

Insights from observations and manipulative experiments into competition between mangroves and salt marsh vegetation

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Table S1. Relative Interaction Intensity (RII). 1) Results from one-way ANOVA analyzing the effects of survey method on the RII for each of the prominent marsh plants to test hypothesis one. Additionally, results from one-way ANOVA analyzing the effects of each of the three marsh species on the RII for each survey method to test hypothesis three. 2) Results from two-way ANOVA analyzing the effects of method, marsh species, and the interaction between method and marsh species on the RII. All significant p -values <0.05 are shown in bold font. 3) Results from a Tukey HSD post-hoc test to compare species across methods (hypothesis one) and methods across species (hypothesis three) are shown. The different lowercase letters indicate survey methods that are similar to one another for each species. The different uppercase letters represent species that are similar to one another within each study method.

ANOVA (1-way)		df	Sum Sq	Mean Sq	F	p
<i>Spartina</i>	Method	3	1.09	0.36	1.89	0.16
	Residuals	24	4.60	0.19		
<i>Batis</i>	Method	3	2.96	0.99	6.20	0.003
	Residuals	25	3.98	0.16		
<i>Sarcocornia</i>	Method	3	0.39	0.13	6.21	0.003
	Residuals	24	0.50	0.02		
Observation	Species	2	1.11	0.55	4.10	0.04
	Residuals	12	1.62	0.13		
Plot Survey	Species	2	<0.0001	<0.0001	1.08	0.36
	Residuals	19	<0.0001	<0.0001		
Transect	Species	2	0.81	0.40	2.30	0.13

	Residuals	21	3.68	0.18		
Transplant	Species	2	0.56	0.28	1.56	0.23
	Residuals	21	3.79	0.18		

ANOVA (2-way)		df	Sum Sq	Mean Sq	F	p
RII	Method	3	2.60	0.87	6.96	0.0003
	Species	2	0.67	0.33	2.69	0.07
	Method × Species	6	1.81	0.30	2.42	0.03
	Residuals	73	9.09	0.12		

Tukey HSD Post-hoc		Groups
<i>Spartina</i>	Observation	a
	Plot Survey	a
	Transect	a
	Transplant	a
<i>Batis</i>	Observation	a
	Plot Survey	b
	Transect	b
	Transplant	ab
<i>Sarcocornia</i>	Observation	a
	Plot Survey	b
	Transect	b
	Transplant	ab
Observation	<i>Spartina</i>	B
	<i>Batis</i>	A
	<i>Sarcocornia</i>	AB
Plot Survey	<i>Spartina</i>	A
	<i>Batis</i>	A
	<i>Sarcocornia</i>	A
Transect	<i>Spartina</i>	A
	<i>Batis</i>	A
	<i>Sarcocornia</i>	A
Transplant	<i>Spartina</i>	A
	<i>Batis</i>	A
	<i>Sarcocornia</i>	A

Table S2. NMDS. Results from two resemblance-based permutation methods, PERMANOVA and PERMDISP, for an NMDS ordination comparing plant abundance across treatment types (marsh versus mangrove) in Appendix Figure S5. The PERMANOVA detects the differences between groups (treatment) while the PERMDISP detects whether some groups are more variable than others. Significant p-values <0.05 are shown in bold font.

Treatment		<i>F</i>	<i>R</i>²	<i>p</i>
PERMANOVA	Marsh	29.10	0.10	0.001
	Mangrove	97.89	0.26	0.001
PERMDISP	Marsh	42.41		0.001
	Mangrove	234.75		0.001

Table S3. Plot Survey. Results from two-way ANOVA of treatment type (marsh or mangrove) and zone (fringe or interior) and their interaction on mangrove, pneumatophore, *Spartina*, *Batis*, and *Sarcocornia* cover. Additionally, results from separate ANCOVA analyses examine species cover in the 3x3 m marsh or mangrove plots (treatment type) as the fixed factor, with one of three covariates: 1) number of mangrove plots in the eight 3x3 m plots immediately surrounding the plot under consideration, 2) number of mangrove plots in the twenty-four 3x3 m plots immediately surrounding the plot under consideration, and 3) the number of mangrove plots in the entire 24x42 m large plot. Significant *p*-values <0.05 are shown in bold font.

