  

# Save Crystal River Phase 1.A Annual Monitoring Report (Year 1 of 3)

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## Abbreviations

| | |
|---|---|
| PU | GrowSAV™ Planting Unit |
| GSHED | GrowSAV™ Herbivory Exclusion Device |
| *V. americana* | May also be (Va), *Vallisneria americana* |
| *H. verticillata* | May also be (Hv), *Hydrilla verticillata* |
| *M. spicatum* | May also be (Ms), *Myriophyllum spicatum* |
| SAV | Submerged Aquatic Vegetation |
| MAC | Macroalgae, most often referring to *Lyngbya wollei* |
| FDACS | Florida Department of Agriculture and Consumer Services |
| s.d. | Calculated Standard Deviation |

## I. Introduction

The City of Crystal River is situated around the headwaters of Crystal River, a 600 acre, spring fed basin known as King's Bay. Crystal River was designated as an Outstanding Florida Water under Chapter 62-302.700 F.A.C, which affords the waters special protection under Florida State law. Crystal River is unique in that the headwaters are a freshwater spring system that transition downstream into a tidally dependent river system spanning nearly 7 miles into Florida's Gulf Coast. Over 50, large spring systems allow for the water temperature near vents to remain around 72° F year-round.

In recent years, the Crystal River system has seen a decrease in water quality that can be attributed to increased nutrient loads and the presence of invasive plants and algae. These two factors are linked, with increased nutrient loading and lack of natural controls allowing invasive plants to flourish. As a continuation of the Save Crystal River Pilot Project, the intent of Save Crystal River Phase 1 was to restore the native macrophyte *Vallisneria americana*, to 19.1 acres within the King's Bay Basin, after the vacuum removal of invasive vegetation and organic "muck" throughout the project area. Restoring *V. americana* to healthy levels would provide immense benefits to the Crystal River system by increasing dissolved oxygen levels, sequestering excess nutrients, that would otherwise be available to invasive vegetation or harmful algae, and providing competition to invasive plants.

The Phase 1.A project site was centralized around Hunter's Spring, a large spring system found in the King's Bay Basin. The permitted area included 3 shallow water flats (designated as Areas 1, 2 and 3), 2 upland canals (designated as Areas B and C) and the deep trench adjacent to Hunter's Spring (designated as Area A). Maps 1 and 2 show the exact boundaries of each area within the project site. Initial benthic surveys revealed that between 18 and 24 inches of substrate remained throughout the project site after the vacuum removal of algae and organic muck. Substrate was comprised mainly of sand and some organic material. Average water depths throughout project site ranged from 0.5 – 6.5 meters. *V. americana* was not observed throughout the project site prior to transplanting.

It was found in both last year's Save Crystal River Pilot project report, as well as similar projects conducted in King's Bay (Hauxwell et al. 2004), that transplant survival chances are maximized when placed under herbivory exclusion enclosures. To account for this, GrowSAV™ Herbivory Exclusion Devices (henceforth GSHEDs) were placed in areas that maintained depths of at least 4' in low-low water. GSHEDs were utilized throughout Areas A, B and C. Prior to November 15, 2016, 525 GSHEDs were installed throughout these areas. To avoid impeding navigation, GSHEDs were placed in rows oriented parallel to the shoreline, with the first row beginning 10 ft. from the shoreline or private docks. 2,625 GrowSAV™ Planting Units (PU) were installed under the GSHEDs (5 PU/ GSHED). An additional 26,608 PU were transplanted in unprotected portions of these areas, and throughout Areas 1, 2 and 3.

Transplanting of PU took place during the month of November 2016. PU were grown-out and harvested from Sea and Shoreline's FDACS certified aquaculture facility located in Ruskin, Fl. PU were comprised of a single shoot and root system given time to pre-root in a peat pellet (JEB units) and Sea and Shoreline's own designed "safety pots". Transplanting was performed both mechanically, utilizing a mechanical planting vessel, and by hand, by a team of certified divers. PU were installed every 3 ft. throughout the project areas. Post installment, monthly maintenance was performed to make sure adequate sunlight and current flow remained available to protected PU.

## II. Methodology

### 2.1 - Sampling Design for Monitoring

A handheld DGPS unit with sub-meter accuracy (Trimble GeoExplorer 6000). was used to delineate the perimeter of each transplanted area, and to record the exact location of each GSHED. For monitoring, 48 GSHEDS, were randomly selected, and a random point was selected no more than 5 m from each selected GSHED to be used as reference points (48 monitoring points and 48 reference points). In addition, 20 monitoring points were randomly selected within each shallow water area (60 additional points). In total, 158 points were selected to be used for monitoring purposes. To assess the health, growth rate and survival of PUs, biological parameters were quantified and compared to the reference sites.

### 2.2 - Biological Parameters

Benthic community was assessed in-water by a Sea and Shoreline biologist using a 0.25 $m^2$ quadrat. Supplementary photo-quadrats of the seafloor were collected at each monitored planting and reference location. Collected photos were later assessed in the laboratory to verify data accuracy and better distinguish SAV species composition. Photos were archived by Sea and Shoreline, and can be seen on pages 27 - 54. The following biological parameters were observed.

#### *2.2-1 Survival of Planting Units*

The survival of PUs was assessed at each selected monitoring location by noting the absence or presence of *V. americana.* Survival was defined as the presence of at least a single shoot, as even a single shoot suggests association with a growing rhizome (Fonseca et al. 1998). Survival rate was estimated by dividing the number of samples that were determined to have survived by the total number of samples taken (Figure 1). Survival rates of reference areas and unprotected areas were not determined.

#### *2.2-2 V. americana Short-Shoot Density*

*V. americana* short-shoot density was estimated by randomly placing a .10 $m^2$ quadrat inside each 0.25 $m^2$ area, placed at each selected monitoring site, and manually counting each short shoot present within the 0.10 $m^2$ area. An estimated number of short-shoots present $m^{-2}$ was determined by multiplying the obtained value by 100. Data were recorded as shoots 0.10 $m^{-2}$, and are presented as mean (+/- 1 s.d.) shoot count $m^{-2}$ (shoots/$m^2$) for planted (N = 48), reference (N = 48) and unprotected (N = 60) sample sites (Figure 2). Mean shoot counts for each individual restoration area are reported as well (Figure 3).

#### *2.2-3 Braun-Blanquet Frequency, Abundance and Density Assessment*

The visual assessment of Braun-Blanquet Coverage was conducted within a 0.25 $m^2$ quadrat at each selected monitoring and reference site (Braun-Blanquet 1965). Total macroalgae community (MAC), total SAV community, *V. americana, H. verticillate*, and *M. spicatum* coverage were assessed and a score between 0 and 5 was recorded for each. Table 1 - provides the corresponding coverage represented by each Braun-Blanquet score. Collected data were used to calculate frequency, abundance, and density of *V. americana* in selected planted, reference, and unprotected sites. Page 54 provides the formulas used to determine each factor. Data are presented in Figures 4 through 10.

#### *2.2-4 Blade Height of V. americana*

*V. americana* blades located within the same 0.10 $m^2$ quadrat, utilized to determine short shoot density, were measured in water by a Sea and Shoreline biologist using a metric ruler. Data were recorded as mean (+/- 1 s.d.) blade height (cm) per sample for each planted, reference and unprotected site. Data are reported as mean values for planted (N=48), reference (N=48) and unprotected (N=60) sample sites (Figure 11).

#### *2.2-5 V. americana Epiphyte Coverage*

Epiphyte coverage of *V. americana* blades located within 0.25 $m^2$ samples was visually observed in-water by a Sea and Shoreline biologist. Data were recorded as numerical values ranging from 0 (clean) to 3 (heavy coverage). Data is reported as the mean (+/- 1 s.d.) score for planted (N = 48), reference (N = 48) and unprotected (N = 60) sample sites (Figure 12). Table - 2 provides the epiphyte coverage that each number corresponds to.

# III. Results

## 3.1 – Biological Parameters

### *3.1-1 Survival of Planting Units*

Survival rate of PU during the year one monitoring event was determined to be 93.2%. (Figure 1)

### *3.1-2 V. americana Short-Shoot Density*

Mean *V. americana* short-shoot density was determined at each selected planting, reference and unprotected site. Overall, short-shoot density was highly variable, ranging from 0 – 6800 shoots $m^{-2}$. Short-shoot density within planted sites ranged from 0 – 6800 shoots $m^{-2}$, with a mean value (+/- 1 s.d.) of 2885 +/- 1640 shoots $m^{-2}$. Short-shoot densities at both reference and unprotected sites were comparable, and considerably lower than planted sites, with mean values (+/- 1 s.d.) of 704 +/- 670 shoots $m^{-2}$ and 715 +/- 240 shoots $m^{-2}$, respectively (Figures 2 and 3).

### *3.1-3 Braun-Blanquet Frequency Assessment*

*3.1-3A Planted Sites and Reference Sites*

Frequency of total SAV was higher in planted sites (.96) than reference sites (.77). In addition, total macroalgae was less frequent in planted sites (.63) than in reference sites (.79). *V. americana* had a higher frequency than *H. verticillate* in both planted (.94 *V. americana;* .17 *H. verticillate)* and reference sites (.67 *V. americana;* .29 *H. verticillate*) (Figure 4).

*3.1-3B Unprotected Sites*

Frequency of total SAV was higher (.98) than frequency of total macroalgae (.65) in unprotected sample sites. *V. americana* was 2.58 times more frequent (.98) than *H. verticillate* (.38) in unprotected areas. *M. spicatum* was not observed in unprotected areas (Figure 5).

### *3.3-4 Braun-Blanquet Abundance Assessment*

*3.1-4A Planted Sites and Reference Sites*

Total SAV was found to be more abundant when present in selected planted sites (3.58) than reference sites (2.38). Inversely, total macroalgae was determined to be less abundant when present in selected planting sites (2.17) than reference sites (2.45). *V. americana* was determined to have the highest frequency and abundance (3.61 planted; 2.41 reference) of observed SAV. *H. verticillata* and *M. spicatum* were both observed to be less abundant in planted sites (.88 and .55 respectively) than in reference sites (1.0 and 1.6 respectively) (Figure 6).

