaranth, NJFO, 2018). Of the 21 SA plants that germinated in experimental plots, 5 in Cast plots, 4 in Cast & Cover plots, and 6 in Plant plots developed true-leaves, and therefore had the potential to develop and deposit seeds.

Cumulative Success Rate

Of the 540 seeds sown, 21 SA plants germinated, 15 of which survived long enough and grew large enough to potentially reproduce. This is a germination success rate of 3.9%, with only 2.8% of the sown seeds maturing to reproduction. Table SG2 and Table SG3 summarize these germination results.

Control Plots Summary

No SA plants were observed in any of the Control plots; therefore we can infer that all SA plants located within the treatment plots germinated from seeds sown as part of this experiment, and were not from pre-existing seeds deposited by plants in previous years.

Germination Results Conclusion and Discussion

The small success rate (3.9%) observed among all treatment types does not provide a robust enough sample size to make any confident conclusions regarding the effectiveness of the three sowing methods. The small size and low success rate observed during this experiment also raises concerns about the viability of the seeds used. All seeds used during this experiment were collected from naturally occurring SA populations on NJ beaches in 2015, had been stored under normal office conditions, and had not been chemically treated to break dormancy. Successful germination and growth of century-old seeds in other amaranth species has been previously documented (Recovery Plan for Seabeach Amaranth, 1996). Freshly harvested SA seeds are physiologically dormant, and require an 84 – 120 day moist-prechilled stratification period in order to germinate (Norden, 2007). This lengthy stratification period can be avoided by chemically treating the seeds for 24 hrs (Norden, 2007). The seeds sown in 2019 were not chemically treated, and no cold or wet stratification methods were implemented prior to planting to break dormancy due to time constraints. However, these seeds were not freshly harvested (~4 yrs old), and therefore may not have required additional stratification. Approximately 4,000 of these seeds were used in a seed propagation effort in 2017, however these seeds had been chemically treated to break dormancy, and planted in peat pots instead of being sown directly into the sand. Results from this survey effort are currently unavailable. Research conducted by the Department of Horticultural Science at North Carolina State University reported an 84% germination success rate for seeds chemically treated and grown in a controlled environment. Research conducted by the School of Biological Sciences at the University of Kentucky reported a 98% germination success rate under optimal light, temperature, and moisture conditions. In addition, the naturally occurring SA plants found on-site (not associated with any plots) grew noticeably larger than those from experimental seeds. Although measurements for the naturally occurring plants were not documented, photographs of these plants, as shown in Appendix H, display a noticeable size difference from experimental plants. This observation supports the concern regarding the viability of the experimental seeds, and suggests that A. Seeds may become non-viable if stored at non-optimal conditions for up to 4 years, or B. The use of non-stratified seeds, through chemical or moist pre-chilling methods, is ineffective, and is not a plausible means for seed propagation. Recommended procedural adjustments to address the low germination success for future seed propagation efforts are discussed in the recommendation section of this report.

Grain Size Analysis

Particle size analysis was completed for one sample from each plot, all of which were collected on 4/17/2019, using a mechanical sieving method. Results can be found in Appendix E. The Wentworth Grade Scale, used by the USGS, was used to categorize the sample based on grain size. There was very little variation between samples, with all samples comprising largely of

coarse to medium sand. All samples ranged from 99.61% and 99.99% sand, 0.00% - 0.38% very fine pebbles, and 0.00% - 0.04% residual silts or clay. The sand comprised of 0.67% - 9.09% very coarse sand, 34.96% - 68.76% coarse sand, 24.81% - 62.10% medium sand, and -0.18% - 2.41% fine sand. Data was analyzed using a linear regression to identify any relationships between grain size and germination success, as shown in Figure 1 of Appendix I.

Moisture Content Analysis

Variation in moisture content between plots was identified as a potential variable that may affect SA growth or germination success. To account for this variable and to identify any observable trends, surveyors planned to collect sand samples from the same location beside each plot twice per month throughout the growing season. However, access to the NPA and SPA was limited due to piping plover activity, so fewer samples were collected than intended. In total, 72 samples were collected and analyzed. Moisture content in individual plots ranged from 2.42% in May to 0.07% in July, with an average of 0.71%. Moisture content data for all samples collected can be found in "Datasheet C: Seabeach Amaranth Experimental Plot – Moisture Content Analysis".

Data was analyzed using a linear regression to identify any relationships between initial moisture content and germination success, and between average moisture content and germination success as shown in Figures 2 and 3 of Appendix I. Control plots were excluded from this analysis. Graphs showing these regressions can be found in Appendix I. No significant relationship was found between either of these variables, with an R^2 value of 0.1432 and 0.1324 for initial moisture content and average moisture content, respectively, as a factor for germination success. Although the regression does show that a positive relationship may exist between initial moisture content and germination success, the small sample size and low R^2 value do not provide enough evidence to make this determination. Additional surveying with a more robust sample size is needed to determine if this relationship between initial moisture content and germination success is significant.

Due to the low variation (sand size standard deviation 0.00076) in grain size among samples, we can assume that there is no significant relationship between grain size and moisture content.

Plot Land-Cover Analysis

Plot photographs taken at the beginning and end of this experiment were analyzed using the procedure defined in the methods section of this report. These photos can be found in Appendix G. Table SG4 summarizes these results. Land-cover in the spring ranged from 0% to 29.70%. Land-cover in the fall ranged from 0% - 69.5%. On average, land-cover increased by 8.68% over the duration of this experiment.

Data was analyzed using a linear regression to identify any relationships between initial land-cover and germination success, and between final land-cover and germination success as shown in Figures 4 and 5 of Appendix I. Control plots were excluded from this analysis. No significant relationship was found between either of these variables, with an R^2 value of 0.0657 and 6E-05 for initial land-cover and final land-cover, respectively, as a factor for germination success. However, an interpretation of the graph suggests that there may be a negative relationship between initial land-cover and germination success, with a germination success of 0% for all plots with initial land-cover greater than 6%. This interpretation of the data supports the theory that SA is intolerant to overcrowding. However, of the 8 plots with less than 2% initial land-cover, only 3 plots produced SA plants. Perhaps a small amount of land-cover is necessary to provide enough shelter for germinating plants to take root before being transported by wind. Additional surveying with a more robust sample size is needed to determine if these relationships between initial land-cover and germination success are significant.

Linear regressions were used to test the hypothesis that a correlation existed between land-cover and moisture content, as shown in Figures 6 and 7 of Appendix I. Control plots were excluded from this analysis because initial sand samples for these plots were collected on a different day than the experimental plots. No relationship was identified between these factors.

Due to the low variation (sand size standard deviation 0.00076) in grain size among samples, we can assume that there is no significant relationship between grain size and land cover.

Plot-Specific Results

Treatment: Cast Method

Plot: 4C

Germination Success: 0% (0 Plants)

True-Leaf Development Success: 0% (0 Plants)

Land-Coverage at Plot Establishment: 14.50%

Land-Coverage at Final Plot Check: 19.83%

Change in Land-Cover: 5.33%

Initial Moisture Content: 0.55%

Average Moisture Content: 0.33%

Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
4C	4C-4-17-2019	4/17/2019	12/2/2019	0.00%	0.78%	53.56%	44.94%	0.71%	0.00%	0.00%

Plot: 5B

Germination Success: 0% (0 Plants)
 True-Leaf Development Success: 0% (0 Plants)
 Land-Coverage at Plot Establishment: 1.09%
 Land-Coverage at Final Plot Check: 8.55%
 Change in Land-Cover: 7.46%
 Initial Moisture Content: 1.13%
 Average Moisture Content: 1.07%
 Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
5B	5B-4-17-2019	4/17/2019	11/25/2019	0.14%	5.15%	54.82%	39.48%	0.41%	0.00%	0.00%

Plot: 6A

Germination Success: 0% (0 Plants)
 True-Leaf Development Success: 0% (0 Plants)
 Land-Coverage at Plot Establishment: 0%
 Land-Coverage at Final Plot Check: 4.06%
 Change in Land-Cover: 4.06%
 Initial Moisture Content: 0.99%
 Average Moisture Content: 1.08%
 Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
6A	6A-4-17-2019	4/17/2019	11/19/2019	0.38%	4.08%	64.34%	30.74%	0.46%	0.00%	0.00%

Plot: 7B

Germination Success: 0% (0 Plants)
 True-Leaf Development Success: 0% (0 Plants)
 Land-Coverage at Plot Establishment: 1.42%
 Land-Coverage at Final Plot Check: 4.39%
 Change in Land-Cover: 2.97%

Initial Moisture Content: 0.73%

Average Moisture Content: 0.44%

Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
7B	7B-4-17-2019	4/17/2019	11/18/2019	0.01%	2.61%	57.39%	39.54%	0.45%	0.00%	0.00%

Plot: 8C

Germination Success: 20% (6 Plants)

True-Leaf Development Success: 10% (3 Plants)

Land-Coverage at Plot Establishment: 2.80%

Land-Coverage at Final Plot Check: 5.14%

Change in Land-Cover: 2.34%

Initial Moisture Content: 1.63%

Average Moisture Content: 1.00%

Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
8C	8C-4-17-2019	4/17/2019	11/18/2019	0.01%	4.44%	68.76%	26.10%	0.68%	0.00%	0.00%

Plot: 9A

Germination Success: 6.67% (2 Plants)

True-Leaf Development Success: 6.67% (2 Plants)

Land-Coverage at Plot Establishment: 5.83%

Land-Coverage at Final Plot Check: 10.55%

Change in Land-Cover: 4.72%

Initial Moisture Content: 0.33%

Average Moisture Content: 0.63%

Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
9A	9A-4-17-2019	4/17/2019	11/15/2019	0.06%	9.09%	59.73%	30.69%	0.41%	0.01%	0.01%

Treatment: Cast & Cover Method

Plot: 4B

Germination Success: 0% (0 Plants)
True-Leaf Development Success: 0% (0 Plants)
Land-Coverage at Plot Establishment: 16.5%
Land-Coverage at Final Plot Check: 8.89%
Change in Land-Cover: -7.61%
Initial Moisture Content: 1.42%
Average Moisture Content: 1.18%
Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
4B	4B-4-17-2019	4/17/2019	12/2/2019	0.01%	0.75%	48.20%	49.78%	1.22%	0.01%	0.03%

Plot: 5A

Germination Success: 13.33% (4 Plants)
True-Leaf Development Success: 13.33% (4 Plants)
Land-Coverage at Plot Establishment: 0%
Land-Coverage at Final Plot Check: 15.54%
Change in Land-Cover: 15.54%
Initial Moisture Content: 1.03%
Average Moisture Content: 0.93%
Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
5A	5A-4-17-2019	4/17/2019	11/25/2019	0.03%	0.67%	35.91%	61.27%	2.09%	0.03%	0.00%

Plot: 6C

Germination Success: 3.33% (1 Plant)
True-Leaf Development Success: 0% (0 Plants)
Land-Coverage at Plot Establishment: 4.23%
Land-Coverage at Final Plot Check: 25.84%
Change in Land-Cover: 21.61%
Initial Moisture Content: 0.84%
Average Moisture Content: 0.57%
Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
6C	6C-4-17-2019	4/17/2019	11/19/2019	0.01%	2.00%	59.87%	37.04%	1.05%	0.03%	0.01%

Plot: 7A

Germination Success: 0% (0 Plants)
 True-Leaf Development Success: 0% (0 Plants)
 Land-Coverage at Plot Establishment: 7.30%
 Land-Coverage at Final Plot Check: 5.31%
 Change in Land-Cover: -1.99%
 Initial Moisture Content: 0.55%
 Average Moisture Content: 0.31%
 Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
7A	7A-4-17-2019	4/17/2019	11/18/2019	0.05%	7.64%	67.31%	24.81%	0.18%	0.01%	0.00%

Plot: 8B

Germination Success: 0% (0 Plants)
 True-Leaf Development Success: 0% (0 Plants)
 Land-Coverage at Plot Establishment: 0.60%
 Land-Coverage at Final Plot Check: 9.29%
 Change in Land-Cover: 8.69%
 Initial Moisture Content: 0.82%
 Average Moisture Content: 0.51%
 Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
8B	8B-4-17-2019	4/17/2019	11/18/2019	0.01%	1.09%	54.79%	43.40%	0.69%	0.01%	0.00%

Plot: 9C

Germination Success: 0% (0 Plants)
 True-Leaf Development Success: 0% (0 Plants)
 Land-Coverage at Plot Establishment: 11.86%
 Land-Coverage at Final Plot Check: 29.33%
 Change in Land-Cover: 17.47%

Initial Moisture Content: 0.67%

Average Moisture Content: 0.72%

Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
9C	9C-4-17-2019	4/17/2019	11/15/2019	0.00%	1.66%	54.81%	42.76%	0.76%	0.01%	0.00%

Treatment: Planting Method

Plot: 4A

Germination Success: 3.33% (1 Plant)

True-Leaf Development Success: 3.33% (1 Plant)

Land-Coverage at Plot Establishment: 0%

Land-Coverage at Final Plot Check: 0%

Change in Land-Cover: 0%

Initial Moisture Content: 0.79%

Average Moisture Content: 0.58%

Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
4A	4A-4-17-2019	4/17/2019	12/2/2019	0.03%	1.30%	54.75%	43.18%	0.74%	0.00%	0.00%

Plot: 5C

Germination Success: 6.67% (2 Plants)

True-Leaf Development Success: 3.33% (1 Plant)

Land-Coverage at Plot Establishment: 0.65%

Land-Coverage at Final Plot Check: 20.77%

Change in Land-Cover: 20.12%

Initial Moisture Content: 1.19%

Average Moisture Content: 1.21%

Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
5C	5C-4-17-2019	4/17/2019	11/25/2019	0.04%	0.73%	34.96%	62.10%	2.13%	0.04%	0.00%

Plot: 6B

Germination Success: 3.33% (1 Plant)

True-Leaf Development Success: 3.33% (1 Plant)

Land-Coverage at Plot Establishment: 4.63%

Land-Coverage at Final Plot Check: 10.30%

Change in Land-Cover: 5.67%

Initial Moisture Content: 1.56%

Average Moisture Content: 1.18%

Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
6B	6B-4-17-2019	4/17/2019	11/19/2019	0.01%	1.12%	60.55%	37.80%	0.52%	0.00%	0.00%

Plot: 7C

Germination Success: 0% (0 Plants)

True-Leaf Development Success: 0% (0 Plants)

Land-Coverage at Plot Establishment: 0%

Land-Coverage at Final Plot Check: 0%

Change in Land-Cover: 0%

Initial Moisture Content: 1.57%

Average Moisture Content: 0.79%

Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
7C	7C-4-17-2019	4/17/2019	11/18/2019	0.00%	1.10%	61.16%	36.93%	0.79%	0.01%	0.00%

Plot: 8A

Germination Success: 3.33% (1 Plant)

True-Leaf Development Success: 3.33% (1 Plant)

Land-Coverage at Plot Establishment: 5.79%

Land-Coverage at Final Plot Check: 11.64%

Change in Land-Cover: 5.85%

Initial Moisture Content: 1.25%

Average Moisture Content: 0.56%

Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
8A	8A-4-17-2019	4/17/2019	11/18/2019	0.02%	2.39%	60.97%	36.21%	0.40%	0.01%	0.00%

Plot: 9B

Germination Success: 10.00% (3 Plants)

True-Leaf Development Success: 6.67% (2 Plants)

