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Effects of Vegetation Management Strategies on the Establishment of Submersed Aquatic Vegetation in Cell 5B of Stormwater Treatment Area 1 West (STA-1W)

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ABSTRACT

This monitoring study was conducted in STA-1W Cell 5B to evaluate effects of four vegetation management strategies on the reestablishment of submersed aquatic vegetation (SAV) at different sites with rice (*Oryza sativa*), sprangletop grass (*Leptochloa fascicularis*), barnyard grass (*Echinochloa* sp.), or miscellaneous plant species dominated. These vegetation management strategies include (A) grass detritus left undisturbed, (B) grass detritus removed to allow reestablishment of SAV from the sediment seedbank, (C) grass detritus left undisturbed and healthy SAV transplanted directly on top of the detritus, and (D) grass detritus removed and healthy SAV transplanted directly into the empty water column.

The study was conducted from November 2006 to December 2007. It should be noted that during this time period the STAs, including this cell, suffered from a two-year drought period. This could have affected the outcome of this experiment.

Primary findings from this study are:

1) Hydrilla (*Hydrilla verticillata*) and Coontail (*Ceratophyllum demersum*) showed increased coverage from April to December in 2007. In contrast, Chara (*Chara* spp.) coverage did not significantly change during the period of the study.
2) Vegetation management strategies significantly affected Coontail areal coverage in stations with different vegetation types. Coontail coverage in harvested stations was higher than in stations with transplanting SAV alone.
3) Vegetation management strategies did not influence Naiad (*Najas guadalupensis*) or Hydrilla coverage but significantly affected Chara coverage. The combination of harvesting and transplanting SAV improved Chara establishment.
4) Rice-dominated stations generally had higher Coontail coverage than sprangletop and barnyard grass-dominated stations.

INTRODUCTION

Stormwater Treatment Areas (STAs) are large constructed wetlands built by the South Florida Water Management District to achieve compliance with phosphorus (P) and other water quality standards as mandated by the 1994 Everglades Forever Act. The STAs remove excess P from stormwater runoff prior to discharge into the Everglades Protection Area. Management of aquatic vegetation is an important component of optimizing the treatment performance of the STAs. Aquatic vegetation serves to sequester nutrients from surface waters, as well as provide a substrate and carbon source for microbiota, e.g. algae, bacteria, and fungi in constructed wetlands (Brix, 1994; Reed et al., 1995; Wetzel, 2000). Transplanting desirable aquatic vegetation species and/or harvesting standing dead plant material have been proposed and used as vegetation management practices, but have not been experimentally tested yet.

Cell 5B of STA-1W was dominated by submersed aquatic vegetation (SAV) prior to the 2004 and 2005 hurricanes. During 2006 and 2007, Cell 5B underwent rehabilitation to repair damage to its vegetation community incurred during 2004 and 2005 hurricanes (Pietro et al., 2008). This effort, coinciding with Long-Term Plan enhancement construction activities (Burns & McDonnell, 2003), involved draining of Cell 5B resulting in dry conditions for five months. Consequently, the southern portion of Cell 5B became dominated by sprangletop grass and barnyard grass that were treated with herbicides (Toth, *personal communication*). After the cell was re-hydrated, both grass species left a substantial quantity of decaying biomass both above and within the water column. The decaying biomass was blamed for unsuccessful establishment of SAV, which is the desired vegetation type for this cell.

The objective of this study was to document the presence/absence of SAV in the areas dominated by sprangletop and barnyard grasses in STA-1W Cell 5B and to evaluate the efficacy of four vegetation management strategies to reestablish SAV in these areas.

MATERIALS AND METHODS

Site description

STA-1W is located approximately 15 miles west of the city of West Palm Beach, and borders Water Conservation Area 1 in Palm Beach County, FL. STA-1W occupies approximately 6,670 acres and consists of three flow-ways; the eastern flow-way with Cells 1A, 1B, and 3; the western flow-way with Cells 2A, 2B, and 4; and the northern flow-way with Cells 5A and 5B (**Figure 1**). The study site, Cell 5B has a treatment area of 2,293 acres, a year-round target water depth of 1.25 feet, and an average ground elevation of 9.0 ft (NGVD).