ANOVA		df	Sum Sq	F	p
Mangroves	Treatment Type	1	476792	17932.75	<0.0001
	Zone	1	129	4.86	0.03
	Treatment Type × Zone	1	46	1.72	0.19
	Residuals	203	5397		
Pneumatophores	Treatment Type	1	145980	170.84	<0.0001
	Zone	1	18564	21.73	<0.0001
	Treatment Type × Zone	1	15471	18.11	<0.0001
	Residuals	203	173464		
<i>Spartina</i>	Treatment Type	1	11000	26.26	<0.0001
	Zone	1	16	0.04	0.84
	Treatment Type × Zone	1	17	0.04	0.84
	Residuals	203	85028		
<i>Batis</i>	Treatment Type	1	19453	43.42	<0.0001
	Zone	1	43	0.10	0.76
	Treatment Type × Zone	1	46	0.10	0.75
	Residuals	203	90947		
<i>Sarcocornia</i>	Treatment Type	1	4609	17.57	<0.0001
	Zone	1	640	2.44	0.12
	Treatment Type × Zone	1	678	2.59	0.11
	Residuals	203	53256		
ANCOVA		df	Sum Sq	F	p
Mangroves	24×42 m	9	1341	6.90	<0.0001
	Treatment Type	1	428005	19828.61	<0.0001
	Residuals	196	4231		

Pneumatophores	Surrounding 24	24	1760	3.48	<0.0001
	Treatment Type	1	390098	18521.57	<0.0001
	Residuals	181	3812		
	Surrounding 8	8	1172	6.56	<0.0001
	Treatment Type	1	466248	20873.84	<0.0001
	Residuals	197	4400		
	24×42 m	9	58560	8.56	<0.0001
	Treatment Type	1	94804	124.76	<0.0001
	Residuals	196	148939		
	Surrounding 24	24	57425	2.89	<0.0001
	Treatment Type	1	90051	108.61	<0.0001
	Residuals	181	150075		
<i>Spartina</i>	Surrounding 8	8	35948	5.16	<0.0001
	Treatment Type	1	136499	156.75	<0.0001
	Residuals	197	171552		
	24×42 m	9	24030	8.57	<0.0001
	Treatment Type	1	5384	17.29	<0.0001
	Residuals	196	61032		
	Surrounding 24	24	26118	3.34	<0.0001
	Treatment Type	1	4774	14.66	<0.0001
	Residuals	181	58943		
	Surrounding 8	8	12840	4.38	<0.0001
	Treatment Type	1	10520	28.69	<0.0001
	Residuals	197	72222		
<i>Batis</i>	24×42 m	9	33019	12.39	<0.0001
	Treatment Type	1	7820	26.42	<0.0001
	Residuals	196	58018		
	Surrounding 24	24	28453	3.43	<0.0001
	Treatment Type	1	9634	27.86	<0.0001
	Residuals	181	62584		
	Surrounding 8	8	17992	6.07	<0.0001
	Treatment Type	1	16812	45.34	<0.0001
	Residuals	197	73045		
<i>Sarcocornia</i>	24×42 m	9	2588	1.08	0.38
	Treatment Type	1	4461	16.82	<0.0001
	Residuals	196	51986		
	Surrounding 24	24	8586	1.41	0.11
	Treatment Type	1	3507	13.81	0.0003
	Residuals	181	45988		

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Surrounding 8	8	2650	1.26	0.27
Treatment Type	1	5132	19.47	<0.0001
Residuals	197	51924		