Land-Coverage at Plot Establishment: 4.45%

Land-Coverage at Final Plot Check: 8.60%

Change in Land-Cover: 4.15%

Initial Moisture Content: 1.59%

Average Moisture Content: 1.28%

Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
9B	9B-4-17-2019	4/17/2019	11/15/2019	0.00%	0.77%	58.33%	39.90%	0.96%	0.02%	0.01%

Treatment: Control

Plot: 1A

Germination Success: 0% (0 Plants)

True-Leaf Development Success: 0% (0 Plants)

Land-Coverage at Plot Establishment: 0%

Land-Coverage at Final Plot Check: 2.62%

Change in Land-Cover: 2.62%

Initial Moisture Content: 0.98%

Average Moisture Content: NA

Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
1A	1A-4-17-2019	4/17/2019	12/2/2019	0.04%	1.20%	48.16%	49.79%	0.80%	0.01%	0.00%

Plot: 1B

Germination Success: 0% (0 Plants)

True-Leaf Development Success: 0% (0 Plants)

Land-Coverage at Plot Establishment: 21.49%

Land-Coverage at Final Plot Check: 65.54%

Change in Land-Cover: 44.05%

Initial Moisture Content: 0.56%

Average Moisture Content: NA

Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
1B	1B-4-17-2019	4/17/2019	12/2/2019	0.01%	2.10%	48.65%	47.54%	1.68%	0.02%	0.00%

Plot: 1C

Germination Success: 0% (0 Plants)

True-Leaf Development Success: 0% (0 Plants)

Land-Coverage at Plot Establishment: 2.02%

Land-Coverage at Final Plot Check: 18.26%

Change in Land-Cover: -3.76%

Initial Moisture Content: 1.79%

Average Moisture Content: NA

Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
1C	1C-4-17-2019	4/17/2019	12/2/2019	0.04%	1.73%	59.02%	38.39%	0.81%	0.00%	0.00%

Plot: 2A

Germination Success: 0% (0 Plants)

True-Leaf Development Success: 0% (0 Plants)

Land-Coverage at Plot Establishment: 0%

Land-Coverage at Final Plot Check: 0%

Change in Land-Cover: 0%

Initial Moisture Content: 1.09%

Average Moisture Content: NA

Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
2A	2A-4-17-2019	4/17/2019	12/2/2019	0.13%	1.20%	43.13%	53.08%	2.41%	0.04%	0.00%

Plot: 2B

Germination Success: 0% (0 Plants)
True-Leaf Development Success: 0% (0 Plants)
Land-Coverage at Plot Establishment: 29.70%
Land-Coverage at Final Plot Check: 69.47%
Change in Land-Cover: 39.77%
Initial Moisture Content: 1.12%
Average Moisture Content: NA
Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
2B	2B-4-17-2019	4/17/2019	12/2/2019	0.04%	1.03%	44.86%	52.14%	1.92%	0.02%	0.00%

Plot: 2C

Germination Success: 0% (0 Plants)
True-Leaf Development Success: 0% (0 Plants)
Land-Coverage at Plot Establishment: 1.89%
Land-Coverage at Final Plot Check: 24.21%
Change in Land-Cover: 22.32%
Initial Moisture Content: 0.65%
Average Moisture Content: NA
Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
2C	2C-4-17-2019	4/17/2019	12/2/2019	0.01%	1.80%	51.04%	45.82%	1.32%	0.01%	0.01%

Plot: 3A

Germination Success: 0% (0 Plants)
True-Leaf Development Success: 0% (0 Plants)
Land-Coverage at Plot Establishment: 0.06%
Land-Coverage at Final Plot Check: 10.99%
Change in Land-Cover: 10.93%
Initial Moisture Content: 0.53%
Average Moisture Content: 0.31%
Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
3A	3A-4-17-2019	4/17/2019	12/2/2019	0.02%	4.18%	56.78%	38.25%	0.74%	0.01%	0.01%

Plot: 3B

Germination Success: 0% (0 Plants)
 True-Leaf Development Success: 0% (0 Plants)
 Land-Coverage at Plot Establishment: 1.79%
 Land-Coverage at Final Plot Check: 3.77%
 Change in Land-Cover: 1.98%
 Initial Moisture Content: 0.71%
 Average Moisture Content: 0.42%
 Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
3B	3B-4-17-2019	4/17/2019	12/2/2019	0.02%	5.79%	65.48%	28.34%	0.37%	0.00%	0.00%

Plot: 3C

Germination Success: 0% (0 Plants)
 True-Leaf Development Success: 0% (0 Plants)
 Land-Coverage at Plot Establishment: 0%
 Land-Coverage at Final Plot Check: 0%
 Change in Land-Cover: 0%
 Initial Moisture Content: 1.13%
 Average Moisture Content: 0.49%
 Grain Size:

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120	Very Fine Sand 120-270	Residual Silts & Clays >Pan
3C	3C-4-17-2019	4/17/2019	12/2/2019	0.01%	2.16%	63.83%	33.27%	0.71%	0.01%	0.01%

Recommendations

1. If additional seed propagation efforts are conducted in the future, it is recommended that a subsample of seeds be grown simultaneously in a greenhouse under controlled conditions to verify the viability of the seeds being used. Stockton University has a large greenhouse at the main campus in Galloway, NJ that could be used for this purpose. A

subsample of seeds should be chemically treated to break dormancy prior to planting. A comparison of plots with chemically treated seeds and non-chemically treated seeds could provide valuable insight for future seed propagation efforts. This should be conducted both in the greenhouse under controlled conditions, and in the field under natural conditions. Controlled conditions should be consistent with known/tested SA propagation procedures, such as those used by the Department of Horticultural Science at North Carolina State University. The article titled “Seed Germination of Seabeach Amaranth (*Amaranthus pumilus*) in Response to Temperature, Light, and Gibberellin A₃ Treatments” published in the Journal of Environmental Horticulture in 2007, provides detailed methods and results for treated SA seeds.

2. If additional seed propagation efforts are conducted in the future, it is recommended that the spacing between plots in a single plot line be increased from 5m to 10m to further reduce the risk of seeds being transported by wind from one plot to another.

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Tables

Table SG1: Assigned Sowing Method

Protection Area	Plot Line	Plot #	Treatment	# of Seeds Sown
NPA	1	1A	Control	0
NPA	1	1B	Control	0
NPA	1	1C	Control	0
NPA	2	2A	Control	0
NPA	2	2B	Control	0
NPA	2	2C	Control	0
SPA	3	3A	Control	0
SPA	3	3B	Control	0
SPA	3	3C	Control	0
NPA	4	4A	PLANT	30
NPA	4	4B	CAST & COVER	30
NPA	4	4C	CAST	30
NPA	5	5A	CAST & COVER	30
NPA	5	5B	CAST	30
NPA	5	5C	PLANT	30
NPA	6	6A	CAST	30
NPA	6	6B	PLANT	30
NPA	6	6C	CAST & COVER	30
SPA	7	7A	CAST & COVER	30
SPA	7	7B	CAST	30
SPA	7	7C	PLANT	30
SPA	8	8A	PLANT	30
SPA	8	8B	CAST & COVER	30
SPA	8	8C	CAST	30
SPA	9	9A	CAST	30
SPA	9	9B	PLANT	30
SPA	9	9C	CAST & COVER	30

Table SG2: Germination Summary 1

Plot	Protection Area	Treatment	Number of Seabeach Amaranth Plants Present						Germination % (MAX/30)	# Plants That Developed True-Leaves	% Plants that Developed True-Leaves
			4/5/2019	4/17/2019	6/24/2019	7/15/2019	8/14/2019	Maximum			
1A	NPA	Control	0	0	UNKN	UNKN	0	0	NA	0	NA
1B	NPA	Control	0	0	UNKN	UNKN	0	0	NA	0	NA
1C	NPA	Control	0	0	UNKN	UNKN	0	0	NA	0	NA
2A	NPA	Control	0	0	UNKN	UNKN	0	0	NA	0	NA
2B	NPA	Control	0	0	UNKN	UNKN	0	0	NA	0	NA
2C	NPA	Control	0	0	UNKN	UNKN	0	0	NA	0	NA
3A	SPA	Control	0	0	0	0	0	0	NA	0	NA
3B	SPA	Control	0	0	0	0	0	0	NA	0	NA
3C	SPA	Control	0	0	0	0	0	0	NA	0	NA
4A	NPA	Plant	0	0	UNKN	UNKN	1	1	3.33%	1	100.00%
4B	NPA	Cast & Cover	0	0	UNKN	UNKN	0	0	0.00%	0	NA
4C	NPA	Cast	0	0	UNKN	UNKN	0	0	0.00%	0	NA
5A	NPA	Cast & Cover	0	0	UNKN	UNKN	4	4	13.33%	4	100.00%
5B	NPA	Cast	0	0	UNKN	UNKN	0	0	0.00%	0	NA
5C	NPA	Plant	0	0	UNKN	UNKN	2	2	6.67%	1	50.00%
6A	NPA	Cast	0	0	UNKN	UNKN	0	0	0.00%	0	NA
6B	NPA	Plant	0	0	UNKN	UNKN	1	1	3.33%	1	100.00%
6C	NPA	Cast & Cover	0	0	UNKN	UNKN	1	1	3.33%	0	NA
7A	SPA	Cast & Cover	0	0	0	0	0	0	0.00%	0	NA
7B	SPA	Cast	0	0	0	0	0	0	0.00%	0	NA
7C	SPA	Plant	0	0	0	0	0	0	0.00%	0	NA
8A	SPA	Plant	0	0	1	1	1	1	3.33%	1	100.00%
8B	SPA	Cast & Cover	0	0	0	0	0	0	0.00%	0	NA
8C	SPA	Cast	0	0	6	6	2	6	20.00%	3	50.00%
9A	SPA	Cast	0	0	2	1	0	2	6.67%	2	100.00%
9B	SPA	Plant	0	0	2	3	2	3	10.00%	2	66.67%
9C	SPA	Cast & Cover	0	0	0	0	0	0	0.00%	0	NA

Table SG3: Germination Summary 2

NPA

Treatment	Total Number of SA Located	Number of SA that developed true-leaves, and therefore may have produced seeds
Control	0	0
Cast	0	0
Cast & Cover	5	4
Plant	4	3

SPA

Treatment	Total Number of SA Located	Number of SA that developed true-leaves, and therefore may have produced seeds
Control	0	0
Cast	8	5
Cast & Cover	0	0
Plant	4	3

NPA & SPA

Treatment	Total Number of SA Located	Number of SA that developed true-leaves, and therefore may have produced seeds	Success Rate (# plants that developed true-leaves/# seeds planted)
Control	0	0	NA
Cast	8	5	2.78%
Cast & Cover	5	4	2.22%
Plant	8	6	3.33%

Table SG4: Plot Land-Cover Summary

Plot	Treatment	Spring: Plot Establishment			Fall: Final Plot Check			Change in Land-Cover (sq.m)	Change in Land-Cover (%)
		Date	Land-Cover (sq.m)	Land-Cover (%)	Date	Land-Cover (sq.m)	Land-Cover (%)		
1A	Control	4/18/2019	0.00	0.00%	10/2/2019	0.10	2.62%	0.10	2.62%
1B	Control	4/18/2019	0.86	21.49%	10/2/2019	2.62	65.54%	1.76	44.05%
1C	Control	4/18/2019	0.88	22.02%	10/30/2019	0.73	18.26%	-0.15	-3.76%
2A	Control	4/18/2019	0.00	0.00%	10/2/2019	0.00	0.00%	0.00	0.00%
2B	Control	4/18/2019	1.19	29.70%	10/2/2019	2.78	69.47%	1.59	39.77%
2C	Control	4/18/2019	0.08	1.89%	10/30/2019	0.97	24.21%	0.89	22.32%
3A	Control	4/18/2019	0.00	0.06%	10/30/2019	0.44	10.99%	0.44	10.93%
3B	Control	4/18/2019	0.07	1.79%	10/30/2019	0.15	3.77%	0.08	1.98%
3C	Control	4/18/2019	0.00	0.00%	10/30/2019	0.00	0.00%	0.00	0.00%
4A	Plant	3/28/2019	0.00	0.00%	10/30/2019	0.00	0.00%	0.00	0.00%
4B	Cast & Cover	3/28/2019	0.66	16.50%	10/30/2019	0.36	8.89%	-0.30	-7.61%
4C	Cast	3/28/2019	0.58	14.50%	10/30/2019	0.79	19.83%	0.21	5.33%
5A	Cast & Cover	3/28/2019	0.00	0.00%	10/2/2019	0.62	15.54%	0.62	15.54%
5B	Cast	3/28/2019	0.04	1.09%	8/14/2019	0.34	8.55%	0.30	7.46%
5C	Plant	3/28/2019	0.03	0.65%	10/30/2019	0.83	20.77%	0.80	20.12%
6A	Cast	3/28/2019	0.00	0.00%	10/30/2019	0.16	4.06%	0.16	4.06%
6B	Plant	3/28/2019	0.19	4.63%	10/30/2019	0.41	10.30%	0.22	5.67%
6C	Cast & Cover	3/28/2019	0.17	4.23%	10/2/2019	1.03	25.84%	0.86	21.61%
7A	Cast & Cover	3/28/2019	0.29	7.30%	10/30/2019	0.21	5.31%	-0.08	-1.99%
7B	Cast	3/28/2019	0.06	1.42%	10/30/2019	0.18	4.39%	0.12	2.97%
7C	Plant	3/28/2019	0.00	0.00%	10/30/2019	0.00	0.00%	0.00	0.00%
8A	Plant	3/28/2019	0.23	5.79%	10/30/2019	0.47	11.64%	0.24	5.85%
8B	Cast & Cover	3/28/2019	0.02	0.60%	10/30/2019	0.37	9.29%	0.35	8.69%
8C	Cast	3/28/2019	0.11	2.80%	10/30/2019	0.21	5.14%	0.10	2.34%
9A	Cast	3/28/2019	0.23	5.83%	10/30/2019	0.42	10.55%	0.19	4.72%
9B	Plant	3/28/2019	0.18	4.45%	10/30/2019	0.34	8.60%	0.16	4.15%
9C	Cast & Cover	3/28/2019	0.47	11.86%	10/30/2019	1.17	29.33%	0.70	17.47%





	Plot Establishment		Final Plot Check		Overall	
	Land-Cover (sq.m)	Land-Cover (%)	Land-Cover (sq.m)	Land-Cover (%)	Change in Land-Cover (sq.m)	Change in Land-Cover (%)
Average: Control Plot	0.34	8.55%	86.56%	0.22	0.52	13.10%
Average: Cast Plot	0.17	4.27%	35.00%	0.09	0.18	4.48%
Average: Cast & Cover Plot	0.27	6.75%	62.67%	0.16	0.36	8.95%
Average: Plant Plot	0.10	2.59%	34.17%	0.09	0.24	5.97%
Overall Average	0.23	5.87%	58.15%	0.15	0.35	8.68%

Plot Figures

Figure SG1
Seabeach Amaranth Experimental
Plot Locations
NPA & SPA
Sea Girt NGTC
2019







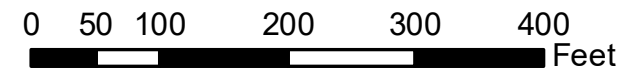
Legend

-  NPA_2019
-  SPA
-  VegThin_Actual_022819
-  Installation_Area

Amaranth Plots 2019

Plot Treatment Method

-  Cast
-  Cast and Cover
-  Control
-  Plant



1 inch = 150 feet



Notes:



Scale:	1 inch = 150 feet
File:	Figure SG1
Date:	11/20/2019
Created By:	John Hallagan