Plot establishment

Seventeen sampling stations were established throughout Cell 5B in November 2006 (**Figure 2**). The selected stations represented four different vegetation types: rice (5B108, 5B127, 5B128), sprangletop grass (5B182, 5B202, 5B203, 5B204, 5B184, 5B164), barnyard grass (5B147, 5B148, 5B167, 5B168), and miscellaneous species (5B106, 5B165, 5B142, and 5B162). Each vegetation type had –three to six sampling stations.

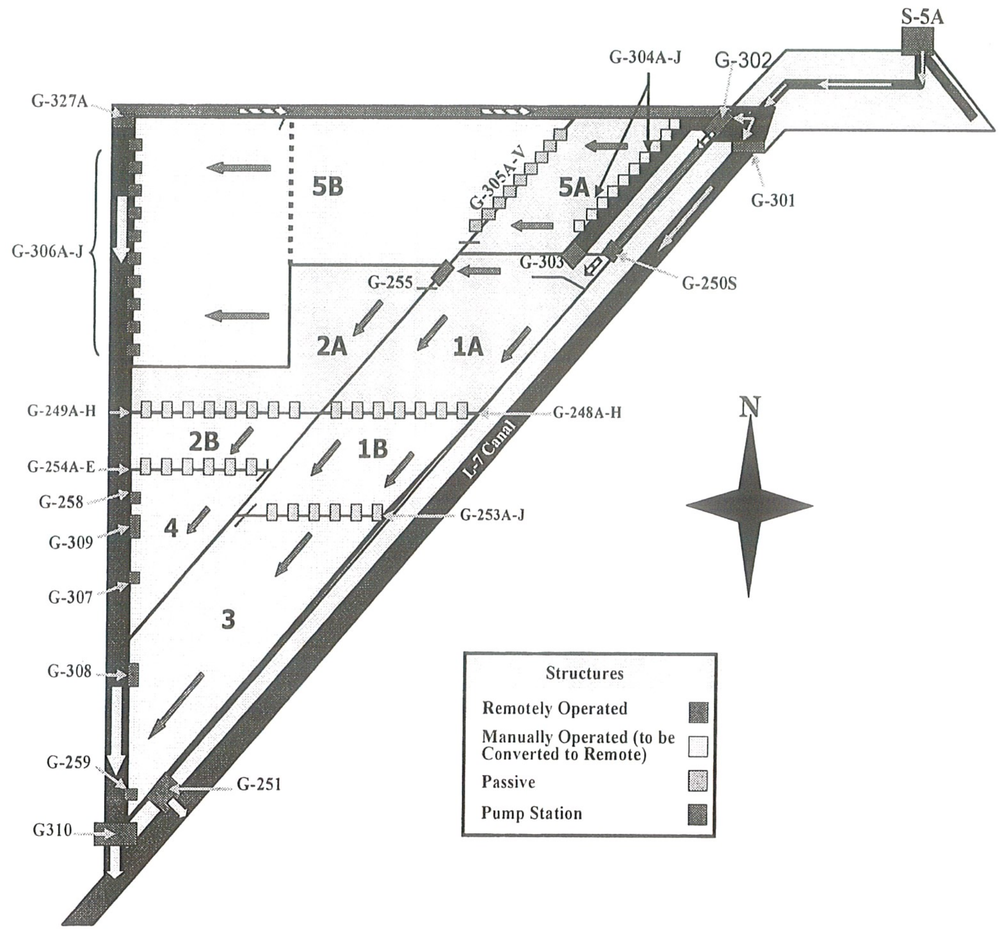

Figure 1. Schematic of STA-1 West (map not drawn to scale).

At each of the 17 sampling stations, four 1m × 1 m corrals were built using PVC poles and orange barrier fence (**Figure 3**); corrals at a given station were spaced approximately 10 m apart from each other. Each corral at a sampling station represented one of the following vegetation management strategies: (A) grass detritus left undisturbed (Control); (B) grass detritus removed to allow reestablishment of SAV from the sediment seedbank (Harvest); (C) grass detritus left undisturbed and healthy SAV transplanted directly on top of the detritus (Transplant); and (D) grass detritus removed and healthy SAV transplanted directly into the empty water column (Harvest/Transplant).