*3.1-4B Unprotected Sites*

Throughout unprotected sites, total SAV was more abundant (3.76), than total macroalgae (1.27) when present. *V. americana* was most abundant when present in Area 1 (4.05) and least abundant when present in Area 3 (2.95). *H. verticillata* was least abundant in Area 1 (0) and most abundant when present in Area 3 (1.68). *M. spicatum* was not observed in unprotected sites (Figure 7).

***3.3-5 Braun-Blanquet Density Assessment***

*3.1-5A Planted Sites and Reference Sites*

Total SAV had a higher density than total MAC in planted sites (3.42 and 1.35 respectively). In reference sites, total MAC was slightly denser (1.93) than total SAV (1.83). *V. americana* was found in higher density than *H. verticillata* and *M. spicatum* in both planted (3.39 Va, 0.15 Hv, 0.023 Ms) and reference (1.6 Va, 0.29 Hv, 0.2 Ms) sites. *V. americana* was found to have a density that was 19.6 times higher (3.39) than the other two observed SAV species combined (0.173) in planted sites (Figure 8).

*3.1-5B Unprotected Sites*

Total SAV had a higher average density (3.6) than total MAC (.97) throughout unprotected areas. *V. americana* had a higher average density (3.42) than *H. verticillata* (.58) throughout unprotected areas as well. Area 1 had the highest density of *V. americana* (4.05) and lowest density of *H. verticillata* (0) of the three unprotected areas. *M. spicatum* was not observed in unprotected areas (Figure 9).

***3.1-6 Braun-Blanquet Coverage Score of V. americana***

Mean Braun-Blanquet score assigned to planted sites was 3.35 +/-1.71. This was significantly higher than reference sites (1.60 +/- 1.71). Interestingly, a higher mean score was observed in unprotected sites (3.42 +/- 1.38) than in planted or reference sites (Figure 10).

***3.1-7 Blade Height of V. americana***

Mean blade height was found to be 28.85 +/- 16.40 cm throughout planted areas. This was over 4 times higher than what was observed in both reference (7.04 +/- 6.70 cm) and unprotected (7.15 +/- 2.39 areas) (Figure 11).

***3.1-8 V. americana Epiphyte Coverage***

Epiphyte cover ranged from clean (0) to moderately heavy (3) throughout the samples. Mean epiphyte cover was light and statistically indistinguishable between planted, reference and unprotected sites (1.58 +/- .86, 1.13 +/- 1.01, 1.19 +/- .43 respectively) (Figure 12).

## IV. Discussion

Qualitative and quantitative assessment of PU in planted, reference and unprotected sites suggest that, after one year, PU have overcome any initial stress, due to relocation, and the Save Crystal River Phase 1.A restoration project is showing a successful trend. Reported survival rate was 93.2%. This surpasses the initial goal of 80% survival rate, and is just 4% shy of the 97% survival rate reported during the year one monitoring campaign of the Save Crystal River Pilot Project. Although survival rate was measured only in protected sites, it is worth noting that *V. americana* occupied 59/60 samples taken in unprotected areas as well.

It was suggested during last year's pilot campaign that much success could be contributed to the utilization of GSHEDs. GSHEDs are designed to protect enclosed PU from large herbivores and human impacts, while allowing optimal current flow and sunlight to enter. GSHEDs were observed to be most beneficial when comparing shoot density and blade height to both reference and unprotected areas. Protected PU were found to have grown twice as dense and four times as tall when protected by GSHEDs. This is ecologically significant, as a dense, thick meadow can provide more habitat for small fauna. PU protected by GSHEDs appeared to be healthy, strong and fully adapted to the environment.

Frequency, abundance and density of total SAV and *V. americana*, reported in protected planting sites, closely mirrored what was reported during last year's pilot project campaign. Interestingly, significant differences were observed when comparing data from reference sites of both projects. The density of *V. americana*, in reference areas, was nearly four times higher than what was observed in the pilot project campaign (.45 Pilot, 1.6 Phase 1.A). *V. americana* was also found to be more than twice as abundant in occupied reference sites during this event (.95 Pilot, 2.45 Phase 1.A). The higher abundance and density, observed in reference areas during this event, suggest that PU are displaying efficient vegetative reproduction and expanding well outside of the protected area during this phase.

Maybe the most surprising results were reported in the three unprotected Areas 1, 2 and 3. As mentioned, previous studies conducted in King's Bay have had little to no success restoring *V. americana* without the use of herbivore exclusion enclosures (Hauxwell et al. 2004, Hauxwell et al. 2004). Unprotected areas 1, 2 and 3 reported an acceptable mean coverage of 3.42 +/- 1.38. Additionally, mean shoot density was comparable to that observed in naturally occurring *V. americana* meadows in King's Bay (200-800 shoots $m^{-2}$) (Hauxwell, 2007).

Overall, biological assessment confirms that PU have adapted well to relocation and are thriving in King's Bay. It is too early, however to confirm the success of this project. Monitoring is scheduled to continue for two years.

## V. References


Braun-Blanquet, J. "Plant sociology (translated by Fuller, GD and Conard, HS)." (1965): 469.

Fonseca, Mark S., and John S. Fisher. "A comparison of canopy friction and sediment movement between four species of seagrass with reference to their ecology and restoration." *Marine Ecology Progress Series* (1986): 15-22.

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## VI. Tables

**Table 1 – Braun-Blanquet Coverage Estimate Scores and Corresponding Grass Cover**

| Braun-Blanquet Coverage Estimate | |
|---|---|
| 0.1 | Solitary |
| 0.5 | Sparse |
| 1 | <5% |
| 2 | 5 – 25% |
| 3 | 26 – 50% |
| 4 | 51 – 75% |
| 5 | 76 – 100% |

**Table 2 – Epiphyte Cover Scale and Corresponding Coverage**

| Epiphyte Cover Scale | |
|---|---|
| 0 | Clean |
| 1 | Light |
| 2 | Moderate |
| 3 | Heavy |

**Table 3 – A Summary of Data by Individual Restoration Areas (A, B, C, 1, 2, and 3)**

| | Braun-Blanquet Assessment | | | Mean Short-Shoot | Survival Rate of PU | Mean Blade Height of Va (cm) |
|---|---|---|---|---|---|---|
| **Area** | **Frequency (Va)** | **Abundance (Va)** | **Density (Va)** | **Density (Va $SS/m^2$)** | | |
| **A** | **0.875** | **3.29** | **2.88** | **1021** | **88%** | **28.85** |
| **B** | **1.0** | **4.67** | **4.67** | **2367** | **100%** | |
| **C** | **1.0** | **3.69** | **3.69** | **1839** | **100%** | |
| **1** | **1.0** | **4.05** | **4.05** | **2575** | **-** | **7.15** |
| **2** | **1.0** | **3.40** | **3.40** | **1775** | **-** | |
| **3** | **0.95** | **2.95** | **2.80** | **1165** | **-** | |

## VII. Figures

**Figure 1 – The Survival Rate of PU at Time Zero and the Year One Monitoring Event**

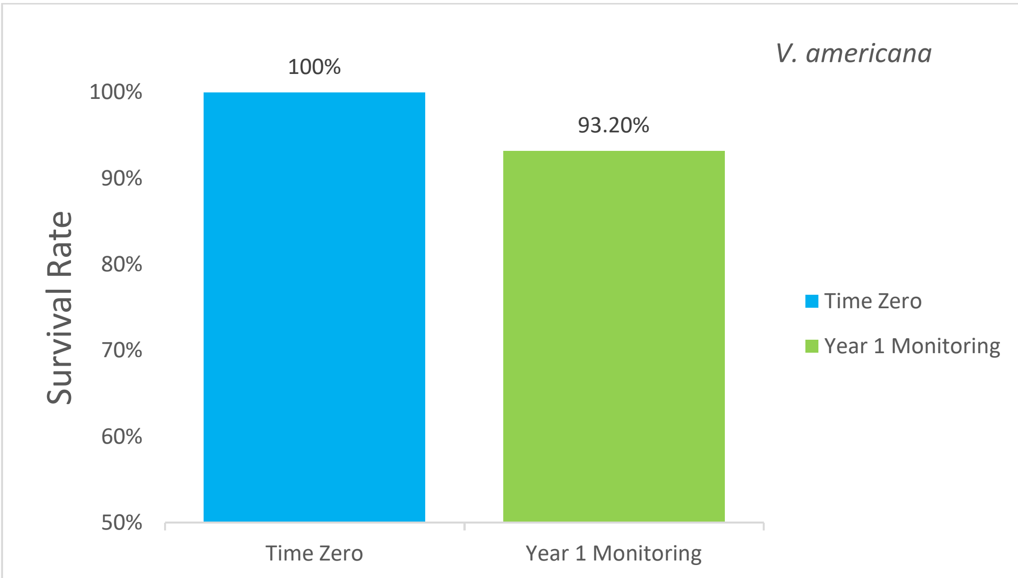



**Figure 2 – Mean *V. americana* Short-Shoot Density and Standard Deviation at Protected (Areas A, B and C) (N = 48) and Reference Sites (N = 48)**