**Figure SG2
Seabeach Amaranth Locations
NPA
Sea Girt NGTC
2019**



Legend

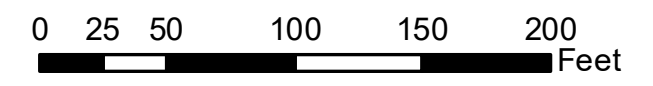
- Experimental SA Plants
- Naturally Occurring SA Plants

- NPA_2019
- VegThin_Actual_022819
- Installation_Area

Amaranth Plots 2019

Plot Treatment Method

- Cast
- Cast and Cover
- Control
- Plant



1 inch = 75 feet



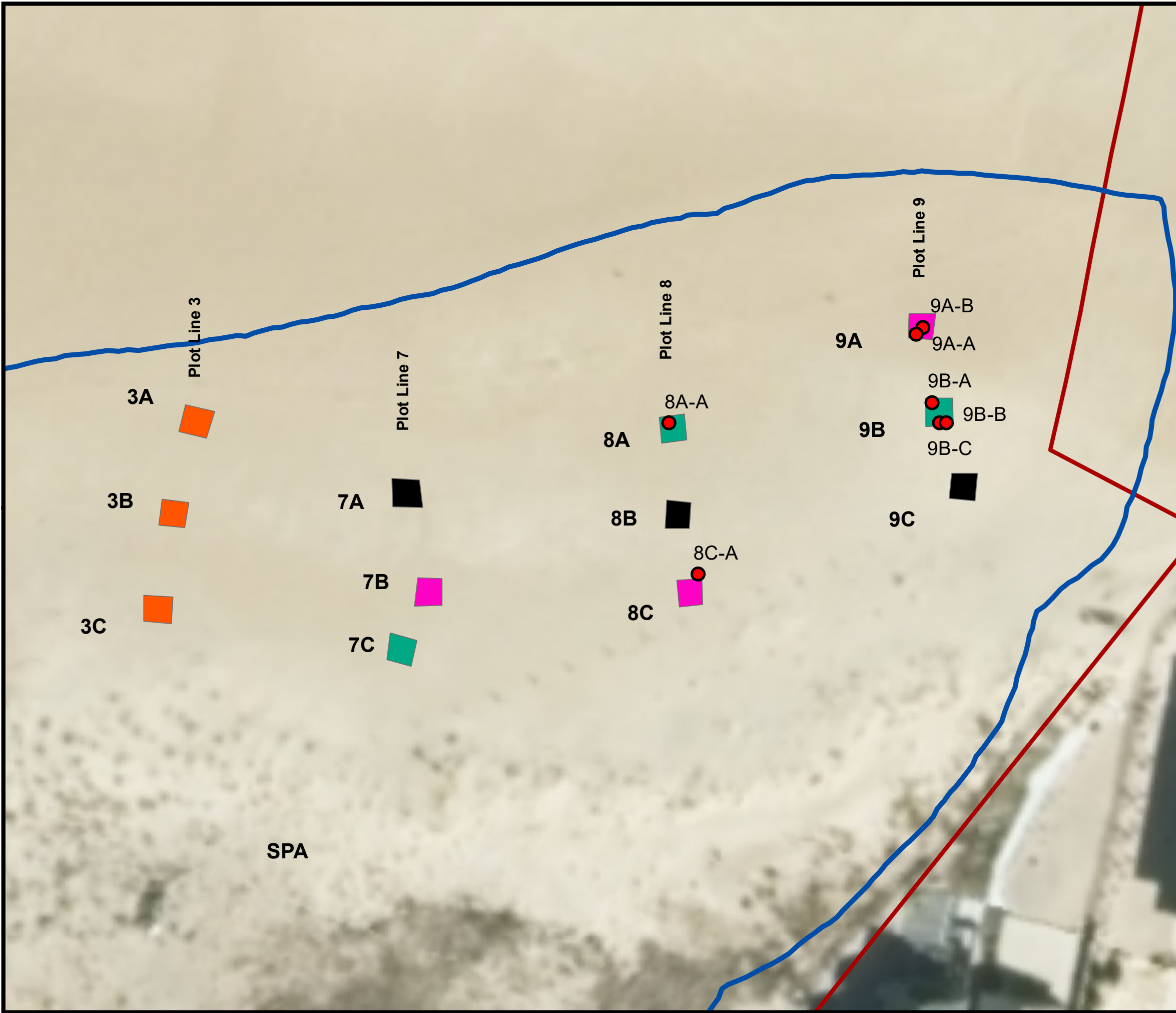
Notes:





Scale: 1 inch = 75 feet
File: Figure SG2
Date: 11/20/2019
Created By: John Hallagan



Figure SG3
Seabeach Amaranth Locations
SPA
Sea Girt NGTC
2019



Legend

-  Naturally Occurring SA Plants
-  Experimental SA Plants

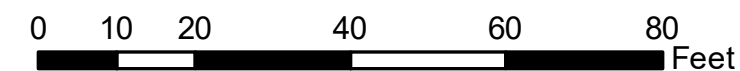
 SPA

 Installation_Area

Amaranth plots 2019

Plot Treatment Method

-  Cast
-  Cast and Cover
-  Control
-  Plant



1 inch = 25 feet



Notes:



Scale: 1 inch = 25 feet

File:
Figure SG3

Date: 11/20/2019

Created By: John Hallagan



Appendix A

Seed Sowing Data

Datasheet A: Seabeach Amaranth Experimental Plot - Sowing

Site: Sea Girt

Surveyors Present: John Hallagan, William McBride, Sarah Helble, Wendy Walsh (USFWS), Greg Fischer, Steven Hoffman, Justin Milillo, Lori Gorczynski

Weather Conditions: Sunny, light northerly breeze, no precip

Date	Time (24 hr clock)	Plot Line	Plot #	Protection Area	Planting Method	# of Seeds Sown	Sand Sample ID	Photo Taken? (Y/N)	Plot Vegetation Notes	Other Notes
3/28/2019	8:52	9	9A	SPA	CAST	30	9A-3-28-2019	Y	5 dune grass plants	
3/28/2019	9:02	9	9B	SPA	PLANT	30	9B-3-28-2019	Y	5 dune grass plants	Medium sand, subrounded
3/28/2019	9:08	9	9C	SPA	CAST & COVER	30	9C-3-28-2019	Y	7 dune grass plants	
3/28/2019	9:13	8	8A	SPA	PLANT	30	8A-3-28-2019	Y	6 dune grass plants	
3/28/2019	9:17	8	8B	SPA	CAST & COVER	30	8B-3-28-2019	Y	4 dune grass plants	
3/28/2019	9:21	8	8C	SPA	CAST	30	8C-3-28-2019	Y	5 dune grass plants	Plot on slight incline - seeds only cast on Eastern/downhill half of plot
3/28/2019	9:25	7	7A	SPA	CAST & COVER	30	7A-3-28-2019	Y	1 dune grass plant	
3/28/2019	9:28	7	7B	SPA	CAST	30	7B-3-28-2019	Y	2 dune grass plants	Plot relocated approx 1m SW of originally assigned location
3/28/2019	9:36	7	7C	SPA	PLANT	30	7C-3-28-2019	Y	0 dune grass plants - bare	
3/28/2019	9:42	6	6A	NPA	CAST	30	6A-3-28-2019	Y	0 dune grass plants - bare	
3/28/2019	9:45	6	6B	NPA	PLANT	30	6B-3-28-2019	Y	1 dune grass plant	Sand color: 10YR 6/3 & 2.5Y 6/3
3/28/2019	9:52	6	6C	NPA	CAST & COVER	30	6C-3-28-2019	Y	1 dune grass plant	
3/28/2019	9:57	5	5A	NPA	CAST & COVER	30	5A-3-28-2019	Y	0 dune grass plants - bare	
3/28/2019	10:00	5	5B	NPA	CAST	30	5B-3-28-2019	Y	2 dune grass plants	
3/28/2019	10:03	5	5C	NPA	PLANT	30	5C-3-28-2019	Y	0 dune grass plants - bare	
3/28/2019	10:10	4	4A	NPA	PLANT	30	4A-3-28-2019	Y	0 dune grass plants - bare	
3/28/2019	10:14	4	4B	NPA	CAST & COVER	30	4B-3-28-2019	Y	3-4 dune grass plants	
3/28/2019	10:20	4	4C	NPA	CAST	30	4C-3-28-2019	Y	4 dune grass plants	
4/17/2019	9:25	3	3A	SPA	Control	0	3A-4-17-2019	Y	3 dune grass plants	
4/17/2019	9:35	3	3B	SPA	Control	0	3B-4-17-2019	Y	4 dune grass plants	
4/17/2019	9:48	3	3C	SPA	Control	0	3C-4-17-2019	Y	0 dune grass plants- bare	
4/17/2019	10:30	2	2A	NPA	Control	0	2A-4-17-2019	Y	0 dune grass plants- bare	
4/17/2019	10:35	2	2B	NPA	Control	0	2B-4-17-2019	Y	13 dune grass plants	
4/17/2019	10:40	2	2C	NPA	Control	0	2C-4-17-2019	Y	2 dune grass plants	
4/17/2019	10:14	1	1A	NPA	Control	0	1A-4-17-2019	Y	0 dune grass plants- bare	
4/17/2019	10:20	1	1B	NPA	Control	0	1B-4-17-2019	Y	17 dune grass plants	
4/17/2019	10:25	1	1C	NPA	Control	0	1C-4-17-2019	Y	11 dune grass plants	

Appendix B

Plot Monitoring Data

Datasheet B: Seabeach Amaranth Experimental Plot - Bi-Weekly Monitoring

Site: Sea Girt

Surveyors Present: John Hallagan, Nicholas Gamarro, Steven Hoffman

Weather Conditions: Mostly cloudy, slight sea breeze, 50's

Date	Time	Plot #	# of Amaranth Plants Observed	Plot Intact?	Sand Sample Collected?	Photo Taken? (Y/N)	# Beach Grass Plants Present	Notes (disturbances to plot, sand sedge presence, etc)
4/17/2019	10:40	4A	0	Y	Y	N	0	
4/17/2019	10:43	4B	0	Y	Y	N	13	
4/17/2019	10:47	4C	0	Y	Y	N	6	
4/17/2019	10:29	5A	0	Y	Y	N	1	2 flags replaced
4/17/2019	10:33	5B	0	Y	Y	N	4	
4/17/2019	10:36	5C	0	Y	Y	N	5	
4/17/2019	10:16	6A	0	Y	Y	N	0	2 flags replaced
4/17/2019	10:21	6B	0	Y	Y	N	4	
4/17/2019	10:24	6C	0	Y	Y	N	2	
4/17/2019	9:18	7A	0	Y	Y	N	1	1 flag replaced
4/17/2019	9:19	7B	0	Y	Y	N	1	
4/17/2019	9:23	7C	0	Y	Y	N	0	1 flag replaced
4/17/2019	9:29	8A	0	Y	Y	N	6	
4/17/2019	9:33	8B	0	Y	Y	N	2	1 flag replaced, picture of plant taken
4/17/2019	9:42	8C	0	Y	Y	N	0	
4/17/2019	9:46	9A	0	Y	Y	N	7	
4/17/2019	9:50	9B	0	Y	Y	Y	5	picture of unidentified plant taken
4/17/2019	9:56	9C	0	Y	Y	N	12	
4/17/2019	10:01	3A	0	Y	Y	Y	4	
4/17/2019	10:05	3B	0	Y	Y	Y	5	
4/17/2019	10:08	3C	0	Y	Y	Y	0	
4/17/2019	10:54	2A	0	Y	Y	Y	0	
4/17/2019	10:58	2B	0	Y	Y	Y	18	
4/17/2019	11:01	2C	0	Y	Y	Y	1	
4/17/2019	11:05	1A	0	Y	Y	Y	0	
4/17/2019	11:07	1B	0	Y	Y	Y	9	
4/17/2019	11:11	1C	0	Y	Y	Y	5	

Datasheet B: Seabeach Amaranth Experimental Plot - Bi-Weekly Monitoring

Site: Sea Girt

Surveyors Present: John Hallagan, Greg Fischer, Bill McBride, Meaghan Lyons

Weather Conditions: Sunny, Hot

Date	Time	Plot #	# of Amaranth Plants Observed	Plot Intact?	Sand Sample Collected?	Photo Taken? (Y/N)	# Beach Grass Plants Present	Notes (disturbances to plot, sand sedge presence, etc)
6/24/2019	10:00	3A	0	Y	Y	Y	5	
6/24/2019	9:57	3B	0	Y	Y	Y	6	
6/24/2019	9:55	3C	0	Y	Y	Y	0	
6/24/2019	9:32	7A	0	Y	Y	Y	3	
6/24/2019	9:40	7B	0	Y	Y	Y	3	
6/24/2019	9:50	7C	0	Y	Y	Y	0	
6/24/2019	9:24	8A	1	Y	Y	Y	8	
6/24/2019	9:16	8B	0	Y	Y	Y	7	
6/24/2019	9:10	8C	6	Y	Y	Y	7	ALL 6 PLANTS ~4" OUTSIDE PLOT
6/24/2019	8:34	9A	2	Y	Y	Y	7	PLANT 9A-1 ~3" OUTSIDE PLOT
6/24/2019	8:40	9B	2	Y	Y	Y	8	
6/24/2019	8:50	9C	0	Y	Y	Y	12	

Datasheet B: Seabeach Amaranth Experimental Plot - Bi-Weekly Monitoring

Site: Sea Girt

Surveyors Present: John Hallagan, Ethan Freeman, Nick Cordivari

Weather Conditions: Sunny, Breezy

Date	Time	Plot #	# of Amaranth Plants Observed	Plot Intact?	Sand Sample Collected?	Photo Taken? (Y/N)	# Beach Grass Plants Present	Notes (disturbances to plot, sand sedge presence, etc)
7/15/2019	10:12	3A	0	Y	Y	Y	3	
7/15/2019	10:10	3B	0	Y	Y	Y	4	
7/15/2019	10:06	3C	0	Y	Y	Y	0	
7/15/2019	9:52	7A	0	Y	Y	Y	3	
7/15/2019	9:58	7B	0	Y	Y	Y	2	
7/15/2019	10:02	7C	0	Y	Y	Y	1	
7/15/2019	9:47	8A	1	Y	Y	Y	11	Plant from 6/24/2019 dead
7/15/2019	9:30	8B	0	Y	Y	Y	6	
7/15/2019	9:23	8C	6	Y	Y	Y	8	
7/15/2019	9:10	9A	1	Y	Y	Y	8	
7/15/2019	9:13	9B	3	Y	Y	Y	9	
7/15/2019	9:20	9C	0	Y	Y	Y	14	

Datasheet B: Seabeach Amaranth Experimental Plot - Bi-Weekly Monitoring

Site: Sea Girt

Surveyors Present: John Hallagan, Nicholas Gamarro, Alexandria Petrosch, Meaghan Lyons

