Supplemental tables and figures

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This document includes all the supplemental tables and figures that accompany "Precipitation moderates associations between native shrubs and invasive buffelgrass (*Pennisetum ciliare*) growth in the Sonoran Desert while local topography has less influence" by Ossanna et al. (2026).

Tables

Table S1. Actual values averaged by year

Actual values of variables measured, averaged across all plots for each year (to contextualize year-to-year change values used in analyses). Precipitation measured in mm, buffelgrass density measured in individuals per m^2, and cover measured in percent.

		Buffelgrass				Native vegetation	
Year	Precipitation	Total culms	Repro culms	Density	Cover	Shrub cover	Herb cover
2020	222	24 ± 19	12 ± 13	3.8 ± 1.5	39 ± 19	18 ± 12	5.9 ± 10.5
2021	362	38 ± 33	14 ± 16	8 ± 7.6	40 ± 21	13 ± 8	9.9 ± 8.7
2022	264	53 ± 40	26 ± 25	6.8 ± 4.1	35 ± 17	12 ± 10	5.1 ± 6.4
2023	250	129 ± 80	53 ± 35	3 ± 1.5	39 ± 13	22 ± 13	2.6 ± 2.7

Table S2. Total culms model

Model coefficients of the buffelgrass culm count model (response variable: year-to-year change in total number of culms). Marginal R^2 = 0.0.119; conditional R^2 = 0.410.

Coefficient	Estimate	Std. Error	df	t value	Pr(>|t|)
Intercept	12.6627	10.4781	3.9758	1.208	0.2938
Previous year precipitation	-3.2292	1.5376	1207.7732	-2.100	0.0359*
Aspect, N	7.8120	7.8661	20.2496	0.993	0.3324
Aspect, S	0.1528	5.6111	19.8523	0.027	0.9786
Aspect, SW	18.3063	7.7117	19.9935	2.374	0.0277*
Aspect, W	4.3308	5.4989	19.3003	0.788	0.4405
Plot slope	-2.0952	1.4049	147.2300	-1.491	0.1380
Change in BG density	-7.6271	1.4079	1080.9177	-5.417	7.45e-08***
Change in shrub cover	5.7765	1.0774	1189.1395	5.362	9.90e-08***
Change in herb cover	0.3447	1.0772	998.0276	0.320	0.7490
Change in BG density * Previous year precip	2.8213	1.6240	242.3700	1.737	0.0836
Change in shrub cover * Previous year precip	-6.7540	1.1241	1190.4146	-6.008	2.49e-09***
Change in herb cover * Previous year precip	2.7597	1.1026	923.9022	2.503	0.0125*

Table S3. Reproductive culms model

Model coefficients of the buffelgrass reproductive culm count model (response variable: year-to-year change in number of reproductive culms). Marginal $R^2 = 0.098$; conditional $R^2 = 0.295$.

Coefficient	Estimate	Std. Error	df	t value	Pr(>|t|)
Intercept	11.4108	4.8289	4.7613	2.363	0.0671
Previous year precipitation	-0.6491	0.9253	1177.4030	-0.702	0.4831
Aspect, N	4.0075	4.5423	19.0498	0.882	0.3886
Aspect, S	-5.4584	3.2472	18.7316	-1.681	0.1094
Aspect, SW	11.3360	4.4508	19.0799	2.547	0.0196*
Aspect, W	0.1771	3.1806	18.1198	0.056	0.9562
Plot slope	0.5335	0.8349	124.5928	0.639	0.5240
Change in BG density	-2.1770	0.8478	1038.5664	-2.568	0.0104*
Change in shrub cover	1.6192	0.6488	1168.6502	2.496	0.0127*
Change in herb cover	2.6827	0.6482	958.5385	4.139	3.8e-05***
Change in BG density * Previous year precip	-1.6667	0.9692	208.9029	-1.720	0.0870
Change in shrub cover * Previous year precip	-0.6967	0.6776	1177.8240	-1.028	0.3041
Change in herb cover * Previous year precip	-0.5582	0.6628	857.6555	-0.842	0.3999

Table S4. Plot density model

Model coefficients of the buffelgrass plot density model (response variable: year-to-year change in plot density [individuals per m^2]). Marginal $R^2 = 0.381$; conditional $R^2 = 0.427$.