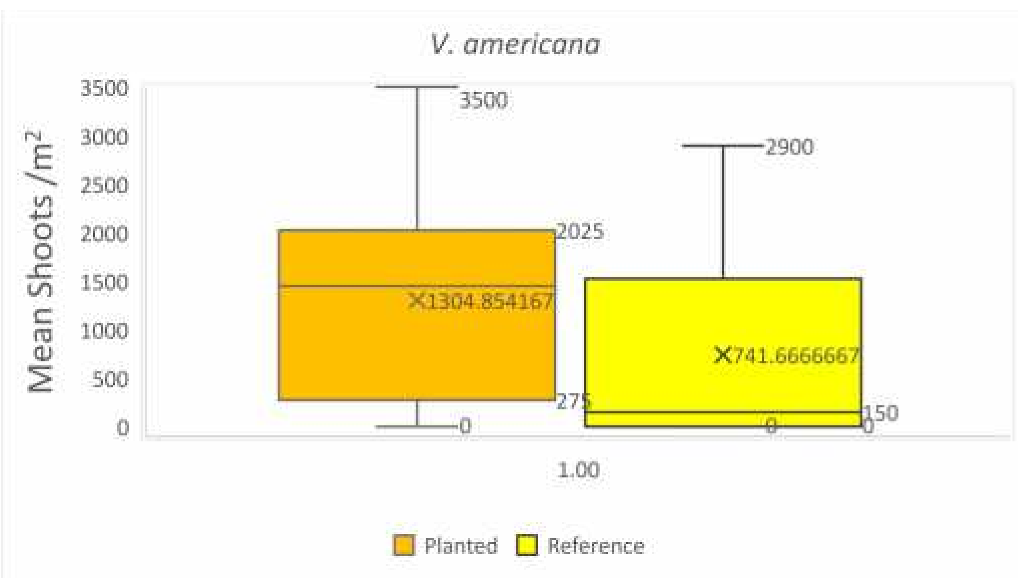


**Figure 3 – Mean *V. americana* Short-Shoot Density by Restoration Area**

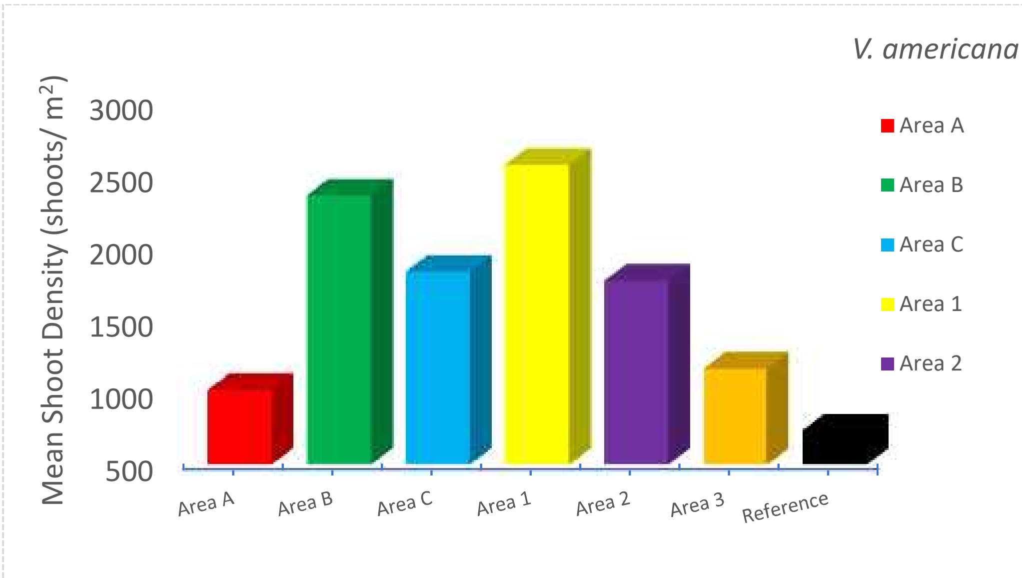



**Figure 4 – Braun-Blanquet Frequency Assessment in Planted (Areas A, B and C) and Reference Sites**

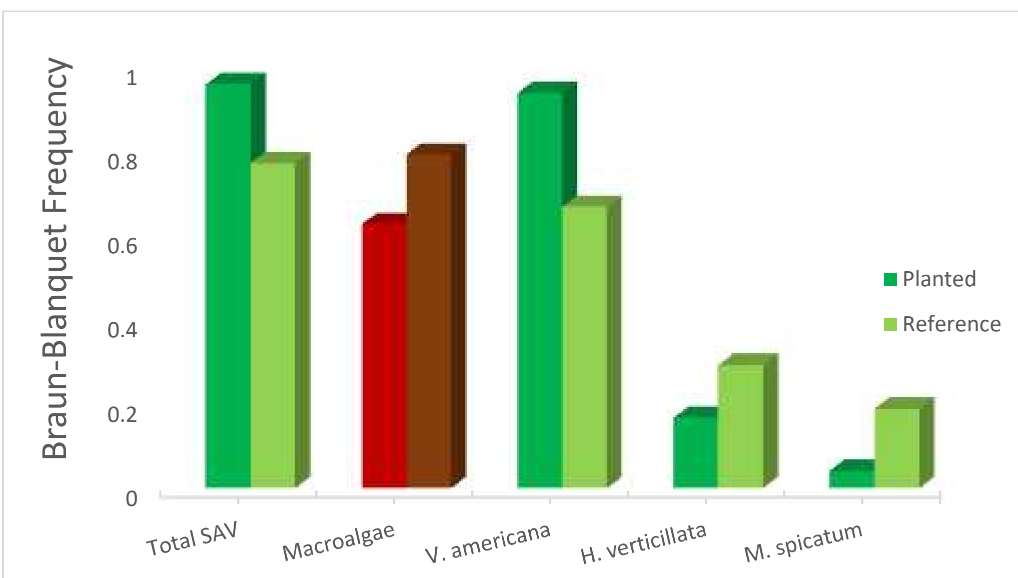


**Figure 5 – Braun-Blanquet Frequency Assessment in Unprotected Areas (Areas 1, 2 and 3)**

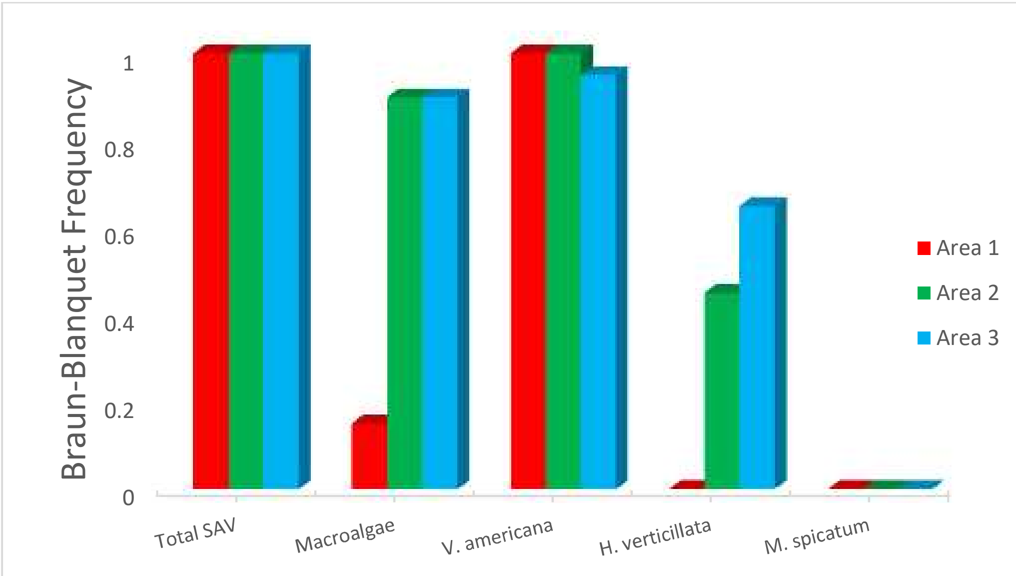



**Figure 6 – Braun-Blanquet Abundance Assessment in Planted (Areas A, B and C) and Reference Sites**

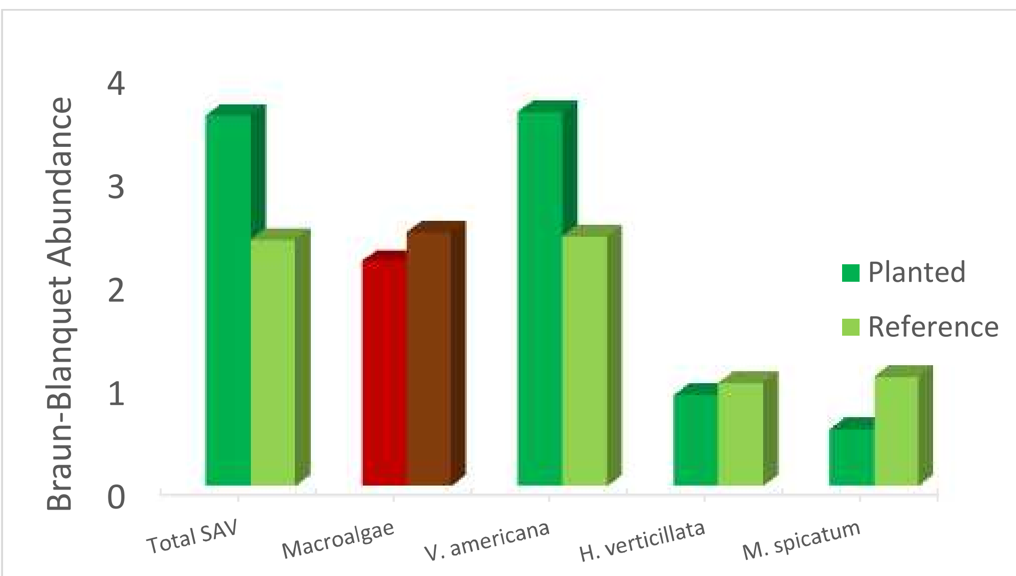


**Figure 7 – Braun-Blanquet Abundance Assessment in Unprotected Areas (Areas 1, 2 and 3)**

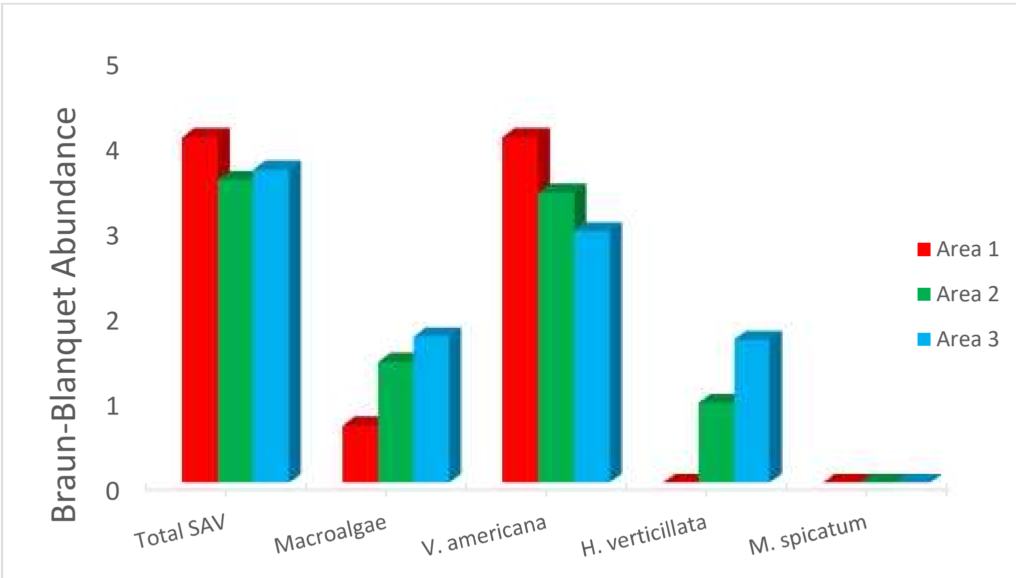