All aboveground plant material was removed from the 34 Harvest and Harvest/Transplant corrals in March 2007. Live SAV biomass and dead plant material (mostly from emergent grasses) from each corral were weighed separately. Healthy SAV was then harvested from the northwest corner of Cell 5B and transplanted into the 34 Transplant and Harvest/Transplant corrals at the end of March 2007. Approximately two pounds wet-weight of SAV, mainly native Naiad and Coontail, were added to each of these aforementioned corrals.

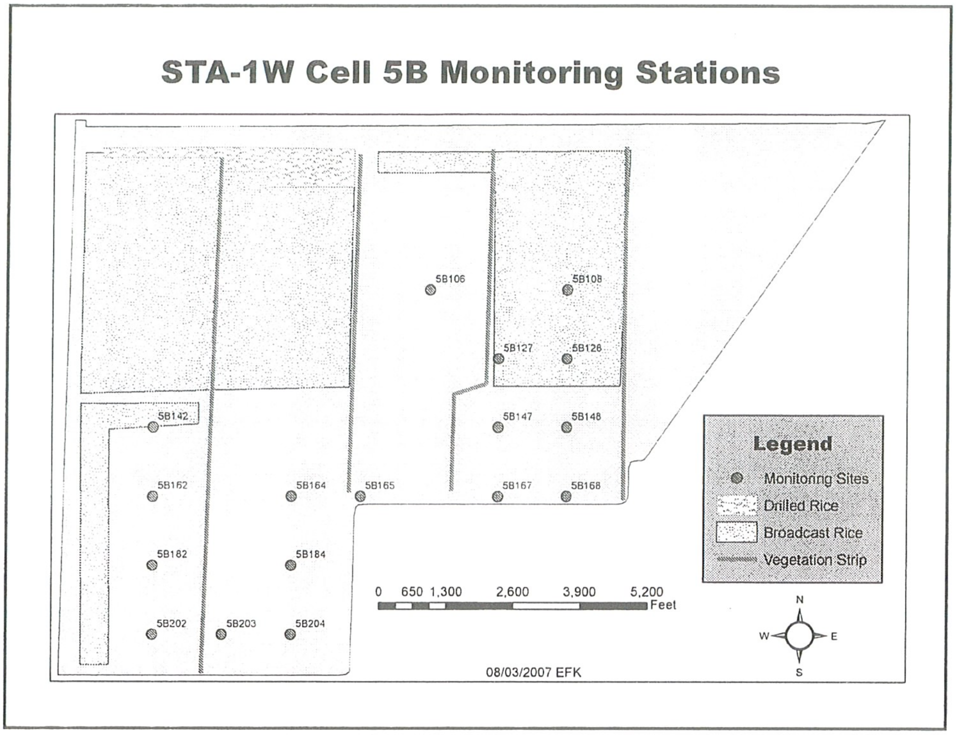

Figure 2. Location of sampling stations in Cell 5B of STA-1 West.

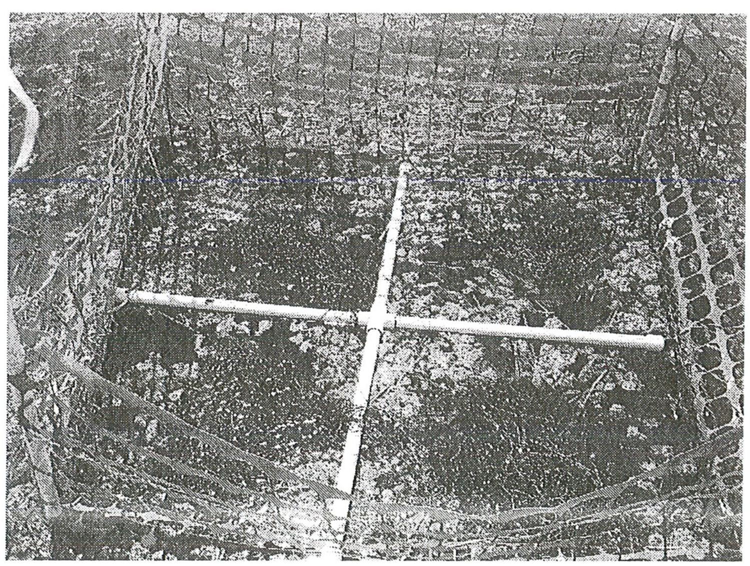

Figure 3. Example of a 1m × 1 m corral showing the four quadrats. This particular corral illustrates the Transplant management strategy in which SAV was placed directly on top of the grass detritus.