Coefficient	Estimate	Std. Error	df	t value	Pr(>|t|)
Intercept	5.3441	1.4503	5.4441	3.685	0.0122*
Previous year precipitation	4.6786	0.6819	19.4349	6.861	1.34e-06***
Aspect, N	-2.2482	2.3683	6.3352	-0.949	0.3773
Aspect, S	-5.5677	1.9113	10.6882	-2.913	0.0145*
Aspect, SW	-2.4519	2.5696	9.1357	-0.954	0.3646
Aspect, W	-4.9278	1.8206	8.3861	-2.707	0.0257*
Plot slope	0.1410	0.6288	17.0859	0.224	0.8252
Change in shrub cover	0.8701	0.6061	108.1021	1.436	0.1540
Change in herb cover	0.5228	0.6348	120.6648	0.824	0.4118
Change in shrub cover * Previous year precip	1.3581	0.6157	113.3788	2.206	0.0294*
Change in herb cover * Previous year precip	0.5841	0.5991	63.5931	0.975	0.3333

Table S5. Plot cover model

Model coefficients of the buffelgrass plot cover model (response variable: year-to-year-change in plot cover [%]). Marginal $R^2 = 0.248$; conditional $R^2 = 0.295$.

Coefficient	Estimate	Std. Error	df	t value	Pr(>|t|)
Intercept	10.5028	3.9864	13.7196	2.635	0.019870*
Previous year precipitation	7.0175	1.8923	41.7200	3.708	0.000609***
Aspect, N	-8.5687	6.1740	22.8041	-1.388	0.178592
Aspect, S	-11.5613	4.8667	24.2617	-2.376	0.025757*
Aspect, SW	-7.7900	6.6895	29.2684	-1.165	0.253624
Aspect, W	-12.0941	4.6391	21.8490	-2.607	0.016147*
Plot slope	2.5520	1.6423	42.6706	1.554	0.127591
Change in shrub cover	-3.4947	1.6328	114.1045	-2.140	0.034459*
Change in herb cover	0.7787	1.6991	121.3027	0.458	0.647583
Change in shrub cover * Previous year precip	-0.3149	1.6527	117.8481	-0.191	0.849220
Change in herb cover * Previous year precip	0.1605	1.6099	104.3456	0.100	0.920785

Table S6. Seedling survival model

Model coefficients of the buffelgrass seedling survival model (response variable: seedling survival [%]). Marginal $R^2 = 0.819$.

Coefficient	Estimate	Std. Error	z value	Pr(>|z|)
Intercept	-1.60229	0.59357	-2.699	0.006946 **
Previous year precipitation	1.48659	0.15485	9.600	<2e-16***
Aspect, N	-0.16101	0.47159	-0.341	0.732783
Aspect, S	-0.23040	0.29582	-0.779	0.436059
Aspect, SW	0.17360	0.34498	0.503	0.614824
Aspect, W	-0.16359	0.27908	-0.586	0.557752
Plot slope	0.09520	0.10787	0.883	0.377496
BG density	0.40963	0.12132	3.377	0.000734***
Shrub cover	-0.10272	0.10029	-1.024	0.305744
Herb cover	0.20032	0.10796	1.856	0.063515
BG density * Previous year precip	0.13036	0.11916	1.094	0.273957
Shrub cover * Previous year precip	-0.08096	0.09154	-0.884	0.376479
Herb cover * Previous year precip	-0.12406	0.10134	-1.224	0.220885