Table S4. Transect Survey. Results from two-way ANOVA of treatment type (marsh or mangrove) and zone (fringe or interior) and their interaction on mangrove, pneumatophore, *Spartina*, *Batis*, and *Sarcocornia* cover. Additionally, results from separate ANCOVA analyses examine species cover in the 3x3 m marsh or mangrove plots (treatment type) as the fixed factor, with one of three covariates: 1) number of mangrove plots in the eight 3x3 m plots immediately surrounding the plot under consideration, 2) number of mangrove plots in the twenty-four 3x3 m plots immediately surrounding the plot under consideration, and 3) the number of mangrove plots in the entire 24x42 m large plot. Significant *p*-values <0.05 are shown in bold font.

ANOVA		df	Sum Sq	<i>F</i>	<i>p</i>
Mangroves	Treatment Type	1	995171	2887.53	<0.0001
	Zone	1	2294	6.66	0.01
	Treatment Type × Zone	1	2913	8.45	0.004
	Residuals	799	275371		
Pneumatophores	Treatment Type	1	108210	130.88	<0.0001
	Zone	1	10996	13.3	0.0003
	Treatment Type × Zone	1	2117	2.56	0.11
	Residuals	799	660613		
<i>Spartina</i>	Treatment Type	1	15509	116.55	<0.0001
	Zone	1	2445	18.37	<0.0001
	Treatment Type × Zone	1	2589	19.45	<0.0001
	Residuals	799	106327		
<i>Batis</i>	Treatment Type	1	32865	141.98	<0.0001
	Zone	1	5444	23.52	<0.0001
	Treatment Type × Zone	1	4795	20.71	<0.0001
	Residuals	799	184953		
<i>Sarcocornia</i>	Treatment Type	1	3780	79.67	<0.0001
	Zone	1	69	1.45	0.23
	Treatment Type × Zone	1	69	1.46	0.23
	Residuals	799	37912		
ANCOVA		df	Sum Sq	<i>F</i>	<i>p</i>
Mangroves	24×42 m	9	25793	8.91	<0.0001
	Treatment Type	1	647177	2011.76	<0.0001
	Residuals	792	254784		

Pneumatophores	Surrounding 24	24	33359	4.37	<0.0001
	Treatment Type	1	651078	2046.32	<0.0001
	Residuals	777	247218		
	Surrounding 8	8	17545	6.61	<0.0001
	Treatment Type	1	740948	2233.83	<0.0001
	Residuals	793	263033		
	24×42 m	9	23080	3.12	0.001
	Treatment Type	1	47545	57.87	<0.0001
	Residuals	792	650646		
	Surrounding 24	24	67938	3.63	<0.0001
	Treatment Type	1	58181	74.62	<0.0001
	Residuals	777	605789		
<i>Spartina</i>	Surrounding 8	8	31311	4.83	<0.0001
	Treatment Type	1	72702	89.74	<0.0001
	Residuals	793	642416		
	24×42 m	9	33672	38.14	<0.0001
	Treatment Type	1	2067	21.07	<0.0001
	Residuals	792	77689		
	Surrounding 24	24	36212	15.60	<0.0001
	Treatment Type	1	2602	26.91	<0.0001
	Residuals	777	75149		
	Surrounding 8	8	14829	15.23	<0.0001
	Treatment Type	1	2770	22.75	<0.0001
	Residuals	793	96532		
<i>Batis</i>	24×42 m	9	83242	65.43	<0.0001
	Treatment Type	1	3879	27.44	<0.0001
	Residuals	792	111950		
	Surrounding 24	24	79358	22.18	<0.0001
	Treatment Type	1	3890	26.09	<0.0001
	Residuals	777	115833		
	Surrounding 8	8	48964	33.19	<0.0001
	Treatment Type	1	6985	37.88	<0.0001
	Residuals	793	146227		
<i>Sarcocornia</i>	24×42 m	9	2408	5.94	<0.0001
	Treatment Type	1	1134	25.20	<0.0001
	Residuals	792	35642		
	Surrounding 24	24	7111.6	7.44	<0.0001
	Treatment Type	1	1241.5	31.18	<0.0001
	Residuals	777	30938.4		