Weather Conditions: Cloudy, slight drizzle

Date	Time	Plot #	# of Amaranth Plants Observed	Plot Intact?	Sand Sample Collected?	Photo Taken? (Y/N)	# Beach Grass Plants Present	Notes (disturbances to plot, sand sedge presence, etc)
8/14/2019	11:23	1A	0	Y	N	Y	0	
8/14/2019	11:19	1B	0	Y	N	Y	22	
8/14/2019	11:16	1C	0	Y	N	Y	13	
8/14/2019	11:07	2A	0	Y	N	Y	0	
8/14/2019	11:10	2B	0	Y	N	Y	29	
8/14/2019	11:13	2C	0	Y	N	Y	7	
8/14/2019	9:59	3A	0	Y	N	Y	5	
8/14/2019	9:57	3B	0	Y	N	Y	5	
8/14/2019	9:55	3C	0	Y	N	Y	0	
8/14/2019	10:46	4A	0+1* (SEE NOTES)	Y	N	Y	0	PLANT 4A-A ~ 3FT EAST OF PLOT BOUNDARY
8/14/2019	10:55	4B	0	N	N	Y	20	2 FLAGS MISSING - REPLACED IN APPROX LOCATION
8/14/2019	11:00	4C	0	Y	N	Y	12	
8/14/2019	10:20	5A	1+3* (SEE NOTES)	Y	N	Y	3	3 PLANTS (5AB-A,B,C) BETWEEN PLOTS 5A AND 5B - CLOSER TO 5A
8/14/2019	10:34	5B	0+3* (SEE NOTES)	Y	N	Y	10	3 PLANTS (5AB-A,B,C) BETWEEN PLOTS 5A AND 5B - CLOSER TO 5A
8/14/2019	10:40	5C	2	Y	N	Y	20	
8/14/2019	10:17	6A	0	Y	N	Y	8	
8/14/2019	10:14	6B	1	Y	N	Y	8	SMALL NIBBLE MARKS ON 6B-A LEAVES - RABBIT?
8/14/2019	10:06	6C	1	Y	N	Y	7	SMALL NIBBLE MARKS ON 6C-A LEAVES - RABBIT?
8/14/2019	9:47	7A	0	Y	N	Y	3	
8/14/2019	9:50	7B	0	Y	N	Y	2	
8/14/2019	9:54	7C	0	Y	N	Y	0	
8/14/2019	9:40	8A	1	Y	N	Y	10	
8/14/2019	9:35	8B	0	Y	N	Y	8	
8/14/2019	9:32	8C	2	Y	N	Y	8	ONE PLANT IN CLUSTER LOOKS DEAD/DYING
8/14/2019	9:16	9A	0	Y	N	Y	9	PLANT 9A-A GONE
8/14/2019	9:20	9B	2	Y	N	Y	9	PLANTS 9B-B,C ALIVE. PLANT 9B-B GONE
8/14/2019	9:25	9C	0	Y	N	Y	14	

Datasheet B: Seabeach Amaranth Experimental Plot - Bi-Weekly Monitoring

Site: Sea Girt

Surveyors Present: John Hallagan

Weather Conditions: Windy, Sunny

Date	Time	Plot #	# of Amaranth Plants Observed	Plot Intact?	Sand Sample Collected?	Photo Taken? (Y/N)	# Beach Grass Plants Present	Notes (disturbances to plot, sand sedge presence, etc)
10/2/2019	9:59	1A	0	Y	N	Y	0	
10/2/2019	9:56	1B	0	Y	N	Y	28	
10/2/2019	9:53	1C	0	Y	N	Y	15	
10/2/2019	9:45	2A	0	Y	N	Y	0	
10/2/2019	9:48	2B	0	Y	N	Y	25	
10/2/2019	9:50	2C	0	Y	N	Y	10	
10/2/2019	8:52	3A	0	Y	N	Y	5	
10/2/2019	8:50	3B	0	Y	N	Y	5	
10/2/2019	8:48	3C	0	Y	N	Y	0	
10/2/2019	9:34	4A	0	Y	N	Y	0	
10/2/2019	9:39	4B	0	Y	N	Y	22	
10/2/2019	9:42	4C	0	Y	N	Y	16	
10/2/2019	9:30	5A	0	Y	N	Y	2	
10/2/2019	9:26	5B	0	Y	N	Y	12	
10/2/2019	9:20	5C	0	Y	N	Y	25	
10/2/2019	9:07	6A	0	Y	N	Y	9	
10/2/2019	9:10	6B	1	Y	N	Y	12	
10/2/2019	9:15	6C	1	Y	N	Y	8	
10/2/2019	8:40	7A	0	Y	N	Y	4	
10/2/2019	8:43	7B	0	Y	N	Y	2	
10/2/2019	8:45	7C	0	Y	N	Y	0	
10/2/2019	8:34	8A	1	Y	N	Y	13	
10/2/2019	8:32	8B	0	Y	N	Y	12	
10/2/2019	8:24	8C	1*	Y	N	Y	9	8C-A DEAD
10/2/2019	8:06	9A	0	Y	N	Y	12	
10/2/2019	8:09	9B	2*	Y	N	Y	13	9B-B DEAD OR WILTED, 9B-C DEAD/WILTED, 9B-A MISSING/GONE
10/2/2019	8:22	9C	0	Y	N	Y	23	

Appendix C

Moisture Content Analysis Data

Appendix D

Plant Measurement Data

Datasheet D: Seabeach Amaranth Experimental Plot - Plant Measurements

Site: Sea Girt

Date	Plot #	Plant or Plant Cluster ID#	Number of Plants in Cluster	Diameter (cm) of Largest Plant In Cluster (if more than 1)	Diameter (cm) of Smallest Plant in Cluster (if more than 1)	Photo Taken? (Y/N)	Other Notes
6/24/2019	9A	9A-1	1	0.8	N/A	N	Plant 9A-1 approx 3" outside plot boundary
6/24/2019	9A	9A-2	1	0.5	N/A	N	
6/24/2019	9B	9B-1	1	0.5	N/A	N	
6/24/2019	9B	9B-2	1	0.4	N/A	N	
6/24/2019	8C	8C-A	6	0.5	0.3	N	All 6 plants approx 4" outside plot boundary
6/24/2019	8A	8A-A	1	0.3	N/A	N	
7/15/2019	9A	9A-A	1	0.4	N/A	Y	
7/15/2019	9B	9B-A	1	0.8	N/A	Y	
7/15/2019	9B	9B-B	1	0.5	N/A	Y	
7/15/2019	9B	9B-C	1	0.4	N/A	Y	
7/15/2019	8A	8A-A	1	0.3	N/A	Y	
7/15/2019	8C	8C-A	6	0.5	0.2	Y	All 6 plants approx 4" outside plot boundary
7/15/2019	N/A	NP-A	1	1.3	N/A	Y	In NPA, not in a plot
7/15/2019	N/A	NP-B	1	0.9	N/A	Y	In NPA, not in a plot
7/15/2019	N/A	NP-C	1	0.6	N/A	Y	In NPA, not in a plot
8/14/2019	9A	9A-A	0	N/A	N/A	Y	PLANT GONE
8/14/2019	9B	9B-A	0	N/A	N/A	Y	PLANT GONE
8/14/2019	9B	9B-B	1	1	N/A	Y	
8/14/2019	9B	9B-C	1	1	N/A	Y	
8/14/2019	8C	8C-A	2	0.6	0.5	Y	ONLY 2/6 PLANTS REMAIN IN THIS CLUSTER
8/14/2019	8A	8A-A	1	1.6	N/A	Y	
8/14/2019	6C	6C-A	1	1.5	N/A	Y	
8/14/2019	6B	6B-A	1	1.7	N/A	Y	
8/14/2019	5A	5A-A	1	2.2	N/A	Y	
8/14/2019	5AB	5AB-A	1	1.5	N/A	Y	LOCATED BETWEEN PLOTS 5A AND 5B - CLOSER TO 5A
8/14/2019	5AB	5AB-B	1	2.9	N/A	Y	LOCATED BETWEEN PLOTS 5A AND 5B - CLOSER TO 5A
8/14/2019	5AB	5AB-C	1	1.9	N/A	Y	LOCATED BETWEEN PLOTS 5A AND 5B - CLOSER TO 5A
8/14/2019	5C	5C-A	1	1.2	N/A	Y	
8/14/2019	5C	5C-B	1	0.8	N/A	Y	

8/14/2019	4A	4A-A	1	3.2	N/A	Y	
10/2/2019	9B	9B-A	0	N/A	N/A	Y	MISSING/GONE
10/2/2019	9B	9B-B	1	0.7	0.7	Y	DYING/WILTED
10/2/2019	9B	9B-C	1	0.7	0.7	Y	DYING/WILTED
10/2/2019	8C	8C-A	1	N/A	N/A	Y	DEAD
10/2/2019	8A	8A-A	1	1.1	1.1	Y	ALIVE
10/2/2019	6B	6B-A	1	0.7	0.7	Y	DEAD
10/2/2019	6C	6C-A	1	1	1	Y	ALIVE
10/2/2019	5C	5C-A	0	N/A	N/A	Y	MISSING/GONE
10/2/2019	5C	5C-B	0	N/A	N/A	Y	MISSING/GONE
10/2/2019	5AB	5A-A	0	N/A	N/A	Y	MISSING/GONE
10/2/2019	5AB	5AB-A	0	N/A	N/A	Y	MISSING/GONE
10/2/2019	5AB	5AB-B	0	N/A	N/A	Y	MISSING/GONE
10/2/2019	5AB	5AB-C	0	N/A	N/A	Y	MISSING/GONE
10/2/2019	4A	4A-A	0	N/A	N/A	Y	MISSING/GONE

Appendix E

Grain Size Analysis Data

Datasheet E: Seabeach Amaranth Experimental Plot - Grain Size Analysis

Site: Sea Girt

Plot	Sample ID	Collection Date	Grain Size Analysis Date	Initial Sample Mass (g) (Pre-Sieve)	Sample Mass Retained In Sieve							% Grain Size of Total Sample							Residual Silts & Clays >Pan	Pebbles	Sand	Residual Silts & Clay	
					10 (2mm)	18 (1mm)	35 (500 µm)	60 (250 µm)	120 (125 µm)	270 (53 µm)	Pan	Final Sample Mass (g) (Post-Sieve)	Sample Lost (g) (Initial - Final)	Very Fine Pebbles >10	Very Coarse Sand 10-18	Coarse Sand 18-35	Medium Sand 35-60	Fine Sand 60-120					Very Fine Sand 120-270
1A	1A-4-17-2019	4/17/2019	12/2/2019	300	0.135	3.623	144.969	149.876	2.418	0.021	0.001	301.043	-1.043	0.04%	1.20%	48.16%	49.79%	0.80%	0.01%	0.00%	0.04%	99.95%	0.01%
1B	1B-4-17-2019	4/17/2019	12/2/2019	300.1	0.017	6.230	144.642	141.365	5.010	0.060	0.006	297.330	2.770	0.01%	2.10%	48.65%	47.54%	1.68%	0.02%	0.00%	0.01%	99.97%	0.02%
1C	1C-4-17-2019	4/17/2019	12/2/2019	300.2	0.133	5.187	176.516	114.821	2.418	0.013	0.007	299.095	1.105	0.04%	1.73%	59.02%	38.39%	0.81%	0.00%	0.00%	0.04%	99.95%	0.00%
2A	2A-4-17-2019	4/17/2019	12/2/2019	301.9	0.400	3.612	129.691	159.600	7.247	0.117	0.012	300.679	1.221	0.13%	1.20%	43.13%	53.08%	2.41%	0.04%	0.00%	0.13%	99.82%	0.04%
2B	2B-4-17-2019	4/17/2019	12/2/2019	300.6	0.105	3.103	134.520	156.340	5.744	0.049	0.005	299.866	0.734	0.04%	1.03%	44.86%	52.14%	1.92%	0.02%	0.00%	0.04%	99.95%	0.02%
2C	2C-4-17-2019	4/17/2019	12/2/2019	300.1	0.016	5.401	153.509	137.805	3.966	0.035	0.016	300.748	-0.648	0.01%	1.80%	51.04%	45.82%	1.32%	0.01%	0.01%	0.01%	99.98%	0.01%
3A	3A-4-17-2019	4/17/2019	12/2/2019	302.7	0.071	12.639	171.646	115.609	2.238	0.037	0.034	302.274	0.426	0.02%	4.18%	56.78%	38.25%	0.74%	0.01%	0.01%	0.02%	99.95%	0.01%
3B	3B-4-17-2019	4/17/2019	12/2/2019	302.5	0.055	17.424	197.053	85.295	1.100	0.013	0.004	300.944	1.556	0.02%	5.79%	65.48%	28.34%	0.37%	0.00%	0.00%	0.02%	99.98%	0.00%
3C	3C-4-17-2019	4/17/2019	12/2/2019	300.6	0.015	6.461	190.888	99.507	2.128	0.039	0.017	299.055	1.545	0.01%	2.16%	63.83%	33.27%	0.71%	0.01%	0.01%	0.01%	99.98%	0.01%
4A	4A-4-17-2019	4/17/2019	12/2/2019	299.7	0.080	3.877	163.681	129.088	2.213	0.004	0.007	298.950	0.750	0.03%	1.30%	54.75%	43.18%	0.74%	0.00%	0.00%	0.03%	99.97%	0.00%
4B	4B-4-17-2019	4/17/2019	12/2/2019	306.4	0.034	2.293	146.588	151.390	3.707	0.039	0.080	304.131	2.269	0.01%	0.75%	48.20%	49.78%	1.22%	0.01%	0.03%	0.01%	99.95%	0.01%
4C	4C-4-17-2019	4/17/2019	12/2/2019	307.1	0.000	2.397	164.483	138.006	2.195	0.015	0.002	307.098	0.002	0.00%	0.78%	53.56%	44.94%	0.71%	0.00%	0.00%	0.00%	99.99%	0.00%
5A	5A-4-17-2019	4/17/2019	11/25/2019	299.6	0.086	2.020	107.558	183.524	6.247	0.084	0.008	299.527	0.073	0.03%	0.67%	35.91%	61.27%	2.09%	0.03%	0.00%	0.03%	99.94%	0.03%
5B	5B-4-17-2019	4/17/2019	11/25/2019	306.1	0.429	15.732	167.471	120.606	1.260	0.007	0.001	305.506	0.594	0.14%	5.15%	54.82%	39.48%	0.41%	0.00%	0.00%	0.14%	99.86%	0.00%
5C	5C-4-17-2019	4/17/2019	11/25/2019	299.4	0.117	2.179	104.670	185.920	6.365	0.133	0.009	299.393	0.007	0.04%	0.73%	34.96%	62.10%	2.13%	0.04%	0.00%	0.04%	99.91%	0.04%
6A	6A-4-17-2019	4/17/2019	11/19/2019	301.1	1.152	12.295	194.092	92.725	1.373	0.009	0.002	301.648	-0.548	0.38%	4.08%	64.34%	30.74%	0.46%	0.00%	0.00%	0.38%	99.61%	0.00%
6B	6B-4-17-2019	4/17/2019	11/19/2019	303.5	0.018	3.393	183.888	114.802	1.582	0.009	0.004	303.696	-0.196	0.01%	1.12%	60.55%	37.80%	0.52%	0.00%	0.00%	0.01%	99.99%	0.00%
6C	6C-4-17-2019	4/17/2019	11/19/2019	299.2	0.033	5.982	178.973	110.714	3.140	0.076	0.016	298.934	0.266	0.01%	2.00%	59.87%	37.04%	1.05%	0.03%	0.01%	0.01%	99.96%	0.03%
7A	7A-4-17-2019	4/17/2019	11/18/2019	307.5	0.146	23.499	207.006	76.304	0.550	0.018	0.010	307.533	-0.033	0.05%	7.64%	67.31%	24.81%	0.18%	0.01%	0.00%	0.05%	99.94%	0.01%
7B	7B-4-17-2019	4/17/2019	11/18/2019	298.5	0.036	7.756	170.559	117.508	1.323	0.009	0.007	297.198	1.302	0.01%	2.61%	57.39%	39.54%	0.45%	0.00%	0.00%	0.01%	99.98%	0.00%
7C	7C-4-17-2019	4/17/2019	11/18/2019	299.8	0.000	3.302	183.402	110.738	2.371	0.037	0.009	299.859	-0.059	0.00%	1.10%	61.16%	36.93%	0.79%	0.01%	0.00%	0.00%	99.98%	0.01%
8A	8A-4-17-2019	4/17/2019	11/18/2019	299.3	0.053	7.152	182.820	108.581	1.186	0.025	0.011	299.828	-0.528	0.02%	2.39%	60.97%	36.21%	0.40%	0.01%	0.00%	0.02%	99.97%	0.01%
8B	8B-4-17-2019	4/17/2019	11/18/2019	300.5	0.025	3.275	164.481	130.298	2.067	0.042	0.009	300.197	0.303	0.01%	1.09%	54.79%	43.40%	0.69%	0.01%	0.00%	0.01%	99.97%	0.01%
8C	8C-4-17-2019	4/17/2019	11/18/2019	306.5	0.030	13.540	209.615	79.569	2.083	0.009	0.002	304.848	1.652	0.01%	4.44%	68.76%	26.10%	0.68%	0.00%	0.00%	0.01%	99.99%	0.00%
9A	9A-4-17-2019	4/17/2019	11/15/2019	295.9	0.172	26.925	176.913	90.885	1.226	0.016	0.028	296.165	-0.265	0.06%	9.09%	59.73%	30.69%	0.41%	0.01%	0.01%	0.06%	99.93%	0.01%
9B	9B-4-17-2019	4/17/2019	11/15/2019	308.7	0.014	2.380	179.684	122.928	2.961	0.074	0.020	308.061	0.639	0.00%	0.77%	58.33%	39.90%	0.96%	0.02%	0.01%	0.00%	99.96%	0.02%
9C	9C-4-17-2019	4/17/2019	11/15/2019	311.1	0.000	5.160	170.077	132.694	2.350	0.032	0.005	310.318	0.782	0.00%	1.66%	54.81%	42.76%	0.76%	0.01%	0.00%	0.00%	99.99%	0.01%