Figures

Figure S1

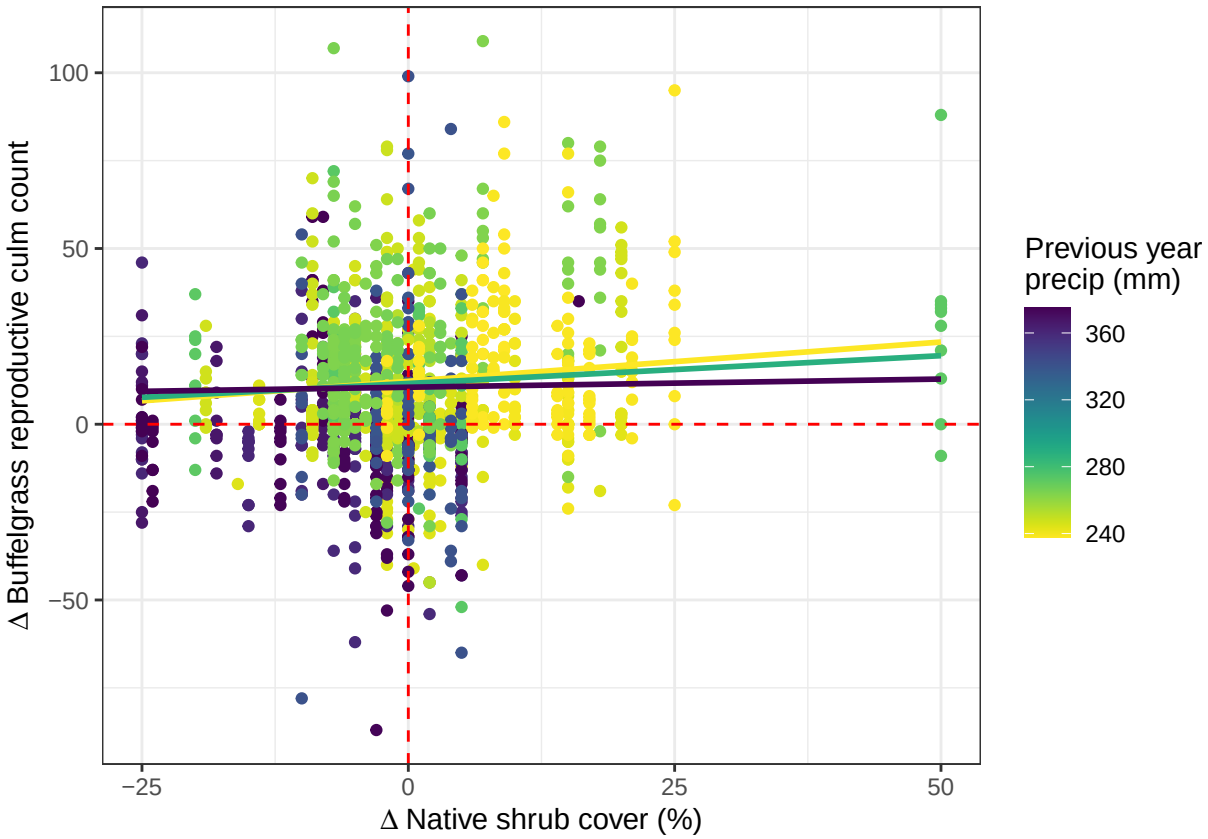

Figure S1. Relationship between year-to-year change in native shrub cover and year-to-year change in reproductive buffelgrass culm count, moderated by precipitation. Colored lines represent model-predicted values under the wettest precipitation conditions experienced (purple line), the driest conditions (yellow line), and average conditions (green line). Vertical red dashed line indicates no change in shrub cover while horizontal line indicates no change in the number of reproductive buffelgrass culms.