**Figure 8 – Braun-Blanquet Density Assessment in Planted (Areas A, B and C) and Reference Sites**

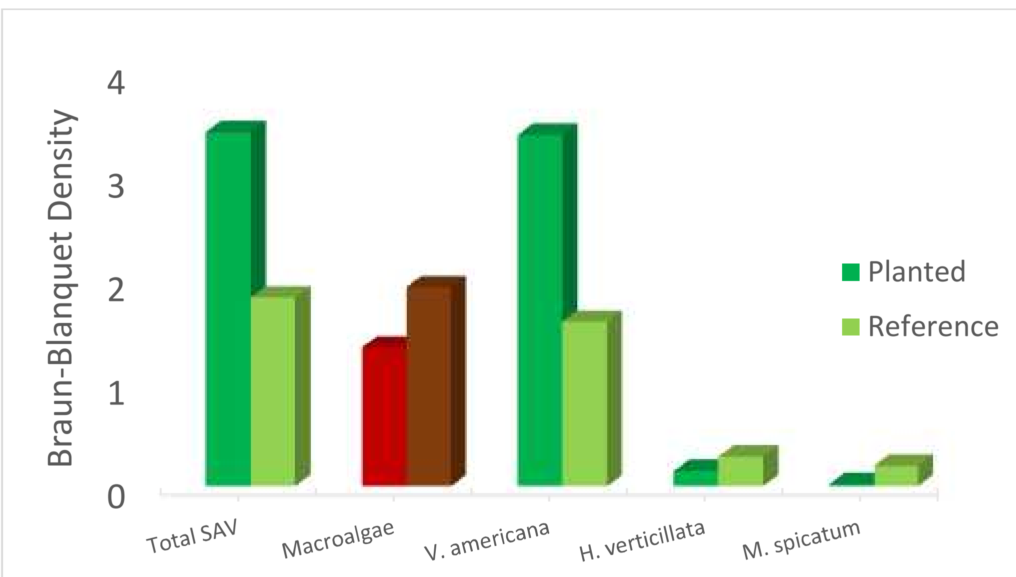


**Figure 9 – Braun-Blanquet Density Assessment for Unprotected Areas (Areas 1, 2 and 3)**

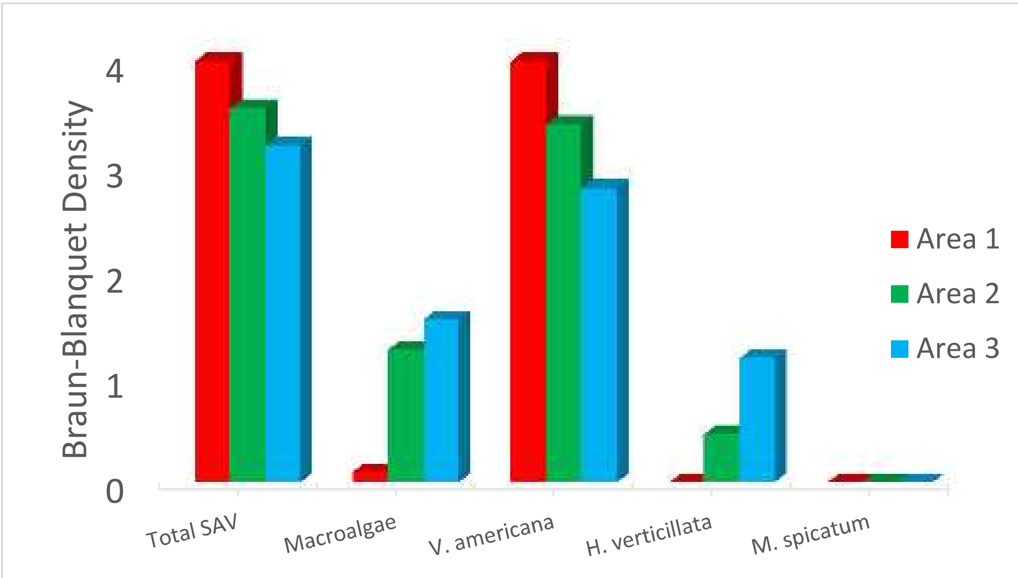



**Figure 10 – Mean Braun-Blanquet Scores (and Standard Deviation) for *V. americana***

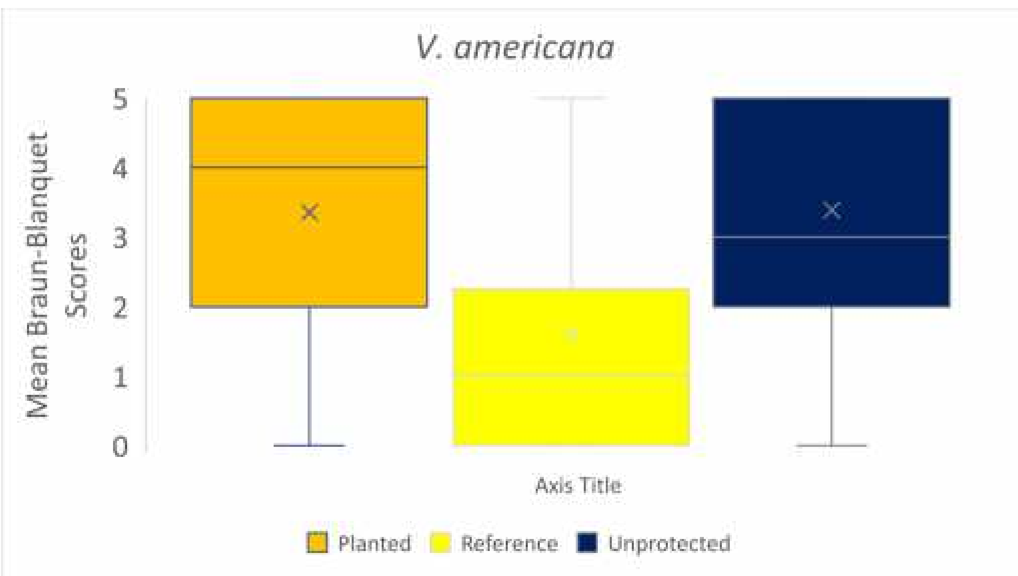


**Figure 11 – Mean *V. americana* Blade Height at Protected, Reference and Unprotected Sites**

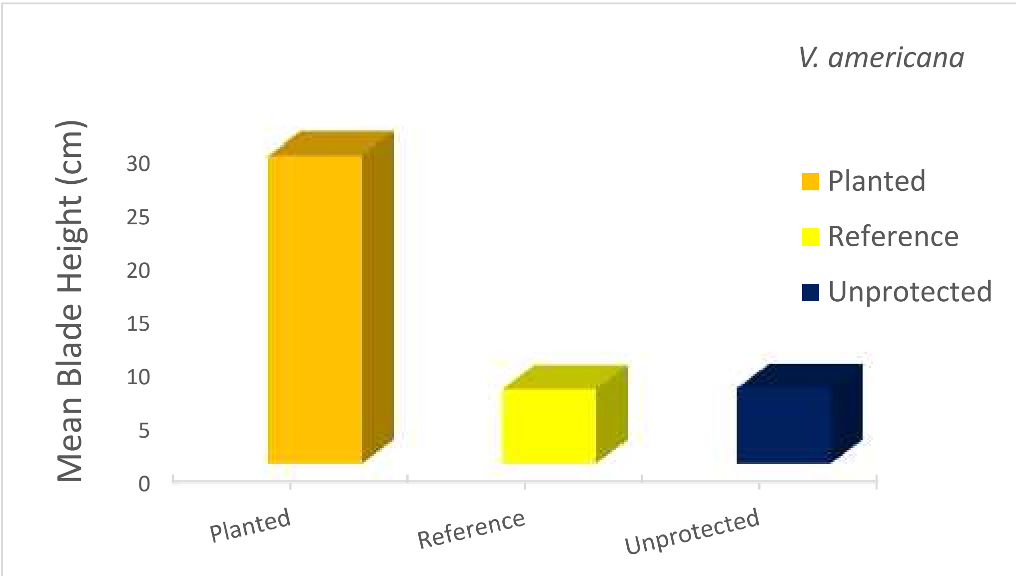
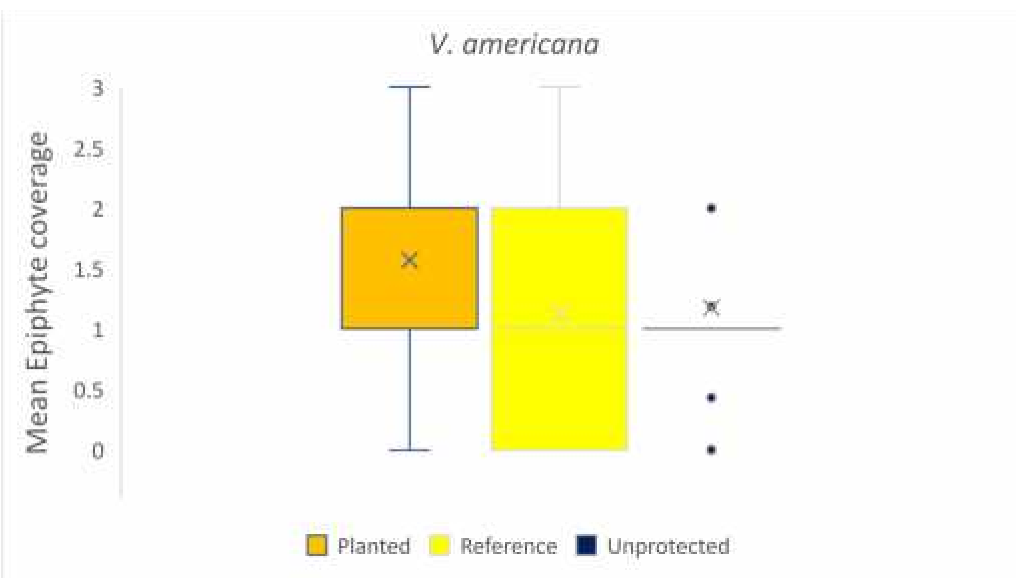