Monitoring procedure

SAV coverage was monitored in all 68 corrals at 1, 3, 5, 7, and 9-month intervals after the start of the experiment (April, June, August, October, and December 2007). Each corral was subdivided into four quadrats as shown in **Figure 3** and SAV areal coverage within each quadrat was estimated using three categories, low (<1/3, mid-range 16.7%), moderate (1/3 to 2/3, mid-range 50%), or high (>2/3, mid-range 83.3%) for each SAV species (Naiad, Hydrilla, Chara, and Coontail). Water depth was measured in each corral on all sampling dates. All data on areal cover of SAV species and water depth for corrals were obtained by calculating their averages of four quadrats and then were used in statistical analyses.

Statistical analysis

SAS PROC LOGISTIC (Version 9.1; SAS Institute, Cary, NC, USA) was used to examine the effects of vegetation type, vegetation management strategy, and sampling interval on SAV coverage in the corrals as well as the effect of water depth on the establishment of SAV. Two stations (5B203 and 5B204) were inaccessible in June 2007 due to low water level, which resulted in the reestablishment of sprangletop grass and subsequent herbicide application to eradicate it in August 2007. Since these stations were treated differently from other sites, they were excluded from data analyses. Figure presentation for response variables was based on the statistical significance of their main effects and interactions at a probability significance level of 0.05. For data presentation purposes, SAV areal coverage was converted to percent cover with the mid-range values of coverage categories and was expressed as percent cover in figures after data analyses were conducted. Regardless of the conversion, areal coverage was not treated as a continuous variable.

RESULTS

Prior to initiating this study, all stations in Cell 5B typically had less than 25% SAV areal coverage, consisting primarily of Hydrilla and Naiad. Of the 34 corrals that were harvested, 65% contained less than one pound (wet weight) of live plant material, whereas all 68 corrals contained some dead plant material and 71% of them contained greater than five pounds of dead biomass.

Effect of vegetation management strategy on Naiad

Maximum likelihood estimates derived from logistic regression indicated that the effect of time (i.e., sampling interval) on Naiad areal coverage was statistically significant while the effects of vegetation type or vegetation management strategy were not (**Table 1**). The significant time effect suggested that the pattern of change in Naiad areal coverage was largely a function of sampling interval. However, the effect of time on areal coverage was significantly influenced by vegetation type based on the significant vegetation type × time interaction term (**Table 1**). From April to August/ October, Naiad areal coverage increased in all corrals but the pattern differed in later months (**Figure 4**). There was a decline in coverage at stations with barnyard grass after

August while Naiad coverage continued increasing until October and then declined at the sprangletop grass and miscellaneous species-dominated stations.

Table 1. Analysis of maximum likelihood estimates derived from logistic regression of Naiad areal coverage in STA-1W Cell 5B corrals.

Parameter	DF	Likelihood Estimate	Standard Error	Wald Chi-square	Pr > Chi-Square
Intercept 0	1	1.4571	0.7982	3.3327	0.0679
Intercept 1	1	3.0349	0.8028	14.2916	0.0002
Intercept 2	1	3.6658	0.8026	20.6747	<0.0010
Vegetation type	1	-0.3210	0.3026	1.1253	0.2888
Time	1	-1.0098	0.2452	16.9592	<0.0010
Strategy*	1	-0.0805	0.2891	0.0775	0.7807
Vegetation type × Time	1	0.3071	0.0947	10.5222	0.0012
Vegetation type × Strategy	1	0.0089	0.1092	0.0066	0.9351
Time × Strategy	1	0.1611	0.0881	3.3449	0.0674
Vegetation type × Time × Strategy	1	-0.0599	0.0339	3.1218	0.0772