Figure S2

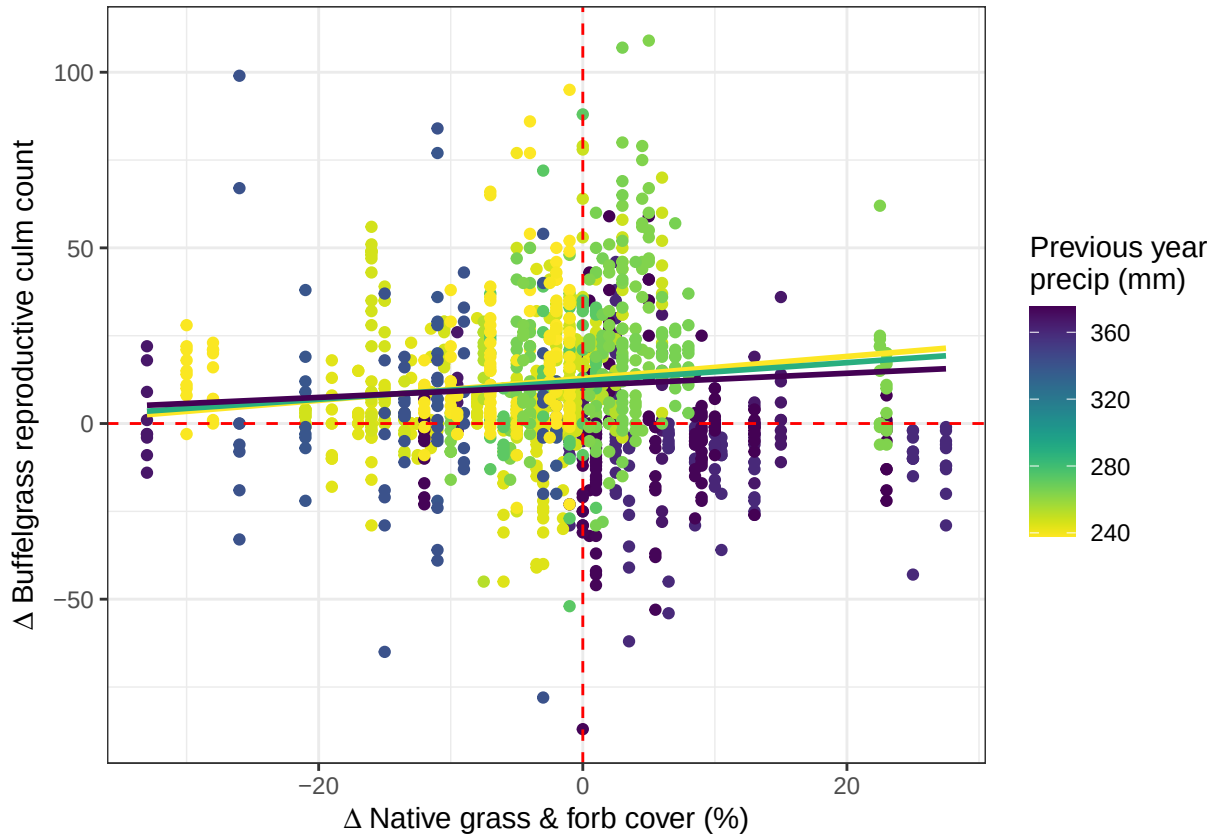

Figure S2. Relationship between year-to-year change in native herbaceous (grass and forb) cover and year-to-year change in reproductive buffelgrass culm count, moderated by precipitation. Colored lines represent model-predicted values under the wettest precipitation conditions experienced (purple line), the driest conditions (yellow line), and average conditions (green line). Vertical red dashed line indicates no change in herb cover while horizontal line indicates no change in the number of reproductive buffelgrass culms.