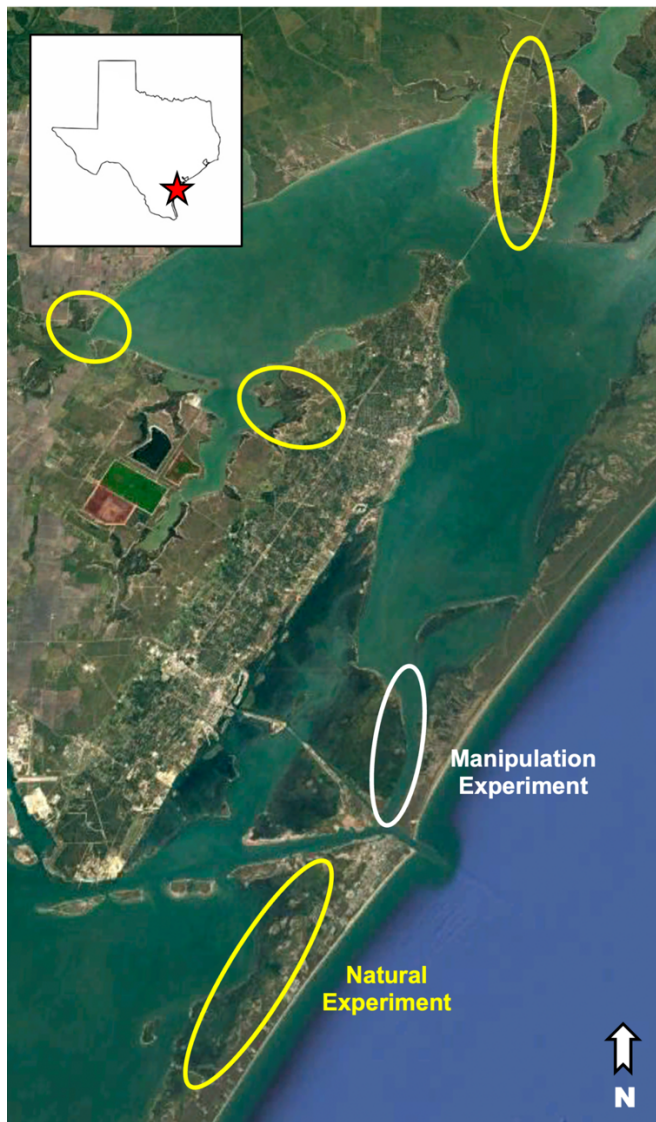
Surrounding 8	8	1706	4.65	<0.0001
Treatment Type	1	1438	31.37	<0.0001
Residuals	793	36344		

Table S5. Transplant Experiment. Results from two-way ANOVA of treatment type (marsh or mangrove) and zone (fringe or interior) and their interaction on *Spartina*, *Batis*, and *Sarcocornia* dry aboveground biomass (g) at the end of the growing season. Additionally, results from separate ANCOVA analyses examine aboveground biomass in the 3x3 m marsh or mangrove plots (treatment type) as the fixed factor, with one of three covariates: 1) number of mangrove plots in the eight 3x3 m plots immediately surrounding the plot under consideration, 2) number of mangrove plots in the twenty-four 3x3 m plots immediately surrounding the plot under consideration, and 3) the number of mangrove plots in the entire 24x42 m large plot. Significant *p*-values <0.05 are shown in bold font.