Appendix F

Blank Datasheets

Datasheet B: Seabeach Amaranth Experimental Plot - Bi-Weekly Monitoring

Site: Sea Girt

Surveyors Present: John Hallagan, Nicholas Gamarro

Weather Conditions:

Date	Time	Plot #	# of Amaranth Plants Observed	Amaranth Diameter	Plot Intact?	Sand Sample Collected?	Photo Taken? (Y/N)	# Beach Grass Plants Present	Notes (disturbances to plot, sand sedge presence, etc)
		1A							
		1B							
		1C							
		2A							
		2B							
		2C							
		3A							
		3B							
		3C							
		4A							
		4B							
		4C							
		5A							
		5B							
		5C							
		6A							
		6B							
		6C							
		7A							
		7B							
		7C							
		8A							
		8B							
		8C							
		9A							
		9B							
		9C							

Appendix G

Plot Photographs

Plot: 1A

Treatment: Control

Number of SA Plants that Germinated: 0

Number of SA Plants that Developed True-Leaves: 0

Photo Date: 4/18/2019 – Plot Establishment

Land Cover Area: 0 sq.m (0%)



Photo Date: 10/2/2019 – Final Plot Check

Land Cover Area: 0.10 sq.m (2.6%)



Plot: 1B

Treatment: Control

Number of SA Plants that Germinated: 0

Number of SA Plants that Developed True-Leaves: 0

Photo Date: 4/18/2019 – Plot Establishment

Land Cover Area: 0.86 sq.m (21.49%)



Photo Date: 10/2/2019 – Final Plot Check

Land Cover Area: 2.62 sq.m (65.5%)



Plot: 1C

Treatment: Control

Number of SA Plants that Germinated: 0

Number of SA Plants that Developed True-Leaves: 0

Photo Date: 4/18/2019 – Plot Establishment

Land Cover Area: 0.88 sq.m (22.02%)



Photo Date: 10/30/2019 – Final Plot Check

Land Cover Area: 0.73 sq.m (18.3%)



Plot: 2A

Treatment: Control

Number of SA Plants that Germinated: 0

Number of SA Plants that Developed True-Leaves: 0

Photo Date: 4/18/2019 – Plot Establishment

Land Cover Area: 0 sq.m (0%)



Photo Date: 10/2/2019 – Final Plot Check

Land Cover Area: 0.0 sq.m (0.0%)



Plot: 2B

Treatment: Control

Number of SA Plants that Germinated: 0

Number of SA Plants that Developed True-Leaves: 0

Photo Date: 4/18/2019 – Plot Establishment

Land Cover Area: 1.19 sp.m (29.70%)



Photo Date: 10/2/2019 – Final Plot Check

Land Cover Area: 2.78 sq.m (69.5%)



Plot: 2C

Treatment: Control

Number of SA Plants that Germinated: 0

Number of SA Plants that Developed True-Leaves: 0

Photo Date: 4/18/2019 – Plot Establishment

Land Cover Area: 0.08 sq.m (1.19%)

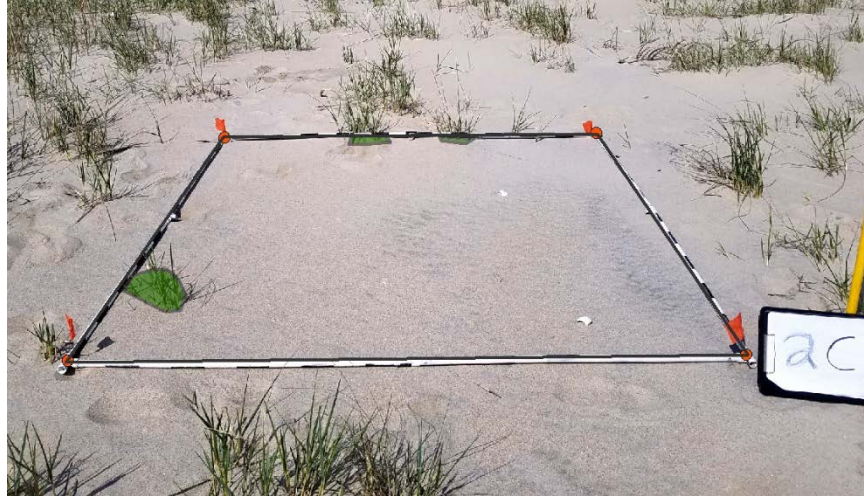


Photo Date: 10/30/2019 – Final Plot

Check Land Cover Area: 0.97 sq.m (24.2%)



Plot: 3A

Treatment: Control

Number of SA Plants that Germinated: 0

Number of SA Plants that Developed True-Leaves: 0

Photo Date: 4/18/2019 – Plot Establishment

Land Cover Area: 0.002 sq.m (0.06%)

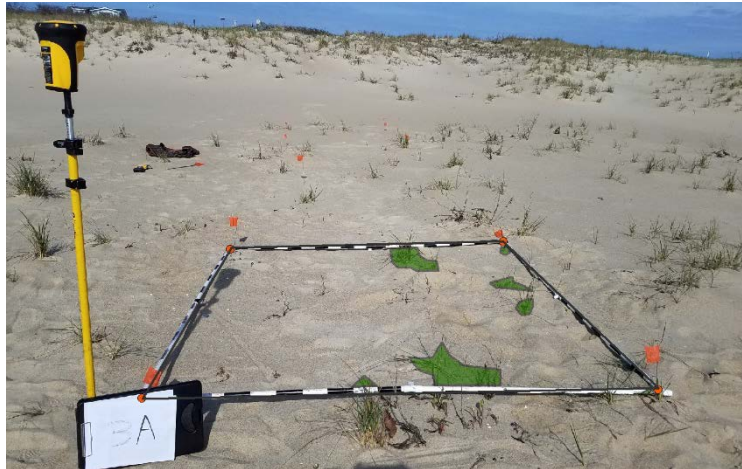


Photo Date: 10/30/2019 – Final Plot

Check Land Cover Area: 0.44 sq.m (11.0%)



Plot: 3B

Treatment: Control

Number of SA Plants that Germinated: 0

Number of SA Plants that Developed True-Leaves: 0

Photo Date: 4/18/2019 – Plot Establishment

Land Cover Area: 0.07 sq.m (1.79%)



Photo Date: 10/30/2019 – Final Plot Check

Land Cover Area: 0.15 sq.m (3.8%)



Plot: 3C

Treatment: Control

Number of SA Plants that Germinated: 0

Number of SA Plants that Developed True-Leaves: 0

Photo Date: 4/18/2019 – Plot Establishment

Land Cover Area: 0 sq.m (0%)



Photo Date: 10/30/2019 – Final Plot Check

Land Cover Area: 0 sq.m (0%)



Plot: 4A

Treatment: Plant Method
Number of SA Plants that Germinated: 1
Number of SA Plants that Developed True-Leaves: 1

Photo Date: 3/28/2019 – Plot Establishment
Land Cover Area: 0 sq.m (0%)



Photo Date: 10/30/2019 – Final Plot Check
Land Cover Area: 0.0 sq.m (0.0%)



Plot: 4B

Treatment: Cast & Cover Method
Number of SA Plants that Germinated: 0

Number of SA Plants that Developed True-Leaves: 0

Photo Date: 3/28/2019 – Plot Establishment
Land Cover Area: 0.66 sq.m (16.5%)

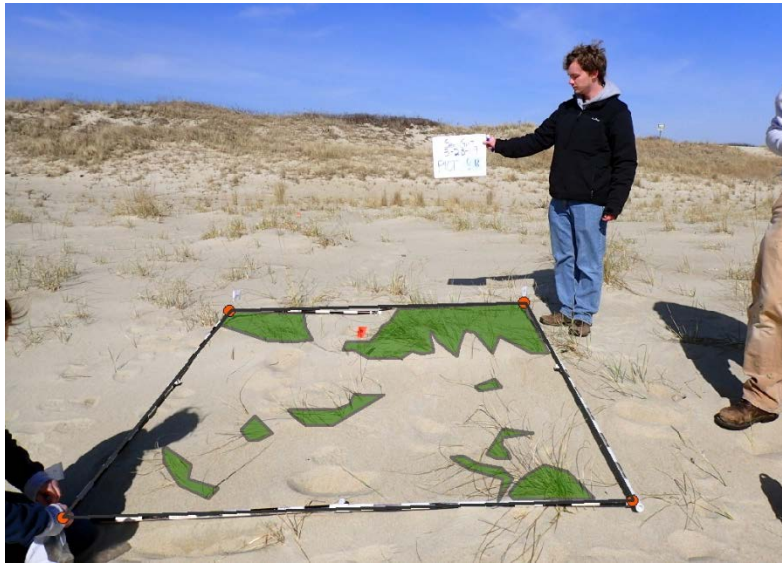


Photo Date: 10/30/2019 – Final Plot Check
Land Cover Area: 0.36 (8.9%)



Plot: 4C

Treatment: Cast Method

Number of SA Plants that Germinated: 0

Number of SA Plants that Developed True-Leaves: 0

Photo Date: 3/28/2019 – Plot Establishment

Land Cover Area: 0.58 sq.m (14.5%)

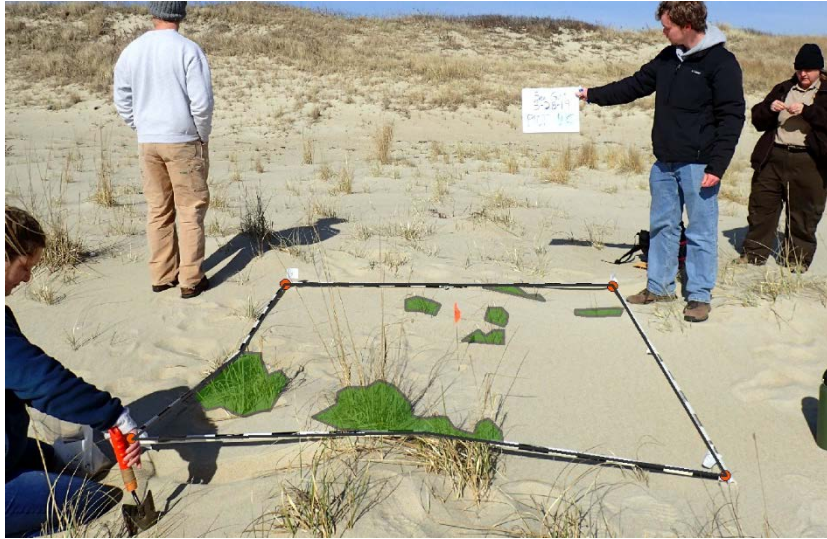


Photo Date: 10/30/2019 – Final Plot Check

Land Cover Area: 0.79 sq.m (19.8%)



Plot: 5A

Treatment: Cast & Cover Method
Number of SA Plants that Germinated: 4
Number of SA Plants that Developed True-Leaves: 4

Photo Date: 3/28/2019 – Plot Establishment
Land Cover Area: 0 sq.m (0%)



Photo Date: 10/2/2019 – Final Plot Check
Land Cover Area: 0.62 sq.m (15.5%)



Plot: 5B

Treatment: Cast Method

Number of SA Plants that Germinated: 0

Number of SA Plants that Developed True-Leaves: 0

Photo Date: 3/28/2019 – Plot Establishment

Land Cover Area: 0.04 sp.m (1.09%)

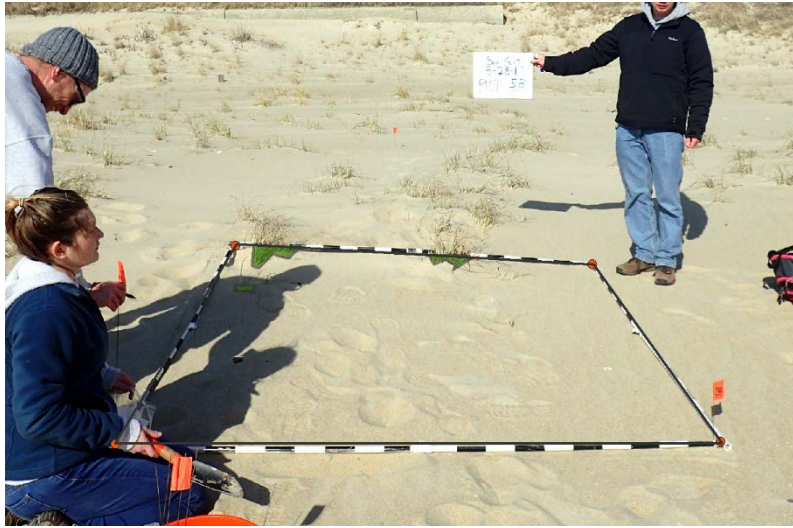
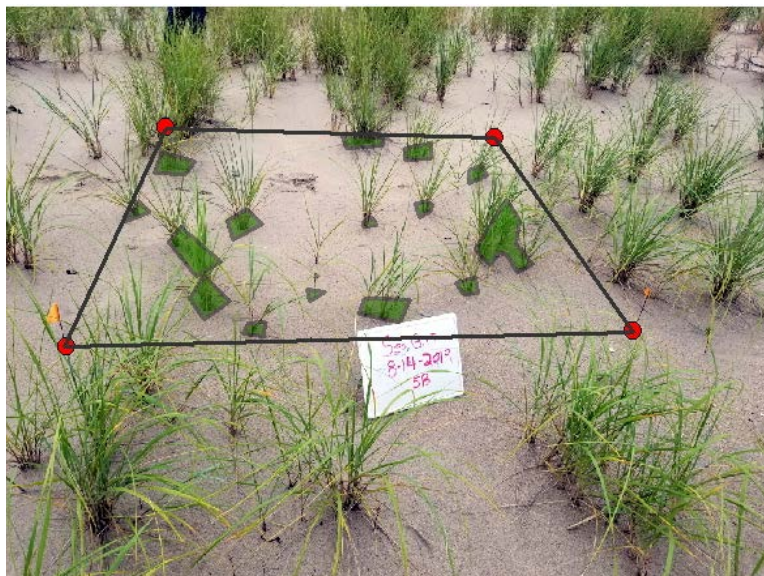