**Figure 12 – Mean Epiphyte Cover of *V. americana* Blades at Protected and Reference Sites**



## VIII. Maps

### Map 1 – Overview of Restoration Areas

## Map 2 – Location of Areas B and C

# IX. Appendices

## 9.1 - Data Sheets

| Station ID | Epiphyte | TMAC | TSAV | Va BB | Va SS | Hv BB | Ms | BH (cm) | Pic ID |
|---|---|---|---|---|---|---|---|---|---|
| **Area A** | | | | | | | | | |
| 1 | 2 | 0 | 4 | 4 | 17 | 0 | 0 | 29 | 3333 |
| 1r | 1 | 1 | 5 | 5 | 20 | 0 | 0 | 8 | 3334 |
| 2 | 2 | 1 | 3 | 3 | 12 | 0 | 0 | 19 | 3335 |
| 2r | 2 | 0 | 4 | 4 | 20 | 2 | 0 | 8 | 3336 |
| 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 20 | 3337 |
| 3r | 2 | 5 | 5 | 5 | 24 | 0 | 0 | 8 | 3338 |
| 4 | 1 | 2 | 2 | 2 | 4 | 0 | 0 | 17 | 3339 |
| 4r | 2 | 3 | 3 | 3 | 18 | 0 | 0 | 11 | 3340 |
| 5 | 3 | 0 | 5 | 5 | 22 | 0 | 0 | 32 | 3341 |
| 5r | 3 | 1 | 5 | 5 | 15 | 0 | 0 | 12 | 3342 |
| 6 | 2 | 2 | 4 | 4 | 11 | 0 | 0 | 28 | 3343 |
| 6r | 0 | 2 | 2 | 0 | 0 | 1 | 2 | 2 | 3344 |
| 7 | 3 | 1 | 4 | 4 | 17 | 1 | 0 | 20 | 3345 |
| 7r | 3 | 3 | 3 | 2 | 5 | 1 | 1 | 15 | 3346 |
| 8 | 2 | 0 | 5 | 5 | 21 | 0 | 0 | 33 | 3347 |
| 8r | 1 | 3 | 1 | 1 | 0 | 1 | 1 | 5 | 3348 |
| 9 | 0 | 0 | 5 | 5 | 11 | 0 | 0 | 43 | 3349 |
| 9r | 2 | 5 | 0.5 | 0.5 | 0 | 0.5 | 0 | 3 | 3350 |
| 10 | 3 | 0 | 5 | 5 | 7 | 0 | 0 | 44 | 3351 |
| 10r | 2 | 5 | 0.5 | 0 | 0 | 0.5 | 0 | 0 | 3352 |
| 11 | 1 | 4 | 1 | 1 | 0 | 0 | 0 | 15 | 3353 |
| 11r | 0 | 5 | 0.5 | 0 | 0 | 0 | 0 | 5 | 3354 |
| 12 | 0 | 5 | 0 | 0 | 0 | 1 | 0 | 0 | 3355 |
| 12r | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3356-7 |
| 13 | 0 | 3 | 0.5 | 0 | 0 | 0 | 0 | 25 | 3358 |
| 13r | 1 | 4 | 2 | 1 | 1 | 0 | 0 | 5 | 3359 |
| 14 | 3 | 2 | 3 | 3 | 7 | 0 | 0 | 24 | 3360 |
| 14r | 2 | 4 | 2 | 2 | 3 | 0 | 0 | 14 | 3361 |
| 15 | 2 | 1 | 5 | 5 | 17 | 1 | 0 | 31 | 3362 |
| 15r | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 3363 |
| 16 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 3364 |
| 16r | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 3365 |
| 17 | 3 | 3 | 3 | 3 | 7 | 0 | 0 | 25 | 3366 |
| 17r | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3367 |
| 18 | 2 | 2 | 2 | 2 | 5 | 0 | 0 | 0 | 3368 |
| 18r | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 3369 |
| 19 | 2 | 5 | 1 | 0.1 | 0 | 0.1 | 0.1 | 5 | 3370 |
| 19r | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3371 |
| 20 | 2 | 2 | 4 | 4 | 11 | 0 | 0 | 25 | 3372 |
| 20r | 0 | 2 | 2 | 0 | 0 | 2 | 1 | 0 | 3373 |
| 21 | 1 | 2 | 2 | 2 | 0 | 1 | 1 | 9 | 3374 |
| | | | | | | | | | |
| 21r | 1 | 3 | 1 | 1 | 2 | 1 | 0 | 0 | 3375 |
| 22 | 1 | 3 | 4 | 4 | 18 | 1 | 0 | 11 | 3376 |
| 22r | 2 | 3 | 2 | 2 | 15 | 0 | 0 | 18 | 3377 |
| 23 | 2 | 2 | 3 | 3 | 12 | 0 | 0 | 25 | 3378 |
| 23r | 2 | 2 | 4 | 4 | 22 | 0 | 0 | 5 | 3379 |
| 24 | 2 | 2 | 4 | 4 | 15 | 0 | 0 | 26 | 3380 |
| 24r | 1 | 1 | 4 | 4 | 24 | 0 | 0 | 4 | 3381 |

| Station ID | Epiphyte | TMAC | TSAV | Va BB | Va SS | Hv BB | Ms | BH (cm) | Pic ID |
|---|---|---|---|---|---|---|---|---|---|
| Area B | | | | | | | | | |
| 1 | 3 | 1 | 3 | 3 | 16 | 0 | 0 | 25 | 3318-19 |
| 1r | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 10 | 3320 |
| 2 | 2 | 0 | 5 | 5 | 21 | 0 | 0 | 40 | 3321 |
| 2r | 3 | 0 | 4 | 4 | 29 | 0 | 0 | 8 | 3322 |
| 3 | 3 | 1 | 5 | 5 | 18 | 0 | 0 | 35 | 3322-25 |
| 3r | 3 | 1 | 4 | 4 | 22 | 0 | 0 | 7 | 3326 |
| 4 | 2 | 1 | 4 | 4 | 17 | 0 | 0 | 36 | 3327 |
| 4r | 3 | 1 | 1 | 1 | 2 | 0 | 0 | 12 | 3328 |
| 5 | 2 | 0 | 5 | 5 | 35 | 0 | 0 | 33 | 3329 |
| 5r | 3 | 0 | 5 | 5 | 29 | 0 | 0 | 7 | 3330 |
| 6 | 1 | 1 | 5 | 5 | 35 | 0 | 0 | 34 | 3331 |
| 6r | 2 | 1 | 4 | 4 | 27 | 0 | 0 | 7 | 3332 |

| Station ID | Epiphyte | TMAC | TSAV | Va BB | Va SS | Hv BB | Ms | BH (cm) | Pic ID |
|---|---|---|---|---|---|---|---|---|---|
| Area C | | | | | | | | | |
| 1 | 2 | 1 | 5 | 5 | 26 | 0 | 0 | 35 | 3282 |
| 1r | 1 | 2 | 2 | 1 | 1 | 1 | 0 | 9 | 3281 |
| 2 | 1 | 0 | 5 | 5 | 16 | 0 | 0 | 55 | 3283 |
| 2r | 1 | 1 | 3 | 2 | 2 | 1 | 1 | 12 | 3284 |
| 3 | 1 | 1 | 4 | 4 | 14 | 0 | 0 | 40 | 3285 |
| 3r | 0 | 1 | 0.5 | 0.5 | 0 | 0.5 | 0 | 3 | 3286 |
| 4 | 2 | 5 | 5 | 5 | 24 | 0 | 0 | 52 | 3287 |
| 4r | 1 | 1 | 3 | 2 | 6 | 1 | 1 | 10 | 3288 |
| 5 | 1 | 1 | 5 | 5 | 20 | 1 | 0 | 48 | 3289 |
| 5r | 1 | 1 | 2 | 2 | 14 | 0.5 | 0.5 | 15 | 3290 |
| 6 | 1 | 1 | 3 | 3 | 21 | 0 | 0 | 46 | 3191 |
| 6r | 1 | 1 | 2 | 2 | 22 | 0 | 0 | 15 | 3292 |
| 7 | 1 | 3 | 1 | 0.5 | 0 | 1 | 0 | 8 | 3293 |
| 7r | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3294 |
| 8 | 1 | 1 | 5 | 5 | 19 | 0 | 0 | 49 | 3295-96 |
| 8r | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 18 | 3297 |
| 9 | 1 | 0 | 5 | 5 | 23 | 0 | 0 | 58 | 3298 |
| 9r | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3299 |
| 10 | 2 | 0 | 2 | 2 | 5 | 0 | 0 | 20 | 3300 |
| 10r | 1 | 0 | 1 | 1 | 2 | 0 | 0 | 4 | 3301 |
| 11 | 1 | 0 | 1 | 1 | 2 | 0 | 0 | 32 | 3302 |
| 11r | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3303 |
| 12 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 10 | 3304 |
| 12r | 1 | 1 | 4 | 4 | 16 | 0 | 0 | 7 | 3305 |
| 13 | 1 | 0 | 2 | 2 | 3 | 0 | 0 | 18 | 3306 |
| 13r | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3307 |
| 14 | 1 | 0 | 5 | 5 | 26 | 0 | 0 | 68 | 3308 |
| 14r | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 20 | 3309 |
| 15 | 1 | 0 | 5 | 5 | 22 | 0 | 0 | 55 | 3310 |
| 15r | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 13 | 3311 |
| 16 | 2 | 0 | 5 | 5 | 29 | 0 | 0 | 48 | 3312 |
| 16r | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 3313 |
| 17 | 2 | 0 | 4 | 4 | 27 | 0 | 0 | 29 | 3314 |
| 17r | 1 | 1 | 1 | 1 | 2 | 0 | 1 | 0 | 3315 |
| 18 | 2 | 0 | 4 | 4 | 19 | 0 | 0 | 5 | 3316 |
| 18r | 2 | 1 | 1 | 1 | 12 | 0 | 1 | 8 | 3317 |
| | | | | | | | | | |