ANOVA		df	Sum Sq	<i>F</i>	<i>p</i>
<i>Spartina</i>	Treatment Type	1	1483.6	12.75	0.0007
	Zone	1	10	0.09	0.77
	Treatment Type × Zone	1	7.2	0.06	0.80
	Residuals	60	6983.7		
<i>Batis</i>	Treatment Type	1	224.12	19.50	<0.0001
	Zone	1	3.94	0.34	0.56
	Treatment Type × Zone	1	5.98	0.52	0.47
	Residuals	60	689.58		
<i>Sarcocornia</i>	Treatment Type	1	429.99	34.42	<0.0001
	Zone	1	0.17	0.01	0.91
	Treatment Type × Zone	1	0.32	0.03	0.87
	Residuals	60	749.47		
ANCOVA		df	Sum Sq	<i>F</i>	<i>p</i>
<i>Spartina</i>	24×42 m	7	871.2	1.12	0.37
	Treatment Type	1	1483.6	13.31	0.0006
	Residuals	55	6129.6		
	Surrounding 24	22	3154.1	1.49	0.13
	Treatment Type	1	918.5	9.55	0.004
	Residuals	40	3846.7		
	Surrounding 8	8	896.8	0.99	0.45
	Treatment Type	1	1205.8	10.67	0.002
	Residuals	54	6140		

<i>Batis</i>	24×42 m	7	102.32	1.35	0.25
	Treatment Type	1	224.12	20.64	<0.0001
	Residuals	55	597.18		
	Surrounding 24	22	178.93	0.63	0.88
	Treatment Type	1	129.13	9.92	0.003
	Residuals	40	520.57		
	Surrounding 8	8	82.15	0.90	0.52
	Treatment Type	1	206.67	18.08	<0.0001
	Residuals	54	617.35		
<i>Sarcocornia</i>	24×42 m	7	108.23	1.33	0.26
	Treatment Type	1	429.99	36.85	<0.0001
	Residuals	55	641.72		
	Surrounding 24	22	201.29	0.67	0.84
	Treatment Type	1	211.8	15.44	0.0003
	Residuals	40	548.66		
	Surrounding 8	8	47.98	0.46	0.88
	Treatment Type	1	282.21	21.71	<0.0001
	Residuals	54	701.97		

Figure S1. Location of the observational study and manipulation experiment. Pictured are the locations for the ten survey sites in the observational study (outlined in yellow), and the ten experimental plots in the manipulation experiment (outlined in white). The manipulative experiment is located within the Mission-Aransas National Estuarine Research Reserve, and most of the observational study sites are located within the Mission-Aransas estuary. Both are along the central Texas coast of the Gulf of Mexico. Zoomed in locations of sites/plots are in figures below.



65 **Figure S2. Layout of the observational study sites.** Pictured are the ten sites; five sites
66 dominated by marsh vegetation (white circles) and five dominated by mangroves (yellow
67 circles).



Figure S3. NMDS comparing between treatment types for each sampling method.

Multivariate composition of communities within marsh (light-shaded polygon with white squares) or mangrove (dark-shaded polygon with grey circles) treatments in a) the observation survey (observational study), b) plot survey (manipulative experiment), and c) transect survey (manipulative experiment). The nonmetric multidimensional scaling (NMDS) ordination is a representation of dissimilarities among treatments based on plant abundance using the Bray-Curtis similarity matrix, square root transformed. 2D stress values are shown.