*Strategy = Vegetation Management Strategy

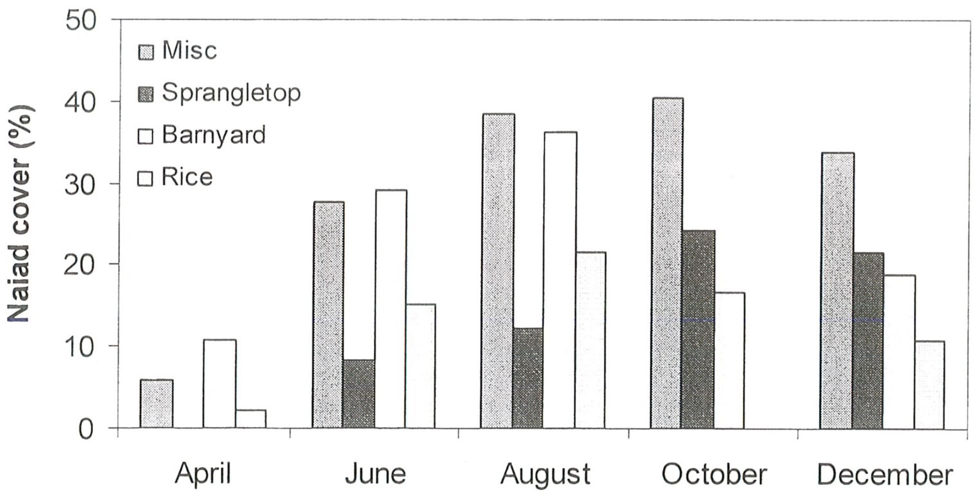

Figure 4. Change in Naiad mean areal coverage in STA-1W Cell 5B corrals as a function of time and emergent vegetation type. Data are pooled over vegetation management strategy. Note that Naiad data at rice stations in October were not available.

Effect of vegetation management strategy on Hydrilla

Hydrilla areal coverage was significantly affected only by time and not by vegetation type or vegetation management strategy (**Table 2**). Hydrilla coverage increased from April to December, probably indicating an SAV grow-in time-course (**Figure 5**).

Table 2. Analysis of maximum likelihood estimates derived from logistic regression of Hydrilla areal coverage in STA-1W Cell 5B corrals.

Parameter	DF	Likelihood Estimate	Standard Error	Wald Chi-square	Pr > Chi-Square
Intercept 0	1	1.8794	0.8217	5.2311	0.0222
Intercept 1	1	3.8128	0.8285	21.1784	<0.0010
Intercept 2	1	4.4095	0.8311	28.1462	<0.0010
Vegetation type	1	-0.3908	0.3081	1.6085	0.2047
Time	1	-0.6543	0.2472	7.0045	0.0081
Strategy*	1	-0.3293	0.3007	1.1990	0.2735
Vegetation type × Time	1	0.0558	0.0936	0.3560	0.5508
Vegetation type × Strategy	1	0.1878	0.1141	2.7090	0.0998
Time × Strategy	1	0.1489	0.0901	2.7325	0.0983
Vegetation type × Time × Strategy	1	-0.0585	0.0344	2.8927	0.0890