Photo Date: 8/14/2019 – Final Plot Check

Land Cover Area: 0.34 sq.m (8.6%)



Plot: 5C

Treatment: Plant Method
Number of SA Plants that Germinated: 2
Number of SA Plants that Developed True-Leaves: 1

Photo Date: 3/28/2019 – Plot Establishment
Land Cover Area: 0.03 sq.m (0.65%)

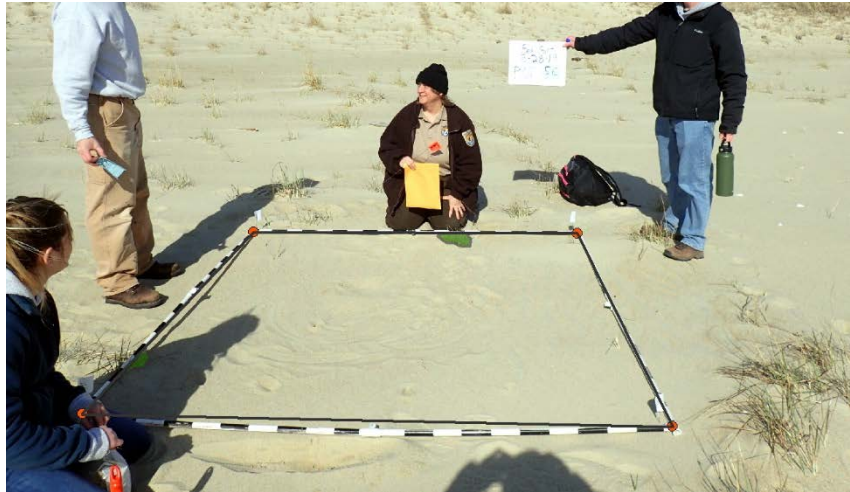


Photo Date: 10/30/2019 – Final Plot Check
Land Cover Area: 0.83 sq.m (20.8%)



Plot: 6A

Treatment: Cast Method

Number of SA Plants that Germinated: 0

Number of SA Plants that Developed True-Leaves: 0

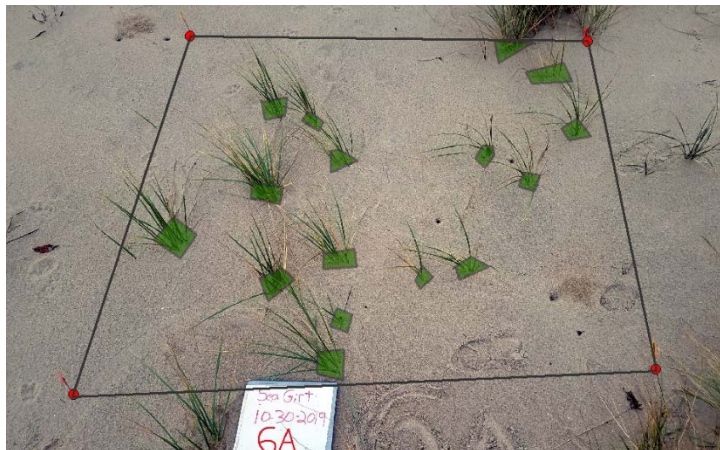
Photo Date: 3/28/2019 – Plot Establishment

Land Cover Area: 0 sq.m (0%)



Photo Date: 10/30/2019 – Final Plot Check

Land Cover Area: 0.16 sq.m (4.1%)



Plot: 6B

Treatment: Plant Method
Number of SA Plants that Germinated: 1
Number of SA Plants that Developed True-Leaves: 1

Photo Date: 3/28/2019 – Plot Establishment
Land Cover Area: 0.19 sq.m (4.63%)

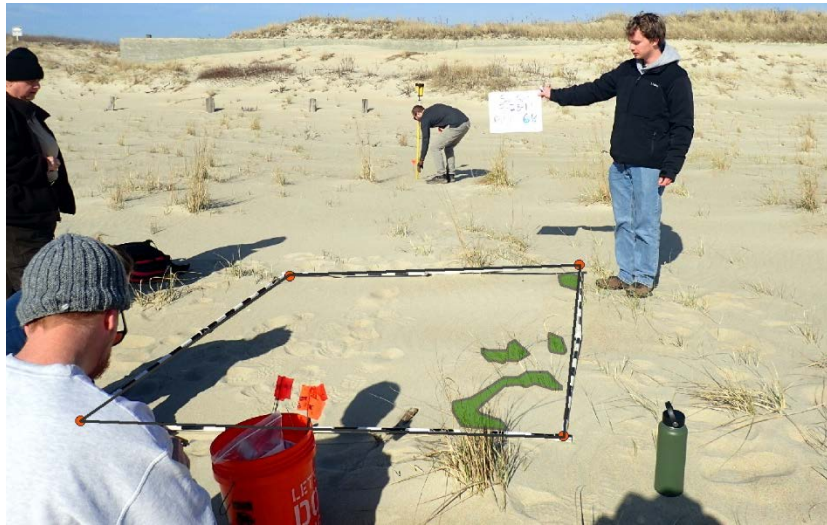


Photo Date: 10/30/2019 – Final Plot Check
Land Cover Area: 0.41 sq.m (4.1%)



Plot: 6C

Treatment: Cast & Cover Method
Number of SA Plants that Germinated: 1
Number of SA Plants that Developed True-Leaves: 0

Photo Date: 3/28/2019 – Plot Establishment
Land Cover Area: 0.17 sq.m (4.23%)



Photo Date: 10/2/2019 – Final Plot Check
Land Cover Area: 1.03 sq.m (25.8%)



Plot: 7A

Treatment: Cast & Cover Method
Number of SA Plants that Germinated: 0
Number of SA Plants that Developed True-Leaves: 0

Photo Date: 3/28/2019 – Plot Establishment
Land Cover Area: 0.29 sq.m (7.30%)



Photo Date: 10/30/2019 – Final Plot Check
Land Cover Area: 0.21 sq.m (5.3%)



Plot: 7B

Treatment: Cast Method

Number of SA Plants that Germinated: 0

Number of SA Plants that Developed True-Leaves: 0

Photo Date: 3/28/2019 – Plot Establishment

Land Cover Area: 0.06 sq.m (1.42%)



Photo Date: 10/30/2019 – Final Plot Check

Land Cover Area: 0.18 sq.m (4.4%)



Plot: 7C

Treatment: Plant Method
Number of SA Plants that Germinated: 0
Number of SA Plants that Developed True-Leaves: 0

Photo Date: 3/28/2019 – Plot Establishment
Land Cover Area: 0 sq.m (0%)



Photo Date: 10/30/2019 – Final Plot Check
Land Cover Area: 0 sq.m (0%)



Plot: 8A

Treatment: Plant Method
Number of SA Plants that Germinated: 1
Number of SA Plants that Developed True-Leaves: 1

Photo Date: 3/28/2019 – Plot Establishment
Land Cover Area: 0.23 sq.m (5.79%)

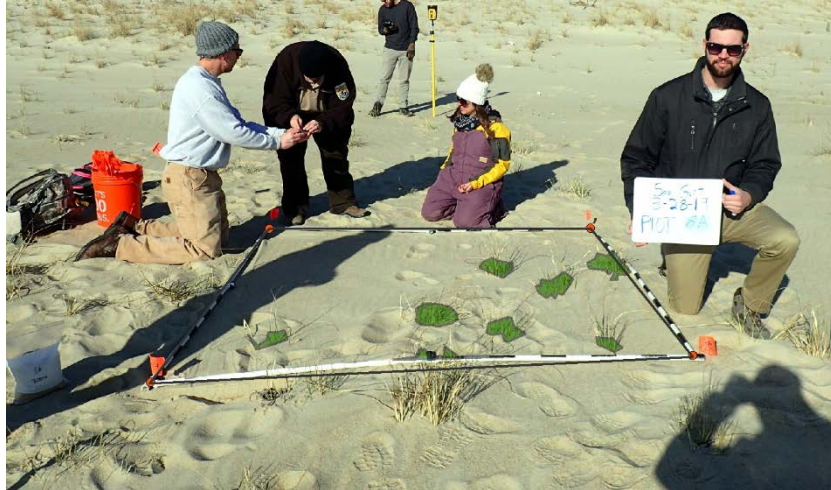
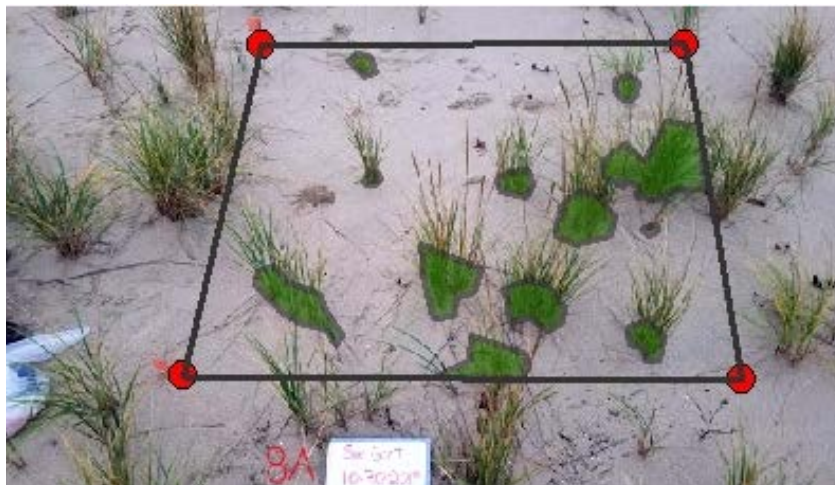


Photo Date: 10/30/2019 – Final Plot Check
Land Cover Area: 0.47 sq.m (11.6%)



Plot: 8B

Treatment: Cast & Cover Method
Number of SA Plants that Germinated: 0
Number of SA Plants that Developed True-Leaves: 0

Photo Date: 3/28/2019 – Plot Establishment
Land Cover Area: 0.02 sq.m (0.60%)

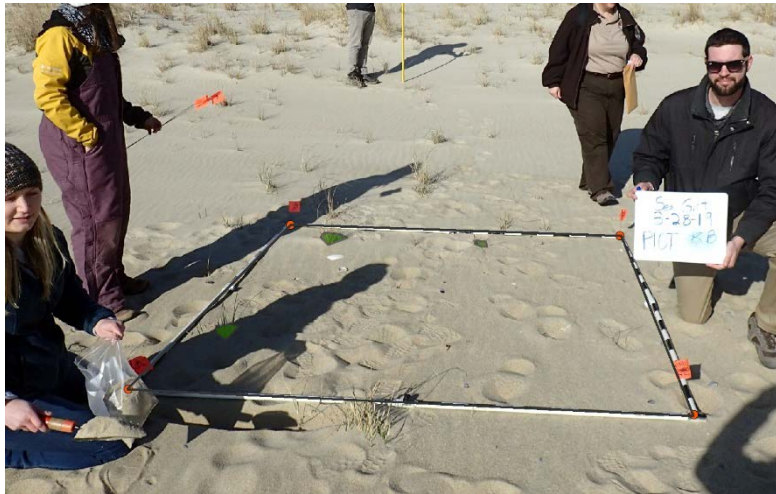


Photo Date: 10/30/2019 – Final Plot Check
Land Cover Area: 0.37 sq.m (9.3%)



Plot: 8C

Treatment: Cast Method

Number of SA Plants that Germinated: 6

Number of SA Plants that Developed True-Leaves: 3

Photo Date: 3/28/2019 – Plot Establishment

Land Cover Area: 0.11 sq.m (2.80%)

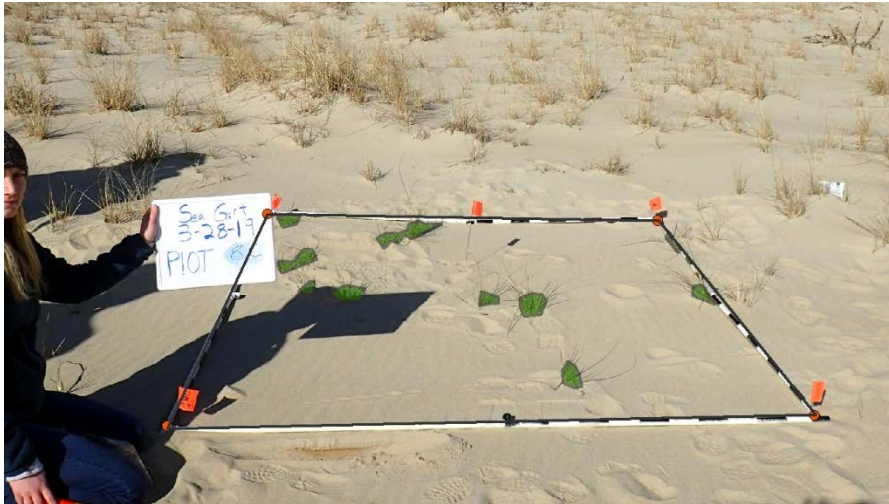
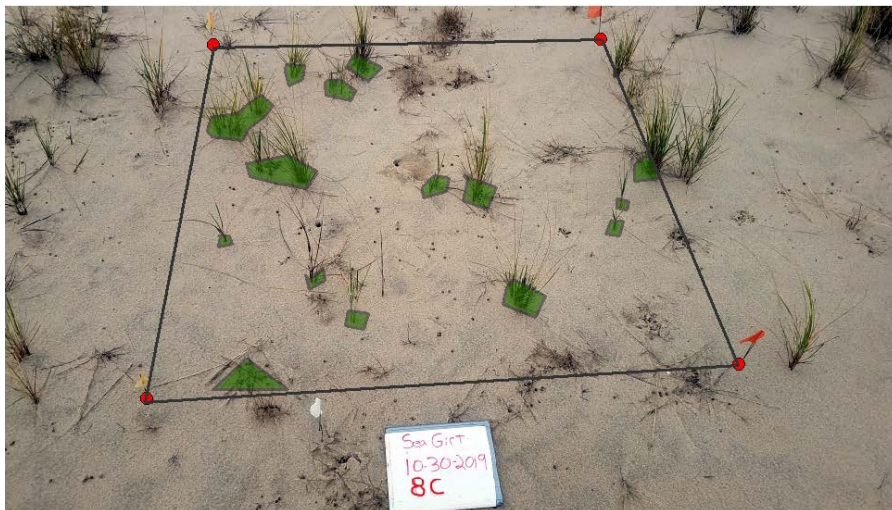


Photo Date: 10/30/2019 – Final Plot Check

Land Cover Area: 0.21 sq.m (5.1%)



Plot: 9A

Treatment: Cast Method

Number of SA Plants that Germinated: 2

Number of SA Plants that Developed True-Leaves: 2

Photo Date: 3/28/2019 – Plot Establishment

Land Cover Area: 0.23 sq.m (5.83%)