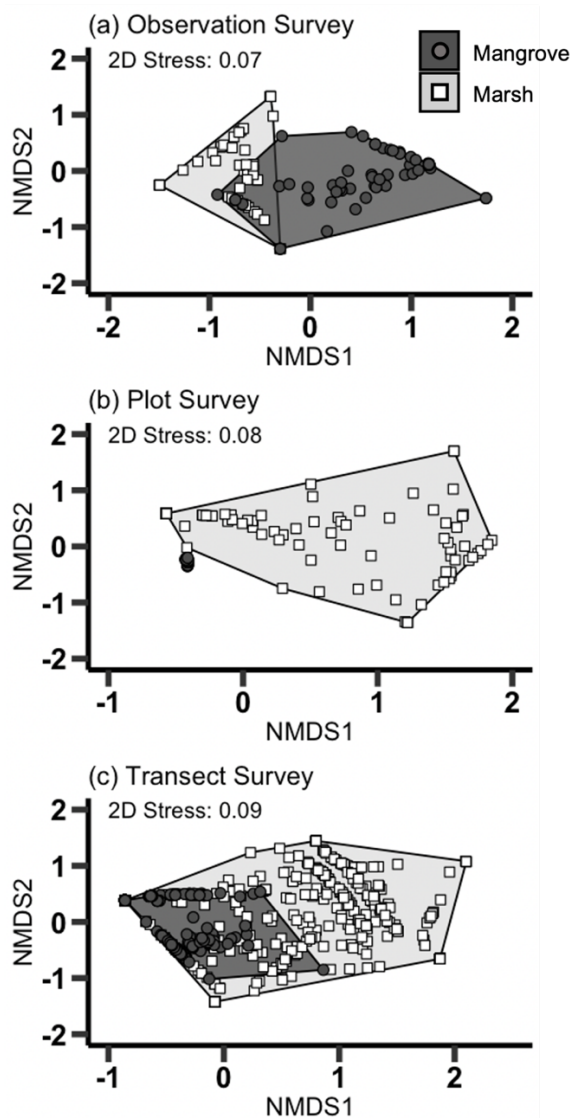


Figure S4. Effect of plot-level mangrove cover on marsh plant cover in the plot survey.

Effect of plot-level mangrove cover (0-100%) on percent species cover of *Spartina*, *Batis* and *Sarcocornia*. Filled circles with solid lines represent average abundance at each plot-level mangrove cover within mangrove plots. Open circles with dotted lines represent average abundance at each plot-level mangrove cover within marsh plots.

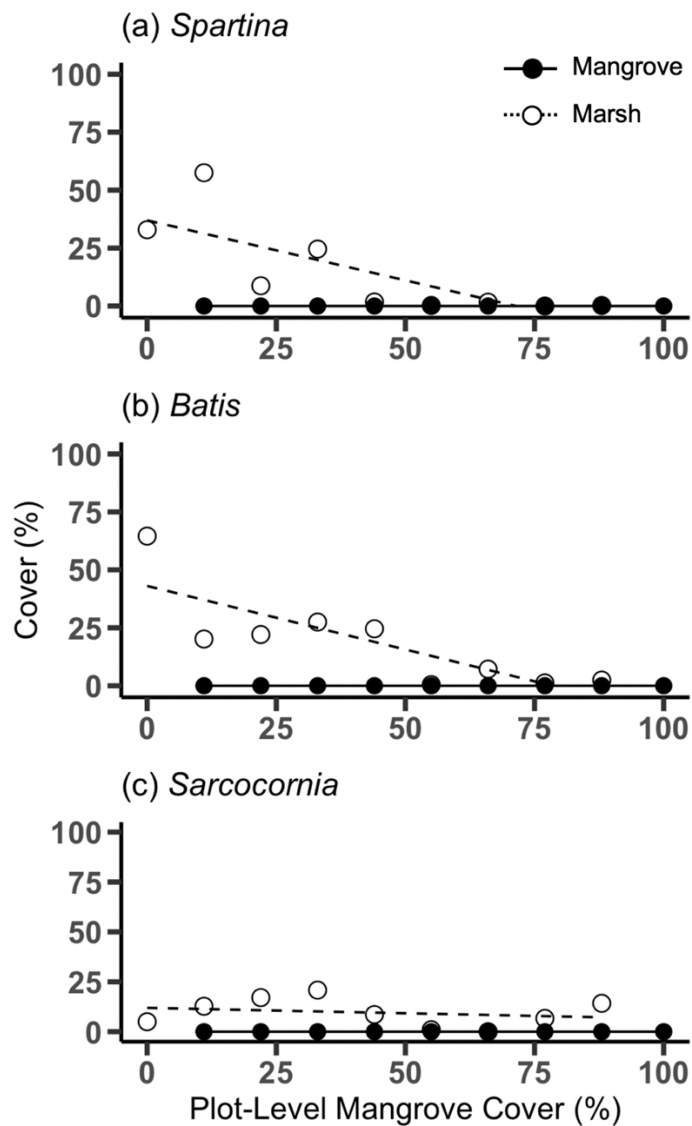


Figure S5. Effect of plot-level mangrove cover on marsh plant cover in the transect survey.