*Strategy = Vegetation Management Strategy

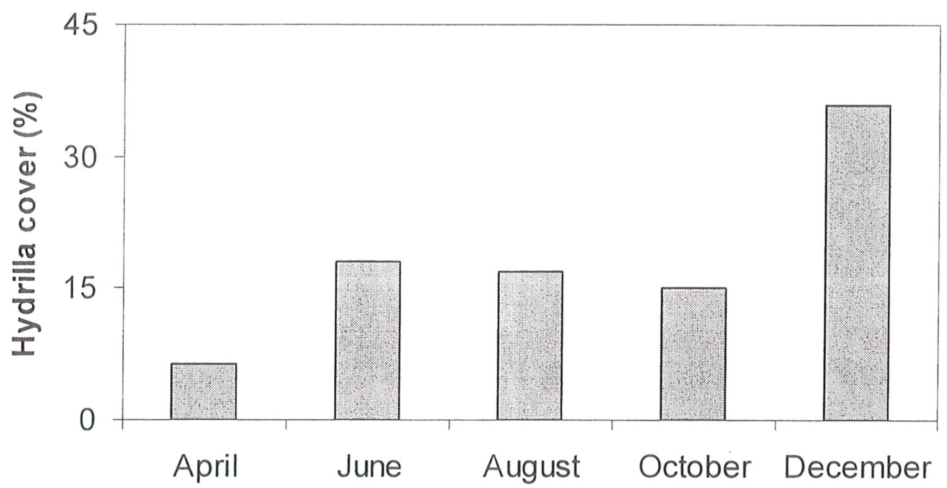

Figure 5. Change in Hydrilla mean areal coverage in STA-1W Cell 5B corrals as a function of time. Data are pooled over emergent vegetation type and vegetation management strategy.

Effect of vegetation management strategy on Chara

Chara areal coverage was significantly affected only by vegetation management strategy and not by time or emergent vegetation type (**Table 3**). Transplanting SAV and harvesting improved the establishment of Chara compared to the control (**Figure 6**). Furthermore, the combination of transplanting SAV and harvesting increased coverage over transplanting SAV or harvesting alone.

Table 3. Analysis of maximum likelihood estimates derived from logistic regression of Chara areal coverage in STA-1W Cell 5B corrals.

Parameter	DF	Likelihood Estimate	Standard Error	Wald Chi-square	Pr > Chi-Square
Intercept 0	1	3.8417	1.2361	9.6583	0.0019
Intercept 1	1	4.9453	1.2402	15.8991	<0.0010
Intercept 2	1	5.9779	1.2462	23.0099	<0.0010
Vegetation type	1	-0.2620	0.5070	0.2671	0.6053
Time	1	-0.5847	0.3476	2.8290	0.0926
Strategy*	1	-0.8253	0.4022	4.2101	0.0402
Vegetation type × Time	1	0.1638	0.1470	1.2414	0.2652
Vegetation type × Strategy	1	0.1765	0.1671	1.1159	0.2908
Time × Strategy	1	0.0322	0.1146	0.0789	0.7788
Vegetation type × Time × Strategy	1	-0.0258	0.0485	0.2826	0.5950

*Strategy = Vegetation Management Strategy

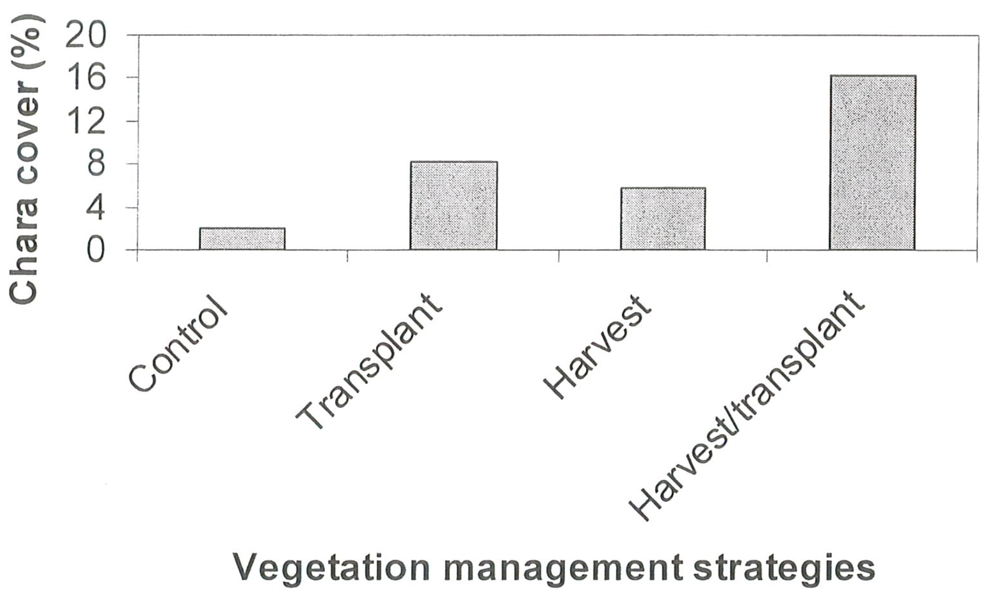

Figure 6. Changes in Chara mean areal coverage in STA-1W Cell 5B corrals as a function of vegetation management strategies. Data are pooled over time and vegetation type.