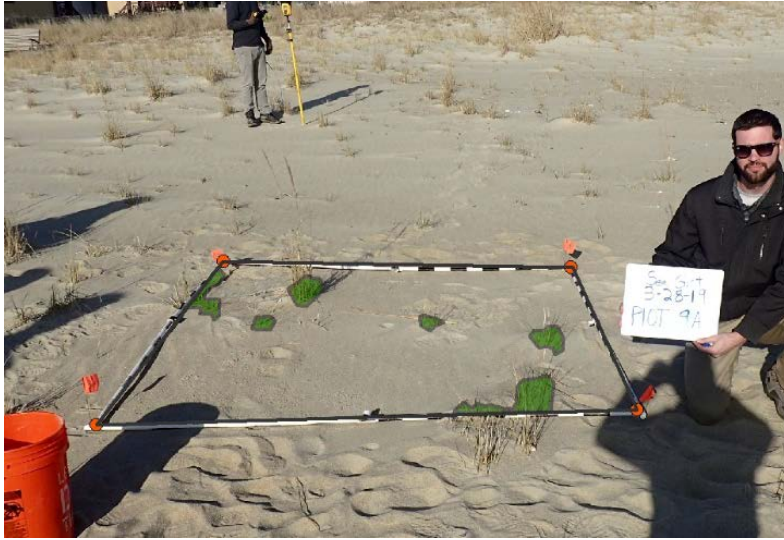


Photo Date: 10/30/2019 – Final Plot Check

Land Cover Area: 0.42 sq.m (10.5%)



Plot: 9B

Treatment: Plant Method
Number of SA Plants that Germinated: 3
Number of SA Plants that Developed True-Leaves: 2

Photo Date: 3/28/2019 – Plot Establishment
Land Cover Area: 0.18 sq.m (4.45%)

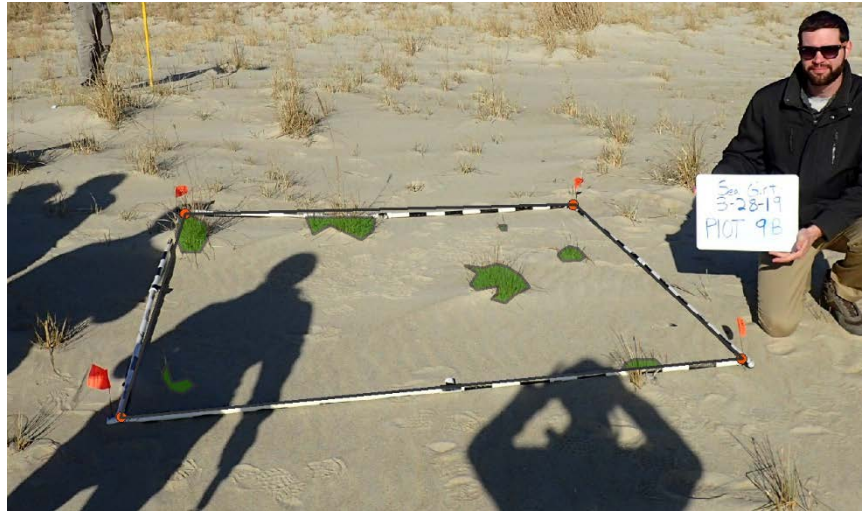
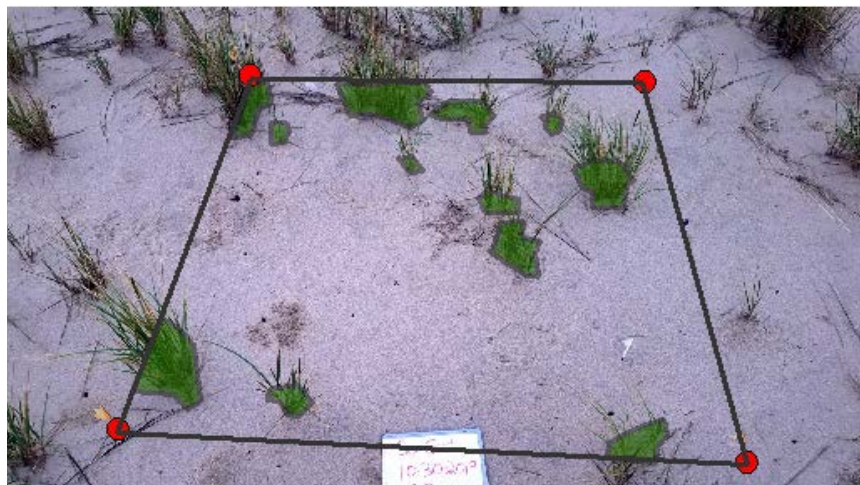


Photo Date: 10/30/2019 – Final Plot Check
Land Cover Area: 0.34 sq.m (8.6%)



Plot: 9C

Treatment: Cast & Cover Method
Number of SA Plants that Germinated: 0
Number of SA Plants that Developed True-Leaves: 0

Photo Date: 3/28/2019 – Plot Establishment
Land Cover Area: 0.47 sq.m (11.86%)

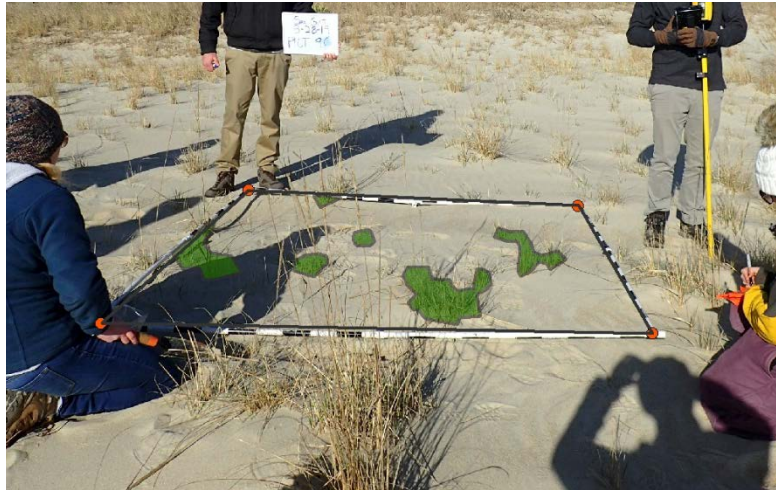


Photo Date: 10/30/2019 – Final Plot Check
Land Cover Area: 1.17 sq.m (29.3%)