Figure S3

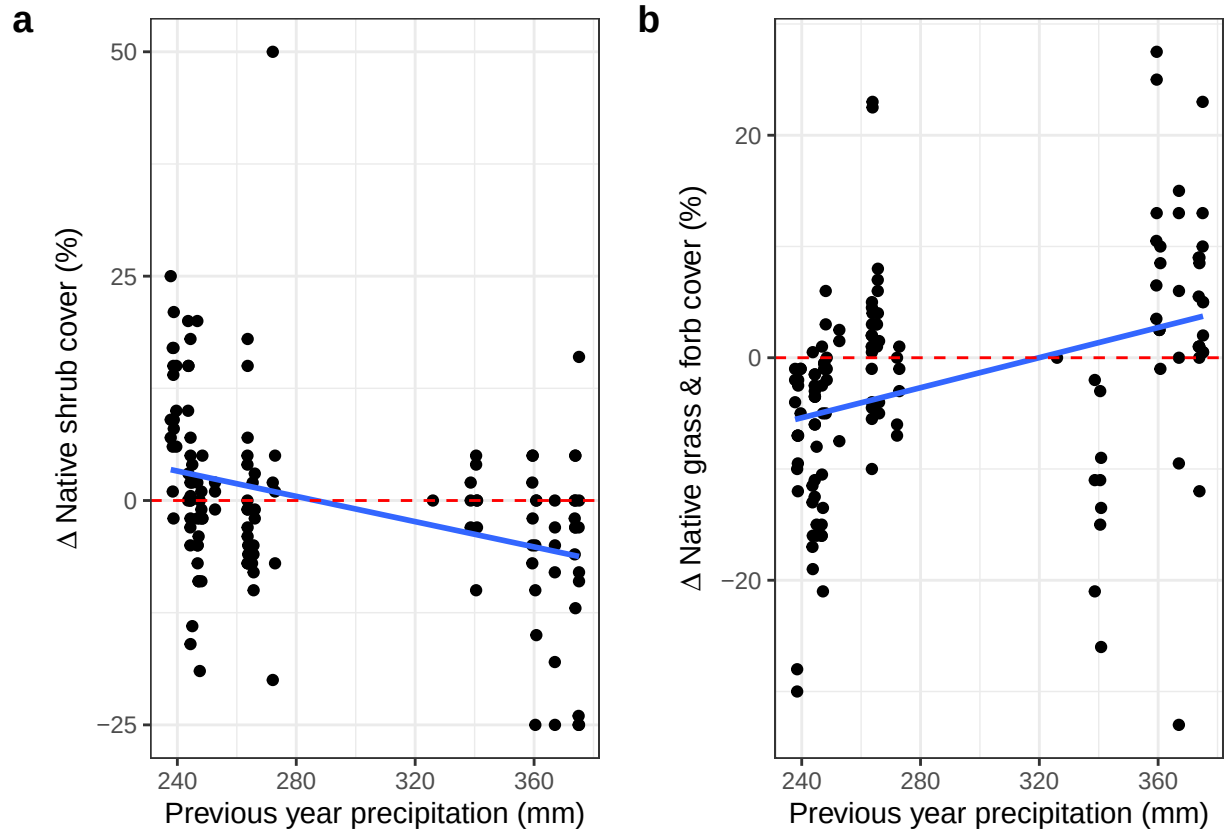

Figure S3. Simple linear regression of (A) year-to-year change in native shrub cover and (B) year-to-year change in native herbaceous cover as a function of the previous year's precipitation, pooling all sampling locations and times. Horizontal red dashed lines indicate no change in shrub or herbaceous cover.