Effect of vegetation management strategy on Coontail

Coontail coverage was significantly affected by vegetation type, time, and vegetation management strategy (**Table 4**). Coverage increased over time from April to December (**Figure 7**), probably reflecting an SAV grow-in process.

Table 4. Analysis of maximum likelihood estimates derived from logistic regression of Coontail areal coverage in STA-1W Cell 5B corrals.

Parameter	DF	Likelihood Estimate	Standard Error	Wald Chi-square	Pr > Chi-Square
Intercept 0	1	14.9629	3.1810	22.1265	<0.0010
Intercept 1	1	16.5831	3.1858	27.0958	<0.0010
Intercept 2	1	17.3943	3.1887	29.7576	<0.0010
Vegetation type	1	-3.3365	0.8809	14.3453	0.0002
Time	1	-1.9591	0.7393	7.0218	0.0081
Strategy*	1	-2.7154	0.9263	8.5935	0.0034
Vegetation type × Time	1	0.3223	0.2112	2.3282	0.1271
Vegetation type × Strategy	1	0.7148	0.2650	7.2769	0.0070
Time × Strategy	1	0.3737	0.2204	2.8746	0.0900
Vegetation type × Time × Strategy	1	-0.0827	0.0654	1.5991	0.2060

*Strategy = Vegetation Management Strategy

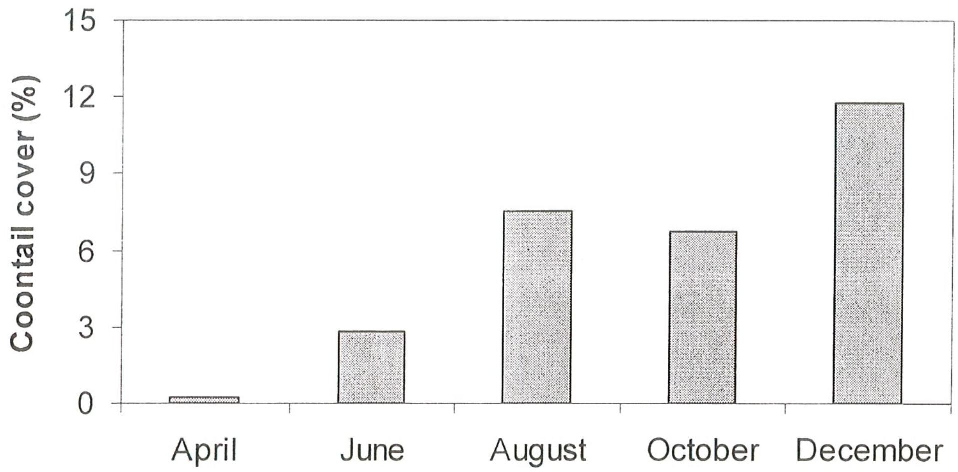

Figure 7. Change in coontail mean areal coverage in STA-1W Cell 5B corrals as function of time. Data are pooled over emergent vegetation type and vegetation management strategy.

The effect of vegetation management strategy on Coontail areal coverage differed among emergent vegetation types as evidenced by the significant Strategy × Vegetation interaction; individual effects of Strategy and Vegetation type were also significant (**Table 4**). Coverage was higher at rice-dominated stations than at most other stations across the different vegetation management strategy, except for in miscellaneous vegetation-dominated corrals with harvesting/ transplanting SAV (**Figure 8**). In addition, transplanting SAV decreased Coontail coverage at stations across all vegetation types compared to the control, while coverage in corrals with dead plant materials harvested was higher than in corrals with transplanting SAV. At stations with miscellaneous vegetation, harvesting and harvesting/transplanting SAV improved Coontail coverage, compared to Transport and Control Strategies.