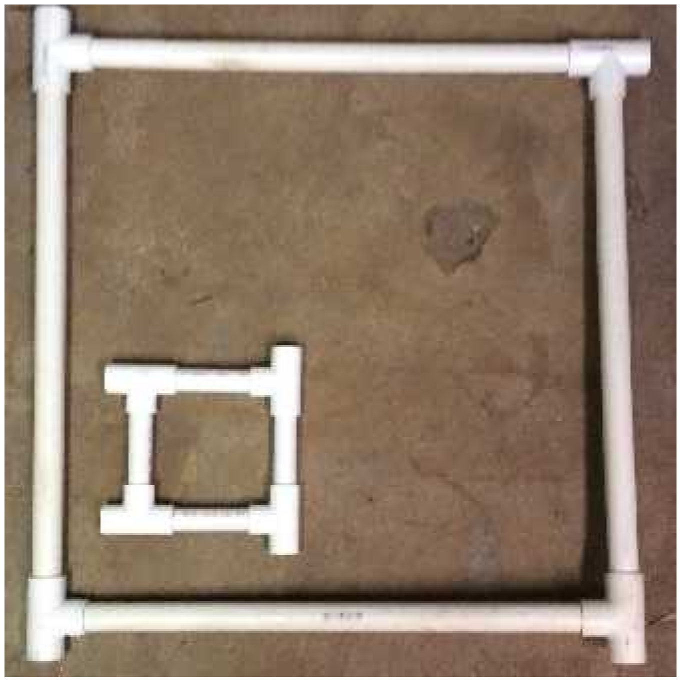
| Station ID | Epiphyte | TMAC | TSAV | Va BB | Va SS | Hv BB | Ms | BH (cm) | Pic ID |
|---|---|---|---|---|---|---|---|---|---|
| Area 1 | | | | | | | | | |
| 1 | 1 | 0.5 | 4 | 4 | 21 | 0 | 0 | 7 | 3418 |
| 2 | 1 | 0 | 2 | 2 | 8 | 0 | 0 | 6 | 3419 |
| 3 | 1 | 0 | 2 | 2 | 13 | 0 | 0 | 4 | 3420 |
| 4 | 2 | 1 | 4 | 4 | 22 | 0 | 0 | 5 | 3421 |
| 5 | 1 | 0 | 5 | 5 | 28 | 0 | 0 | 5 | 3422 |
| 6 | 1 | 0 | 3 | 3 | 19 | 0 | 0 | 4 | 3423 |
| 7 | 1 | 0 | 2 | 2 | 6 | 0 | 0 | 5 | 3424 |
| 8 | 1 | 0 | 3 | 3 | 16 | 0 | 0 | 6 | 3425 |
| 9 | 1 | 0 | 2 | 2 | 5 | 0 | 0 | 5 | 3426 |
| 10 | 1 | 0 | 5 | 5 | 41 | 0 | 0 | 6 | 3427 |
| 11 | 2 | 0 | 5 | 5 | 37 | 0 | 0 | 5 | 3428 |
| 12 | 1 | 0 | 5 | 5 | 34 | 0 | 0 | 5 | 3429 |
| 13 | 1 | 0 | 5 | 5 | 29 | 0 | 0 | 4 | 3430 |
| 14 | 1 | 0 | 5 | 5 | 31 | 0 | 0 | 4 | 3431 |
| 15 | 1 | 0 | 4 | 4 | 26 | 0 | 0 | 5 | 3432 |
| 16 | 1 | 0 | 5 | 5 | 38 | 0 | 0 | 5 | 3433 |
| 17 | 1 | 0.5 | 5 | 5 | 42 | 0 | 0 | 8 | 3434 |
| 18 | 2 | 0 | 5 | 5 | 37 | 0 | 0 | 7 | 3435 |
| 19 | 1 | 0 | 5 | 5 | 33 | 0 | 0 | 9 | 3436 |
| 20 | 1 | 0 | 5 | 5 | 29 | 0 | 0 | 9 | 3437 |

| Station ID | Epiphyte | TMAC | TSAV | Va BB | Va SS | Hv BB | Ms | BH (cm) | Pic ID |
|---|---|---|---|---|---|---|---|---|---|
| Area 2 | | | | | | | | | |
| 1 | 1 | 2 | 2 | 2 | 8 | 0 | 0 | 6 | 3393 |
| 2 | 2 | 2 | 2 | 1 | 4 | 1 | 0 | 4 | 3394 |
| 3 | 1 | 0 | 5 | 5 | 36 | 0 | 0 | 7 | 3395 |
| 4 | 1 | 0 | 4 | 4 | 19 | 1 | 0 | 10 | 3396 |
| 5 | 1 | 2 | 3 | 3 | 14 | 0 | 0 | 6 | 3397 |
| 6 | 1 | 1 | 5 | 5 | 33 | 0 | 0 | 5 | 3398 |
| 7 | 2 | 0.5 | 3 | 3 | 13 | 0.5 | 0 | 8 | 3399 |
| 8 | 1 | 0.5 | 2 | 2 | 2 | 0 | 0 | 4 | 3400 |
| 9 | 1 | 0.5 | 5 | 5 | 31 | 0.5 | 0 | 6 | 3401 |
| 10 | 1 | 1 | 4 | 4 | 18 | 0.5 | 0 | 7 | 3402 |
| 11 | 2 | 1 | 5 | 5 | 28 | 0 | 0 | 7 | 3403 |
| 12 | 2 | 2 | 5 | 5 | 26 | 0 | 0 | 9 | 3404 |
| 13 | 1 | 1 | 4 | 3 | 15 | 1 | 0 | 8 | 3405 |
| 14 | 1 | 2 | 2 | 2 | 8 | 0 | 0 | 12 | 3406 |
| 15 | 1 | 2 | 5 | 4 | 26 | 2 | 0 | 6 | 3407 |
| 16 | 1 | 1 | 4 | 4 | 19 | 1 | 0 | 9 | 3408 |
| 17 | 1 | 1 | 5 | 5 | 28 | 1 | 0 | 10 | 3409 |
| 18 | 2 | 1 | 2 | 2 | 9 | 0 | 0 | 7 | 3410 |
| 19 | 1 | 3 | 1 | 1 | 1 | 0 | 0 | 10 | 3411 |
| 20 | 1 | 2 | 3 | 3 | 17 | 0 | 0 | 8 | 3412 |

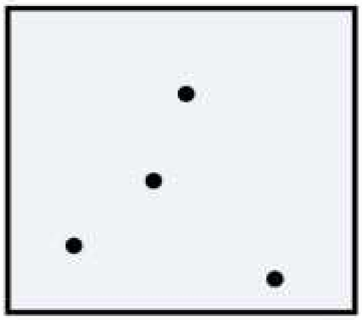
| Station ID | Epiphyte | TMAC | TSAV | Va BB | Va SS | Hv BB | Ms | BH (cm) | Pic ID |
|---|---|---|---|---|---|---|---|---|---|
| **Area 3** | | | | | | | | | |
| 1 | 1 | 1 | 3 | 3 | 11 | 0 | 0 | 7 | 3440 |
| 2 | 2 | 1 | 3 | 3 | 14 | 0 | 0 | 8 | 3441 |
| 3 | 1 | 0 | 3 | 3 | 13 | 0.5 | 0 | 10 | 3442 |
| 4 | 1 | 1 | 3 | 2 | 9 | 2 | 0 | 11 | 3443 |
| 5 | 2 | 2 | 3 | 2 | 7 | 2 | 0 | 8 | 3444 |
| 6 | 1 | 3 | 2 | 2 | 9 | 2 | 0 | 9 | 3445 |
| 7 | 1 | 1 | 5 | 4 | 19 | 2 | 0 | 12 | 3446 |
| 8 | 1 | 3 | 2 | 2 | 8 | 0.5 | 0 | 10 | 3447 |
| 9 | 1 | 1 | 3 | 2 | 6 | 2 | 0 | 6 | 3448 |
| 10 | 1 | 5 | 2 | 2 | 1 | 0 | 0 | 9 | 3449 |
| 11 | 2 | 2 | 5 | 3 | 16 | 2 | 0 | 8 | 3450 |
| 12 | 1 | 1 | 3 | 3 | 11 | 2 | 0 | 8 | 3451 |
| 13 | 1 | 1 | 5 | 5 | 26 | 0.5 | 0 | 7 | 3452 |
| 14 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3453 |
| 15 | 1 | 0 | 2 | 2 | 1 | 0 | 0 | 13 | 3454 |
| 16 | 1 | 1 | 5 | 4 | 22 | 3 | 0 | 8 | 3455 |
| 17 | 2 | 1 | 5 | 5 | 24 | 1 | 0 | 6 | 3456 |
| 18 | 1 | 1 | 5 | 5 | 29 | 2 | 0 | 10 | 3457 |
| 19 | 1 | 2 | 2 | 2 | 4 | 0 | 0 | 9 | 3458 |
| 20 | 1 | 2 | 3 | 2 | 3 | 2 | 0 | 7 | 3459 |

## 9.2 - Visual References

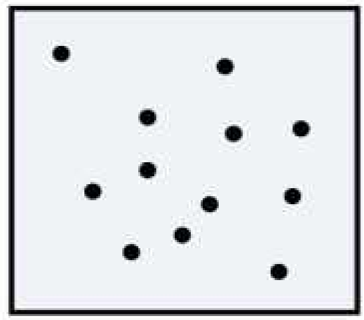
***Visual Reference 1 – Example of 0.25$^2$ (outside) and 0.10$^2$ (inside) Quadrats Used for Monitoring***



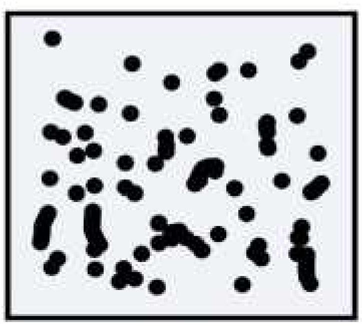
***Visual Reference 2 – Example of Braun-Blanquet Coverage to Corresponding Score***



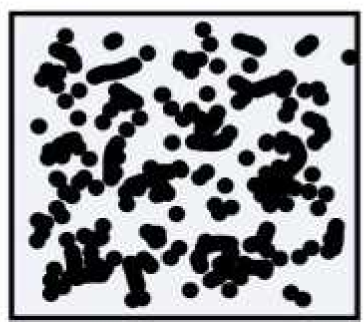
.5 (sparse)