Figure S4

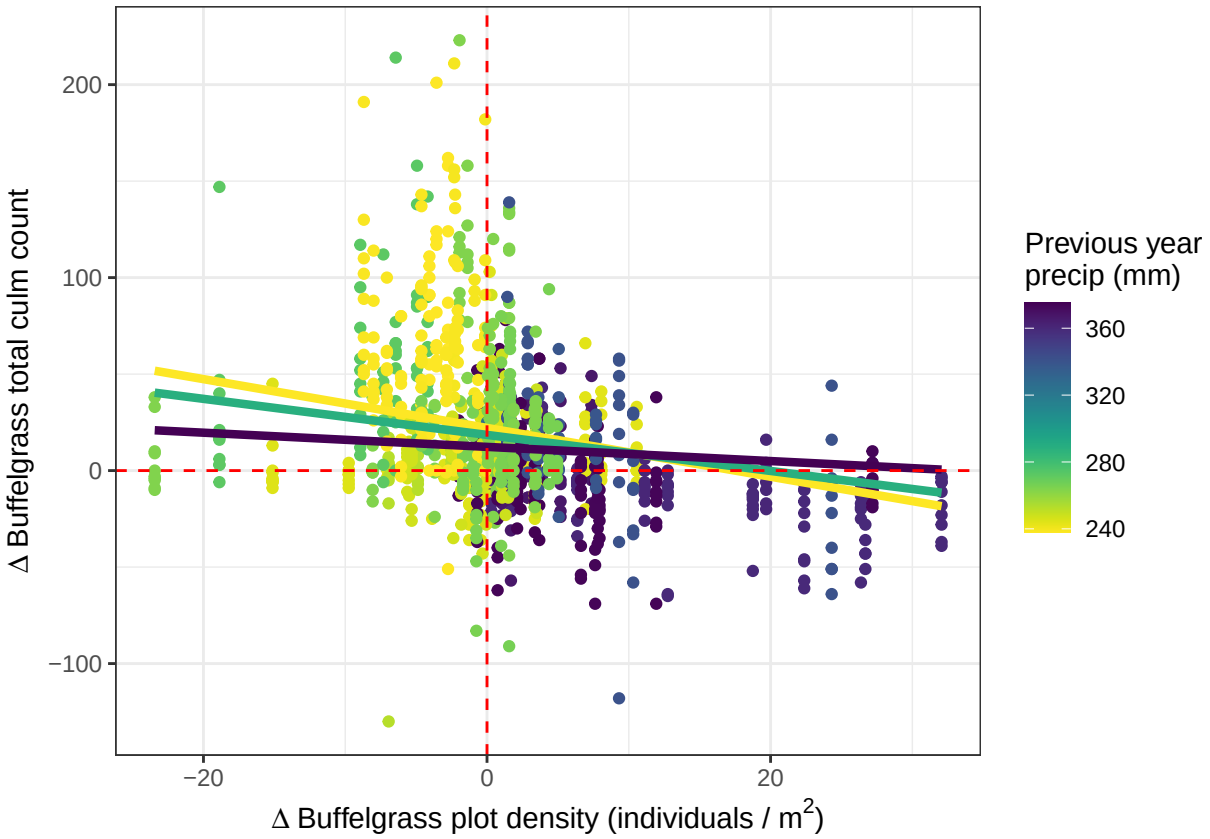

Figure S4. Relationship between year-to-year change in buffelgrass plot density and year-to-year change in total buffelgrass culm count, moderated by precipitation. Colored lines represent model-predicted values under the wettest precipitation conditions experienced (purple line), the driest conditions (yellow line), and average conditions (green line). Vertical red dashed line indicates no change in buffelgrass plot density while horizontal line indicates no change in the number of buffelgrass culms.

Figure S5

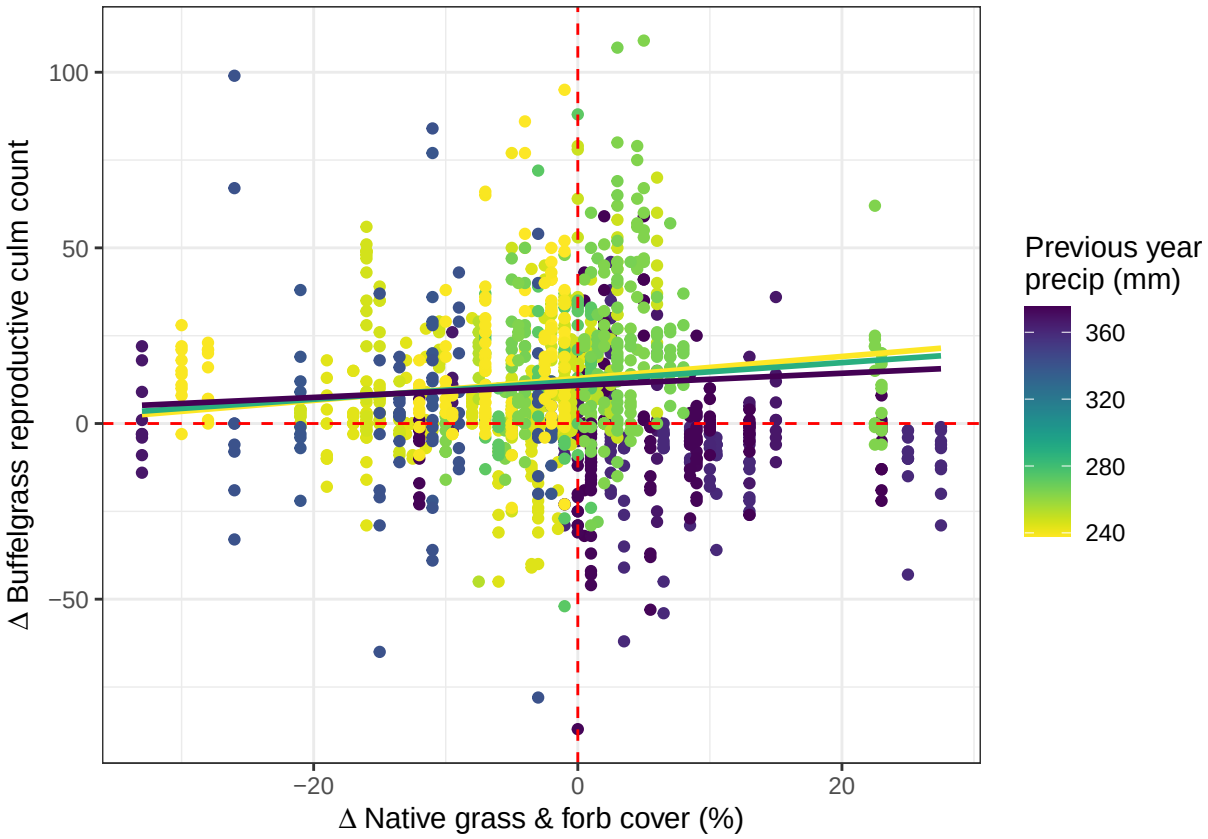

Figure S5. Relationship between year-to-year change in buffelgrass plot density and year-to-year change in reproductive buffelgrass culm count, moderated by precipitation. Colored lines represent model-predicted values under the wettest precipitation conditions experienced (purple line), the driest conditions (yellow line), and average conditions (green line). Vertical red dashed line indicates no change in buffelgrass plot density while horizontal line indicates no change in the number of reproductive buffelgrass culms.