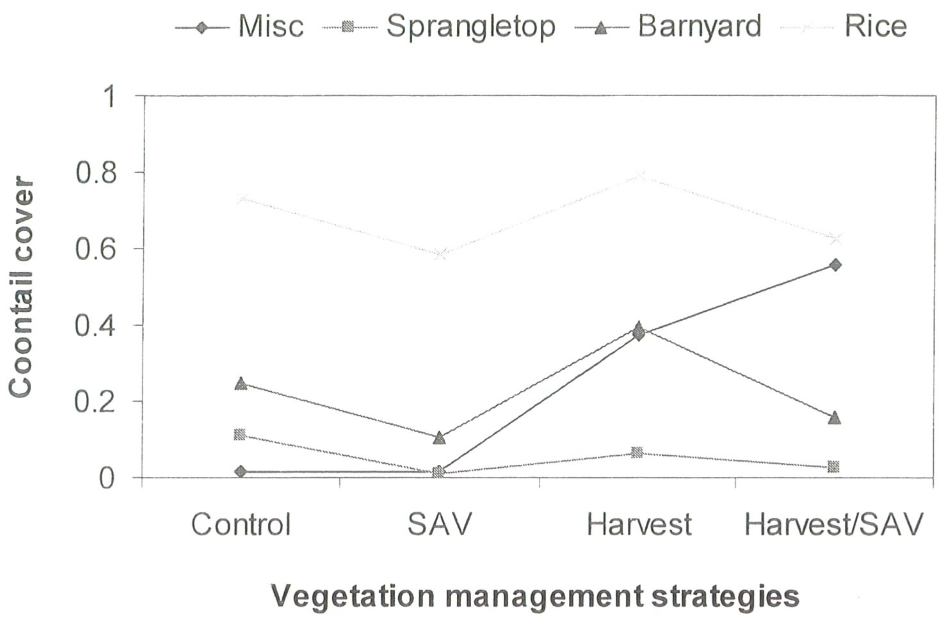

Figure 8. Coontail areal coverage as influenced by vegetation management strategy and vegetation type.

Effect of water depth

Due to a regional drought in 2007, water depths in some of the corral locations fell below 10 cm which likely influenced the observed decrease in SAV coverage by the end of the study compared to corrals that maintained at least 20 cm of water. Analysis of maximum likelihood estimates indicated that water depth had significant negative effects on the coverage of Naiad, Hydrilla, and Coontail but no significant effect on Chara (**Table 5**). Local difference in ground elevation may also have contributed to water depth difference in the corrals.

Table 5. Analysis of maximum likelihood estimates derived from logistic regression of SAV areal coverage in STA-1W Cell 5B corrals.

SAV species	Parameter	DF	Likelihood Estimate	Standard Error	Wald Chi-square	Pr > Chi-Square
Naiad	Intercept 0	1	0.5886	0.1302	20.4406	<0.0001
	Intercept 1	1	2.0707	0.1437	207.7654	<0.0001
	Intercept 2	1	2.6698	0.1546	298.0894	<0.0001
	Water depth	1	-0.0137	0.0028	24.4889	<0.0001
Hydrilla	Intercept 0	1	1.1716	0.1382	71.8942	<0.0001
	Intercept 1	1	3.0776	0.1627	357.6825	<0.0001
	Intercept 2	1	3.6997	0.1760	441.7514	<0.0001
	Water depth	1	-0.0299	0.0029	103.3293	<0.0001
Chara	Intercept 0	1	1.1991	0.1568	58.4789	<0.0001
	Intercept 1	1	2.2885	0.1739	173.2630	<0.0001
	Intercept 2	1	3.2407	0.2103	237.3602	<0.0001
	Water depth	1	0.0013	0.0034	0.1502	0.6983
Coontail	Intercept 0	1	2.7867	0.2153	167.6086	<0.0001
	Intercept 1	1	4.2138	0.2435	299.3989	<0.0001
	Intercept 2	1	5.0908	0.2814	327.3810	<0.0001
	Water depth	1	-0.0304	0.0041	53.7899	<0.0001

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