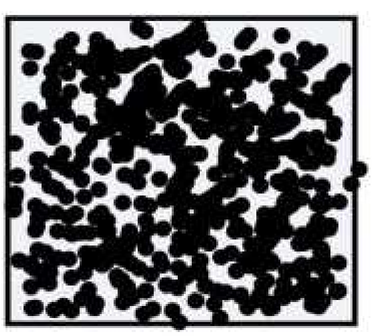
1 ( less than 5%)



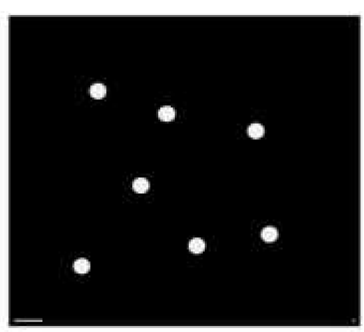
2 (5 - 25%)



3 (26 - 50%)



4 (51 - 75%)



5 (76 - 100%)

## 9.3 - Quadrat Photos

### *Planted Area 1 and Reference Site*

### *Planted Area 2 and Reference Site*

*Planted Area 3 and Reference Site*

*Planted Area 4 and Reference Site*

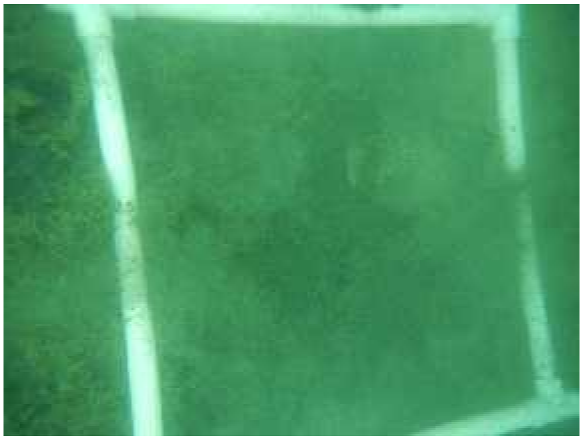
*Planted Area 5 and Reference Site*

*Planted Area 6 and Reference Site*

*Planted Area 7 and Reference Site*

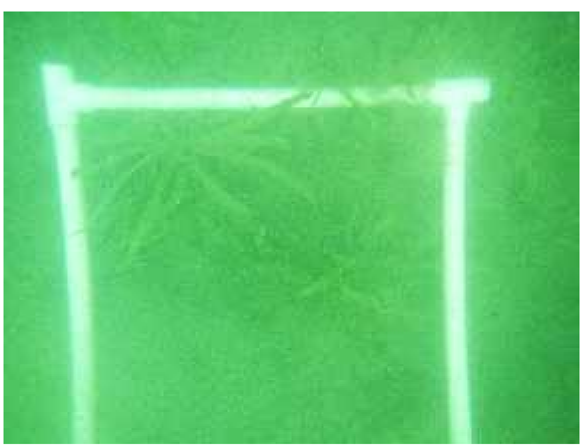
*Planted Area 8 and Reference Site*

*Planted Area 9 and Reference Site*

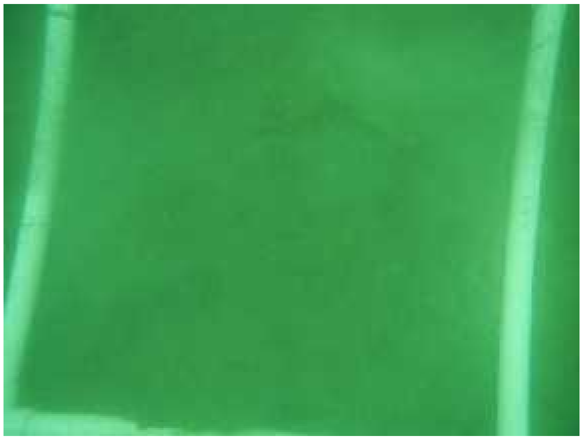


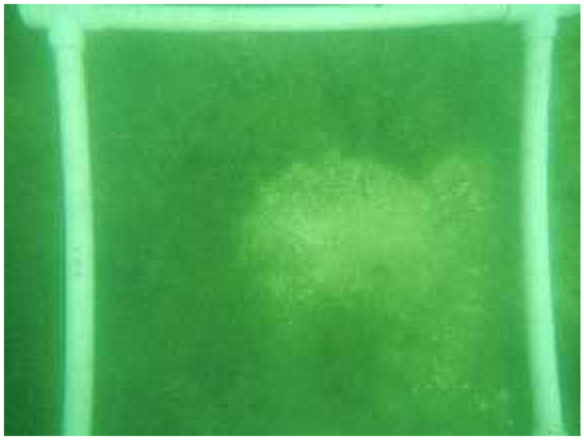
*Planted Area 10 and Reference Site*

*Planted Area 11 and Reference Site*

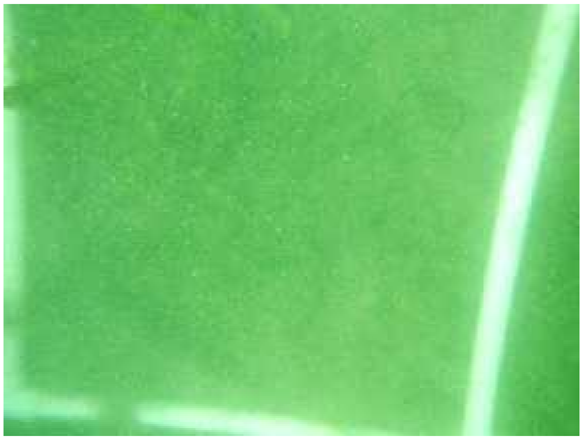


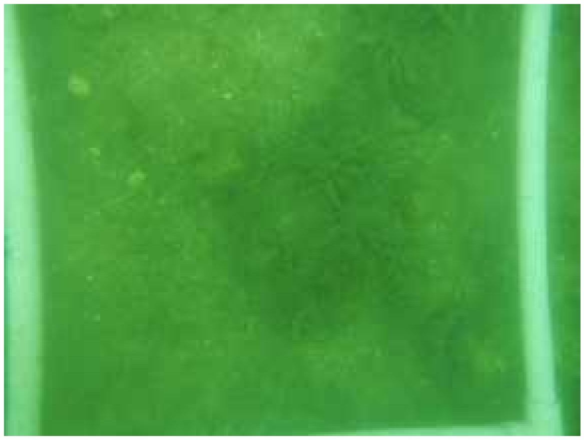
*Planted Area 12 and Reference Site*





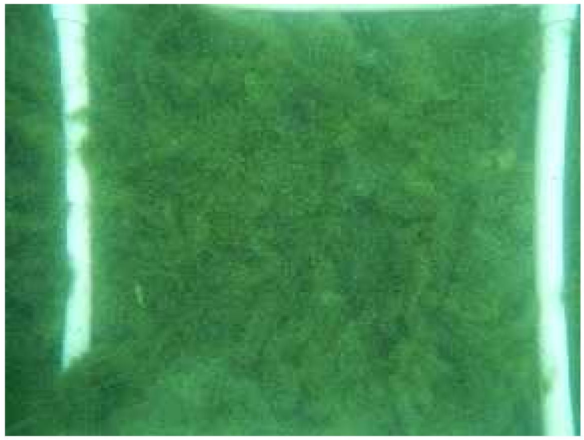
*Planted Area 13 and Reference Site*



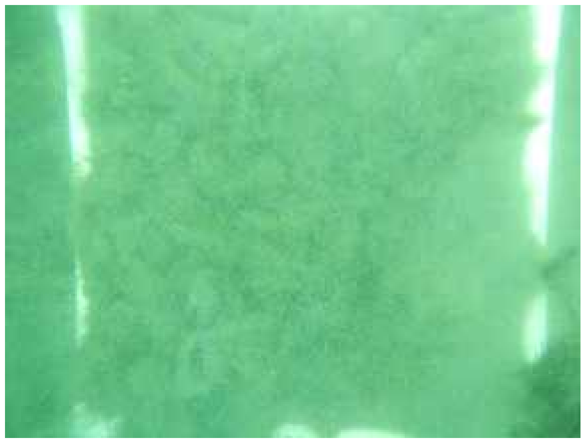


*Planted Area 14 and Reference Site*

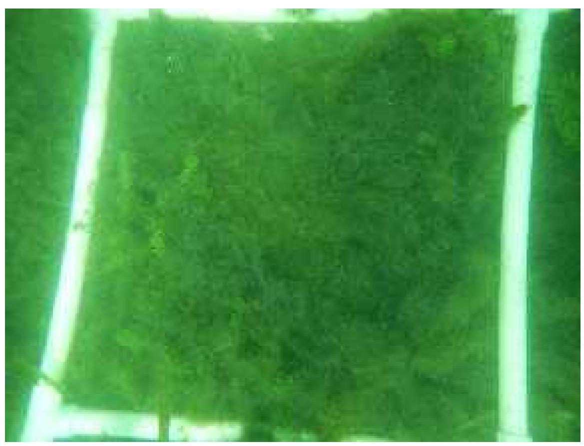
### *Planted Area 15 and Reference Site*



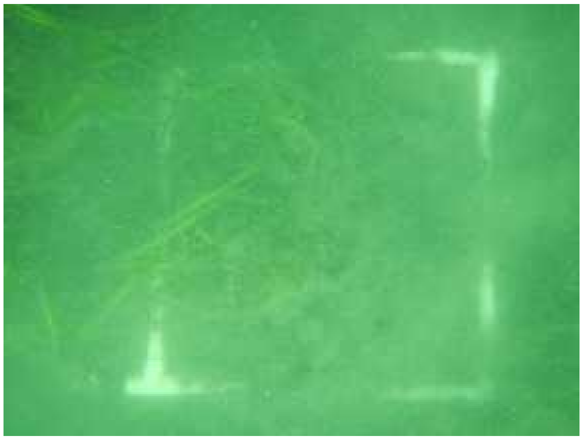
### *Planted Area 16 and Reference Site*