Appendix H

Plant Photographs

Plot: 4A-A

Treatment: Plant Method

6/24/2019

Plot Not Surveyed

7/15/2019

Plot Not Surveyed

8/14/2019



10/2/2019

No Plant Present

Plot: 5A-A

Treatment: Cast & Cover Method

6/24/2019

Plot Not Surveyed

7/15/2019

Plot Not Surveyed

8/14/2019



10/2/2019

No Plant Present

Plot: 5AB-A

Treatment: Cast & Cover Method

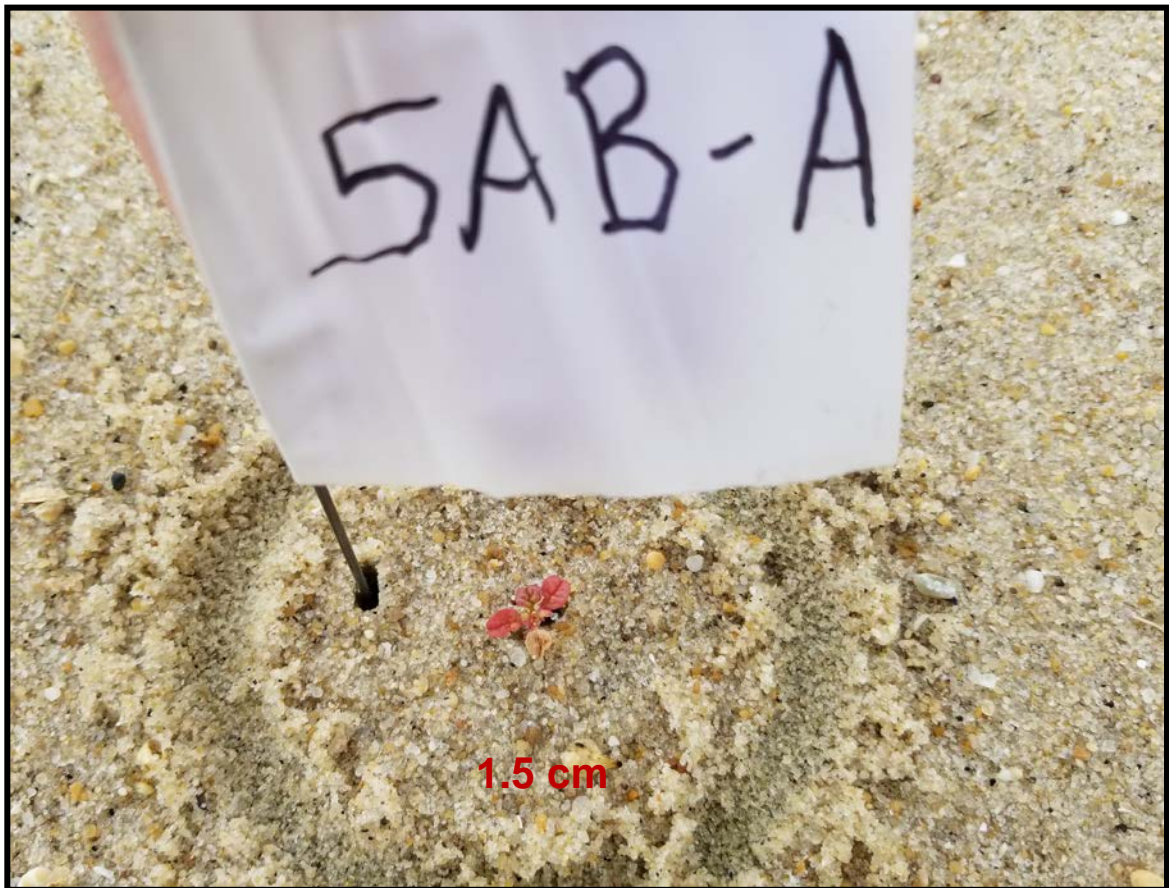
6/24/2019

Plot Not Surveyed

7/15/2019

Plot Not Surveyed

8/14/2019



10/2/2019

No Plant Present

Plot: 5AB-B

Treatment: Cast & Cover Method

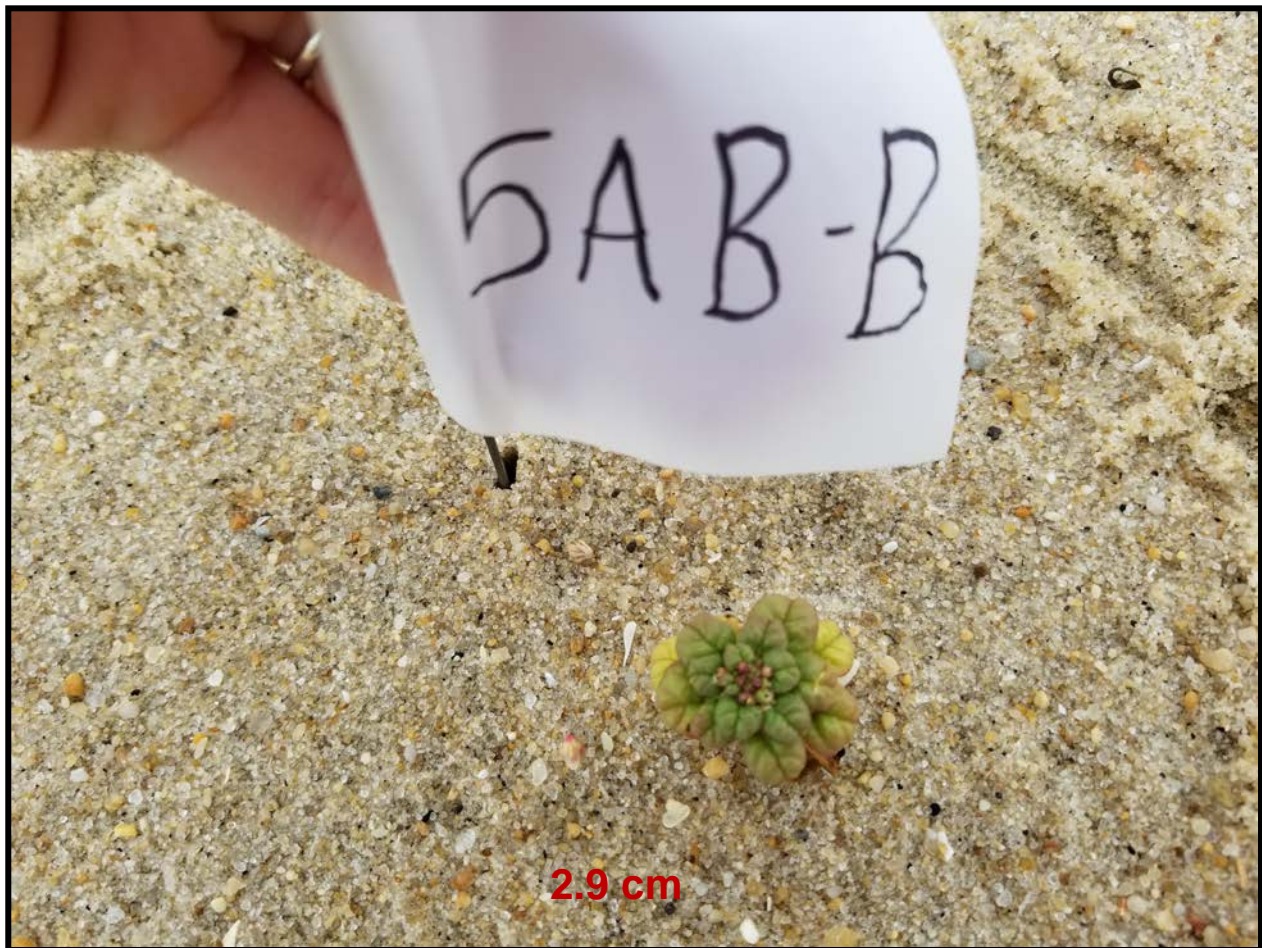
6/24/2019

Plot Not Surveyed

7/15/2019

Plot Not Surveyed

8/14/2019



10/2/2019

No Plant Present

Plot: 5AB-C

Treatment: Cast & Cover Method

6/24/2019

Plot Not Surveyed

7/15/2019

Plot Not Surveyed

8/14/2019



10/2/2019

No Plant Present

Plot: 5C-A

Treatment: Plant Method

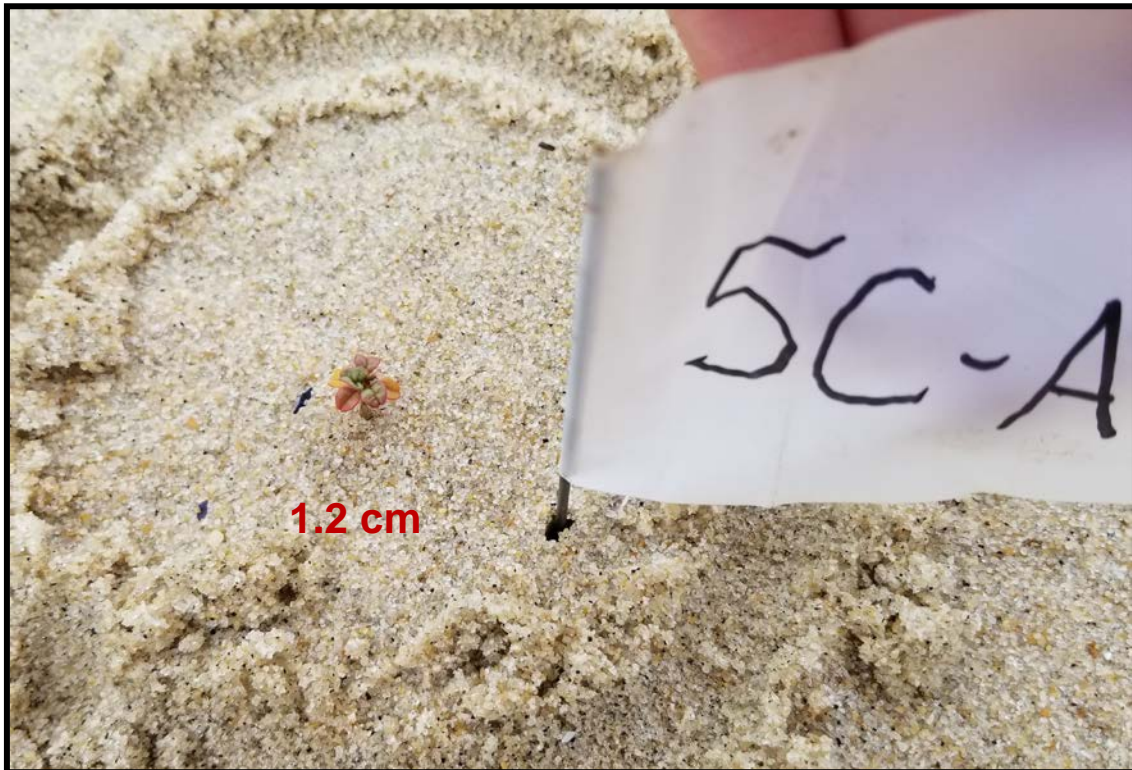
6/24/2019

Plot Not Surveyed

7/15/2019

Plot Not Surveyed

8/14/2019



10/2/2019

No Plant Present

Plot: 5C-B

Treatment: Plant Method

6/24/2019

Plot Not Surveyed

7/15/2019

Plot Not Surveyed

8/14/2019



10/2/2019

No Plant Present

Plot: 6B-A

Treatment: Plant Method

6/24/2019

Plot Not Surveyed

7/15/2019

Plot Not Surveyed

8/14/2019



10/2/2019



Plot: 6C-A

Treatment: Cast & Cover Method

6/24/2019

Plot Not Surveyed

7/15/2019

Plot Not Surveyed

8/14/2019



10/2/2019



Plot: 8A-A

Treatment: Plant Method

6/24/2019



7/15/2019



8/14/2019



10/2/2019



8C-A

Treatment: Cast Method

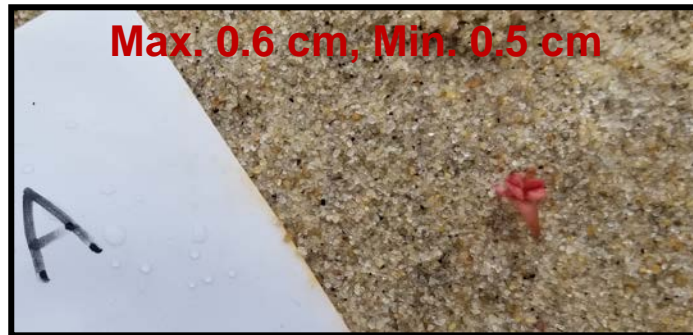
6/24/2019



7/15/2019



8/14/2019



10/2/2019



Plot: 9A-A

Treatment: Cast Method

6/24/2019



7/15/2019



8/14/2019

No Plant Present

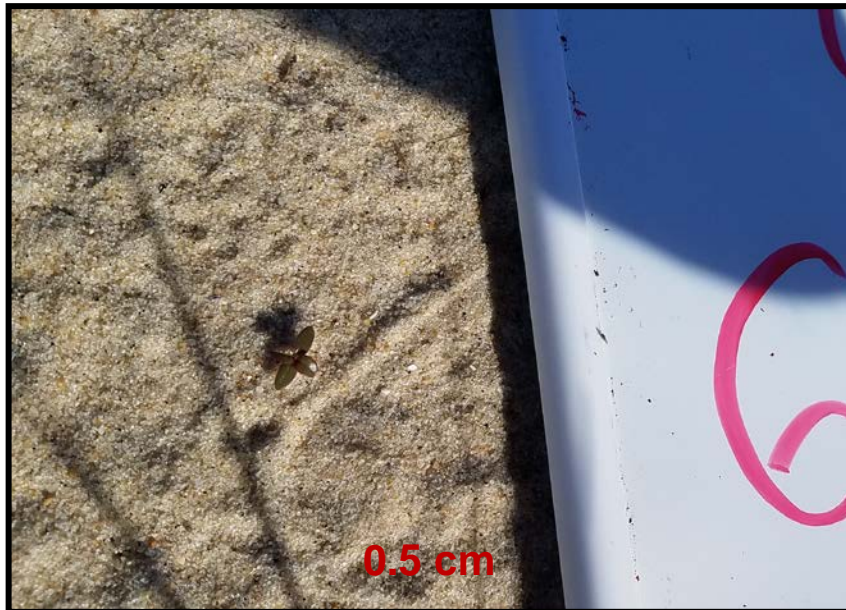
10/2/2019

No Plant Present

Plot: 9A-B

Treatment: Cast Method

6/24/2019



7/15/2019

No Plant Present

8/14/2019

No Plant Present

10/2/2019

No Plant Present

Plot: 9B-A

Treatment: Plant Method

6/24/2019



7/15/2019



8/14/2019

No Plant Present

10/2/2019

No Plant Present

Plot: 9B-B

Treatment: Plant Method

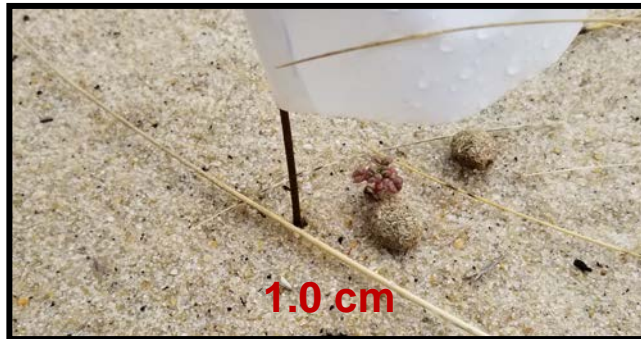
6/24/2019



7/15/2019



8/14/2019



10/2/2019



Plot: 9B-C

Treatment: Plant Method

6/24/2019

No Plant Present

7/15/2019



8/14/2019



10/2/2019



Non-Experimental SA Plants (Naturally Occurring)

Treatment: N/A



Appendix I

Regression Figures

Figure 1: Grain Size vs. Germination Success

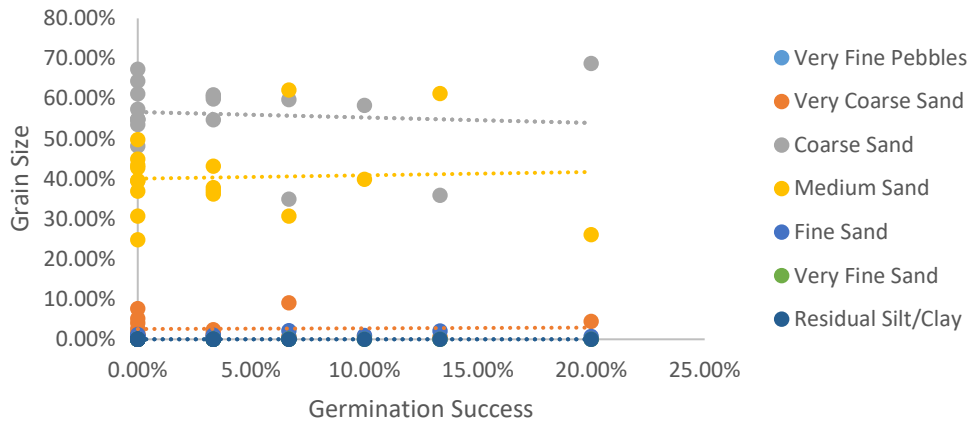


Figure 2: Initial Moisture Content vs. Germination Success

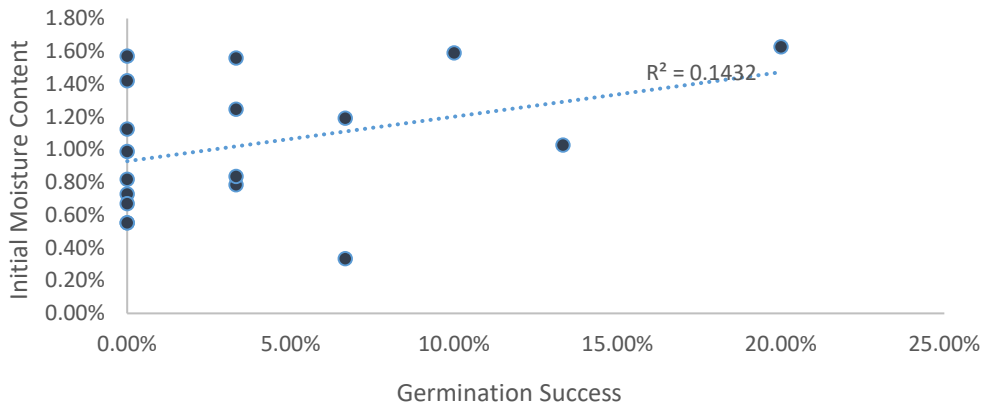


Figure 3: Avg. Moisture Content vs. Germination Success

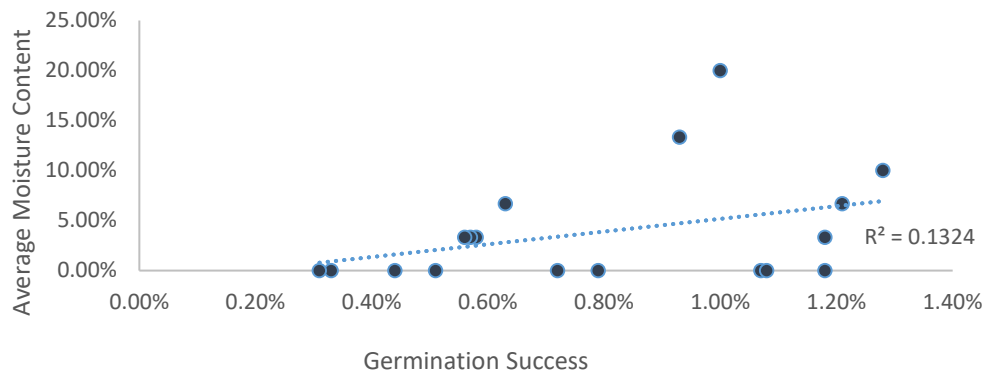


Figure 4: Initial Land-Cover vs. Germination Success

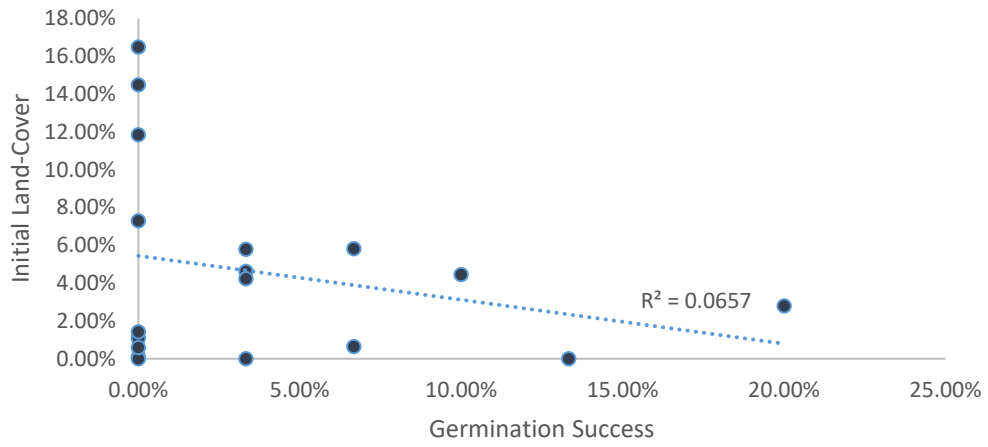


Figure 5: Final Land-Cover vs. Germination Success

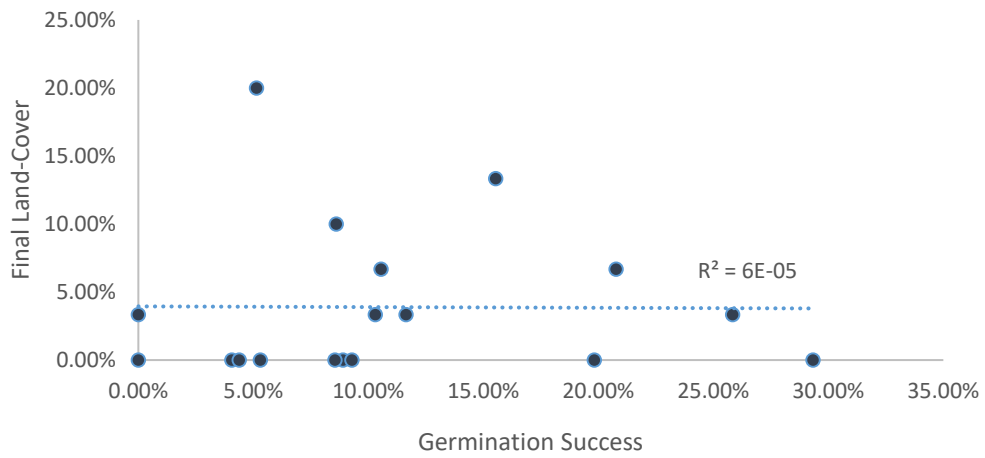


Figure 6: Initial Moisture Content vs. Initial Land-Cover

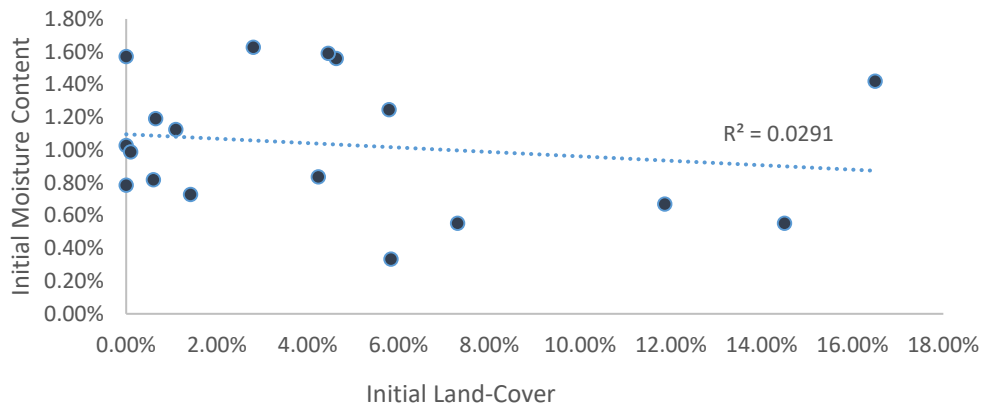


Figure 7: Avg. Moisture Content vs. Final Land-Cover