Effect of plot-level mangrove cover (0-100%) on percent species cover of *Spartina*, *Batis* and *Sarcocornia*. Filled circles with solid lines represent average abundance at each plot-level mangrove cover within mangrove plots. Open circles with dotted lines represent average abundance at each plot-level mangrove cover within marsh plots.

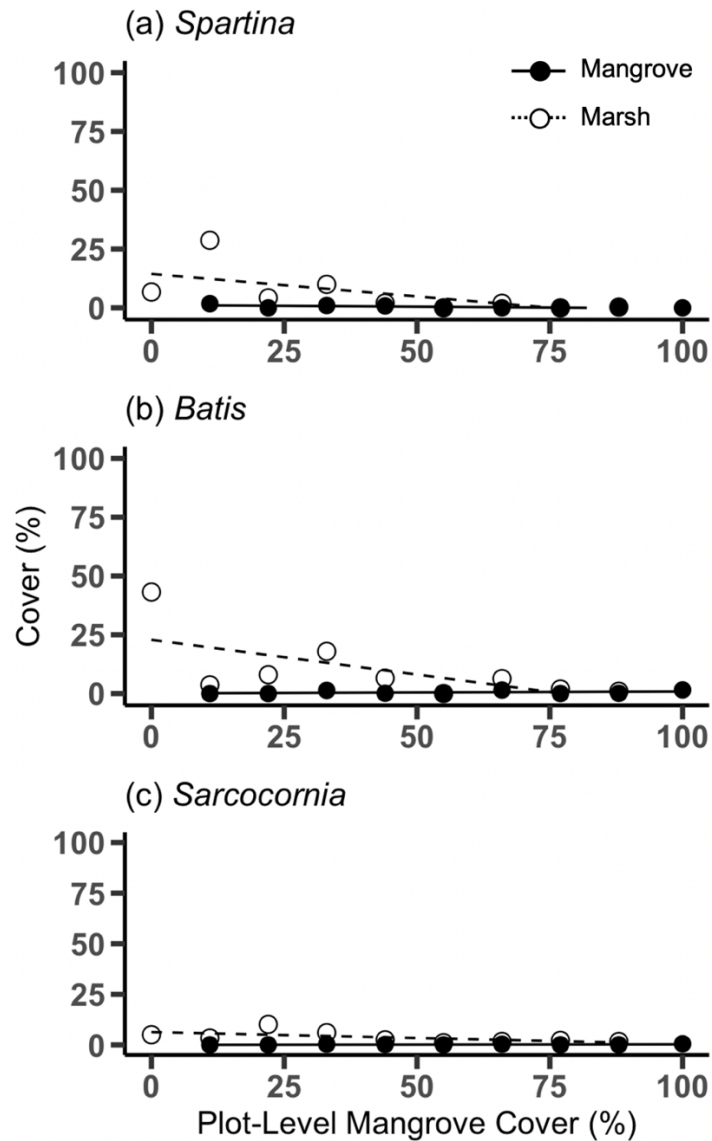


Figure S6. Effect of plot-level mangrove cover on marsh plant cover in the transplant experiment. Effect of plot-level mangrove cover (0-100%) on percent species cover of *Spartina*, *Batis* and *Sarcocornia*. Filled circles with solid lines represent average abundance at each plot-level mangrove cover for marsh plants planted within mangrove plots. Open circles with dotted lines represent average abundance at each plot-level mangrove cover for marsh plants planted within marsh plots. Transplants were not performed for 0% or 100% plot-level mangrove cover because those plots did not allow comparisons between treatment types.