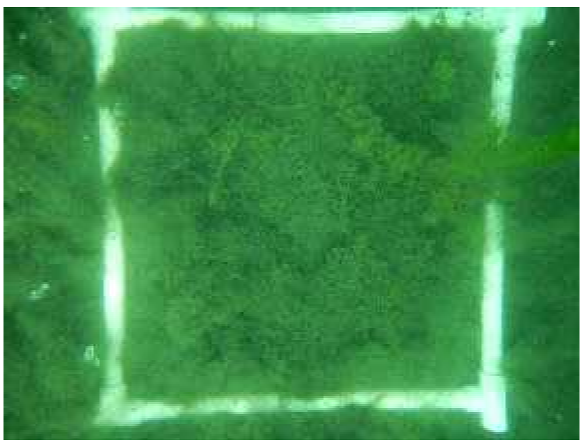
### *Planted Area 17 and Reference Site*



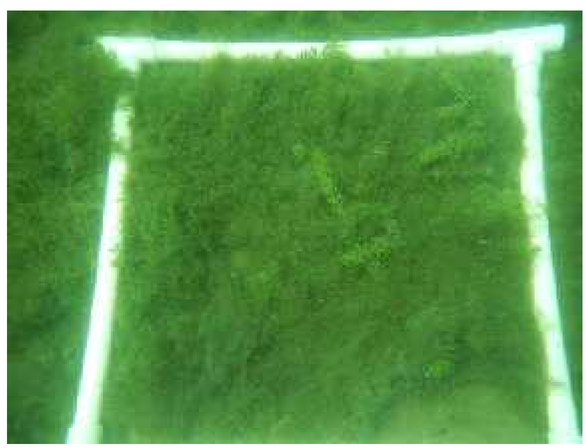
***Planted Area 18 and Reference Site***



***Planted Area 19 and Reference Site***



***Planted Area 20 and Reference Site***



### *Planted Area 21 and Reference Site*

### *Planted Area 22 and Reference Site*

### *Planted Area 23 and Reference Site*

*Planted Area 24 and Reference Site*

*Planted Area 25 and Reference Site*

*Planted Area 26 and Reference Site*

***Planted Area 27 and Reference Site***

***Planted Area 28 and Reference Site***

***Planted Area 29 and Reference Site***

*Planted Area 30 and Reference Site*

*Planted Area 31 and Reference Site*

*Planted Area 32 and Reference Site*

***Planted Area 33 and Reference Site***

***Planted Area 34 and Reference Site***

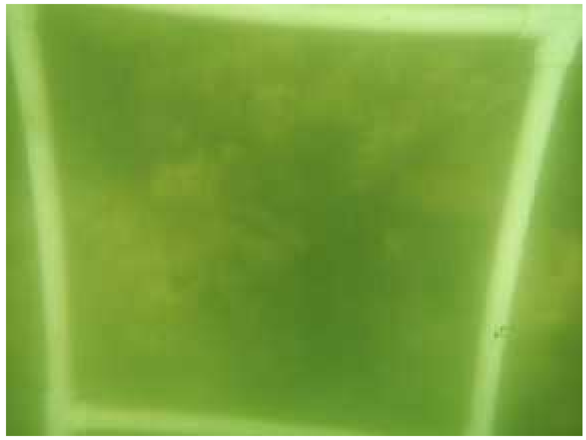
***Planted Area 35 and Reference Site***

*Planted Area 36 and Reference Site*

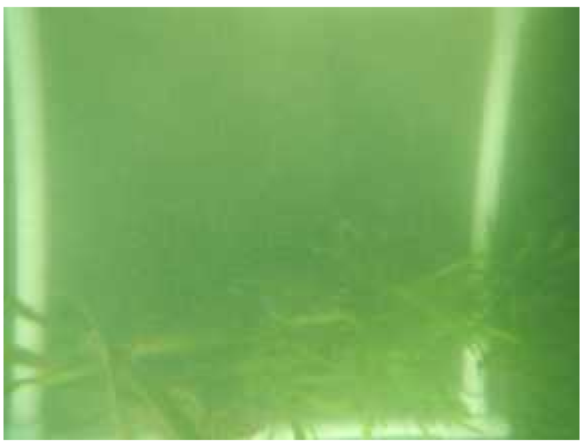
*Planted Area 37 and Reference Site*

*Planted Area 38 and Reference Site*

***Planted Area 39 and Reference Site***



***Planted Area 40 and Reference Site***



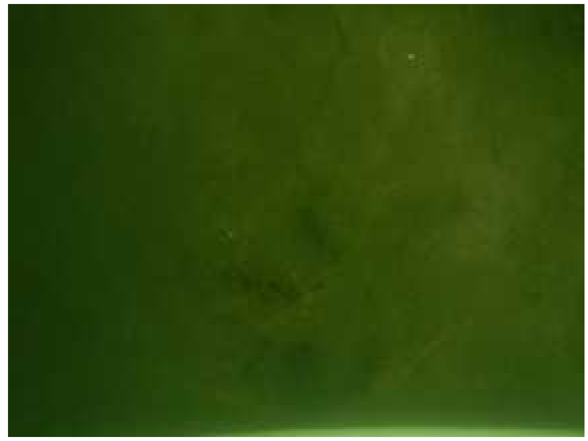
***Planted Area 41 and Reference Site***

*Planted Area 42 and Reference Site*

*Planted Area 43 and Reference Site*

*Planted Area 44 and Reference Site*

## *Planted Area 45 and Reference Site*



## *Planted Area 46 and Reference Area*

## *Planted Area 47 and Reference Site*

*Planted Area 48 and Reference Site*

*Unprotected Area 1*

Quadrat 1

Quadrat 2

Quadrat 3

Quadrat 4

Quadrat 5

Quadrat 6

Quadrat 7

Quadrat 8

Quadrat 9

Quadrat 10

Quadrat 11

Quadrat 12

Quadrat 13

Quadrat 14

Quadrat 15

Quadrat 16

Quadrat 17

Quadrat 18

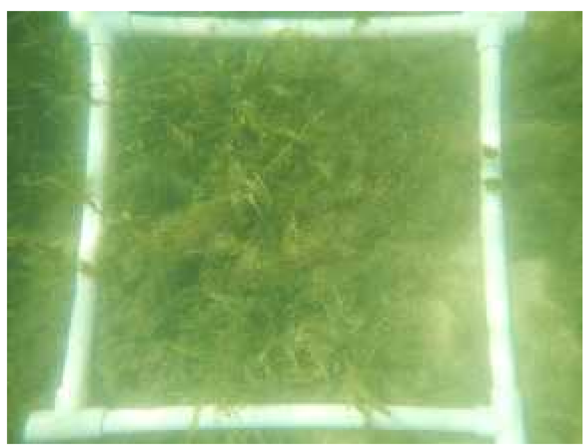
Quadrat 19

Quadrat 20

***Unprotected Area 2***

Quadrat 1

Quadrat 2

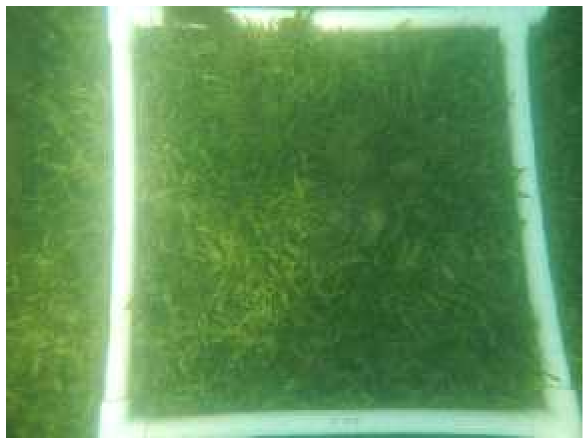


Quadrat 3

Quadrat 4

Quadrat 5

Quadrat 6



Quadrat 7

Quadrat 8

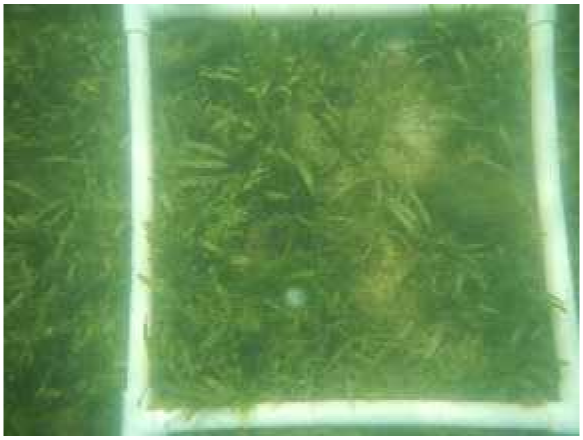
Quadrat 9

Quadrat 10

Quadrat 11

Quadrat 12

Quadrat 13



Quadrat 14

Quadrat 15

Quadrat 16

Quadrat 17

Quadrat 18

Quadrat 19

Quadrat 20

### *Unprotected Area 3*

Quadrat 1

Quadrat 2

Quadrat 3

Quadrat 4

Quadrat 5

Quadrat 6

Quadrat 7

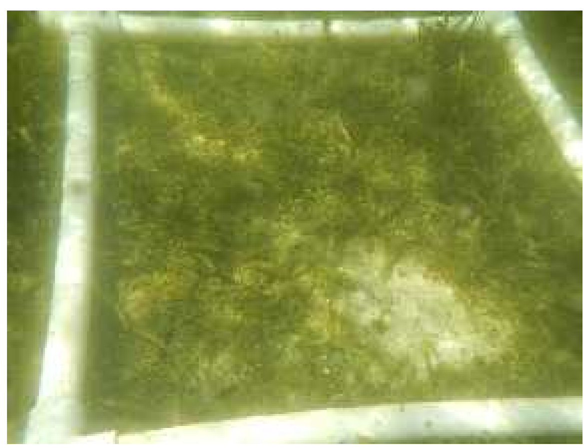
Quadrat 8

Quadrat 9

Quadrat 10

Quadrat 11

Quadrat 12



Quadrat 13

Quadrat 14

Quadrat 15

Quadrat 16

Quadrat 17

Quadrat 18

Quadrat 19

Quadrat 20

**9.4 - Formulas**

Braun-Blanquet Frequency = Number of quadrats a species occupies / total number of quadrats

Braun-Blanquet Abundance = Sum of a species Braun Blanquet Score / Number of quadrats that species occupies

Braun-Blanquet Density = Sum of a species Braun-Blanquet Score / total number of quadrats