Figure S6

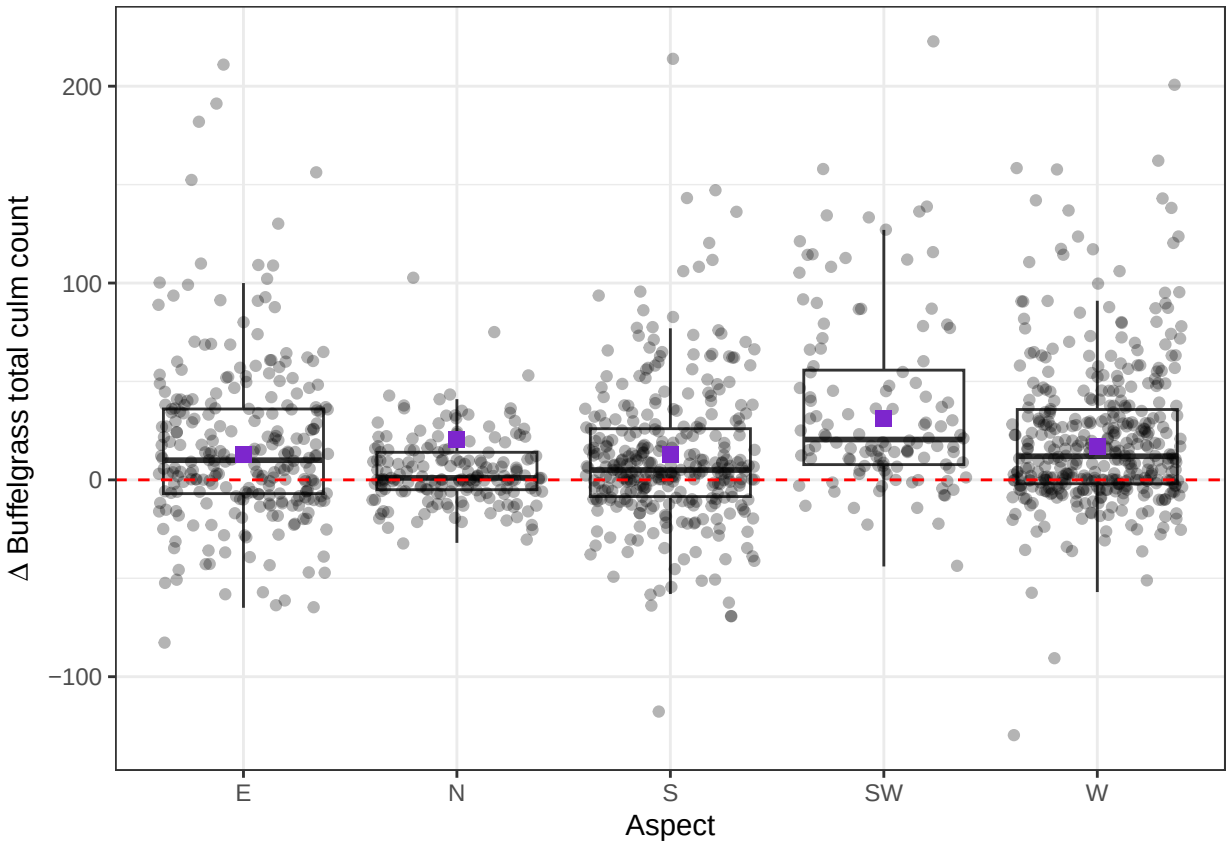

Fig. S6. Effects of aspect on year-to-year change in total buffelgrass culm count. Purple squares represent model-predicted averages. Horizontal red dashed line indicates no change in the number of buffelgrass culms.

Figure S7

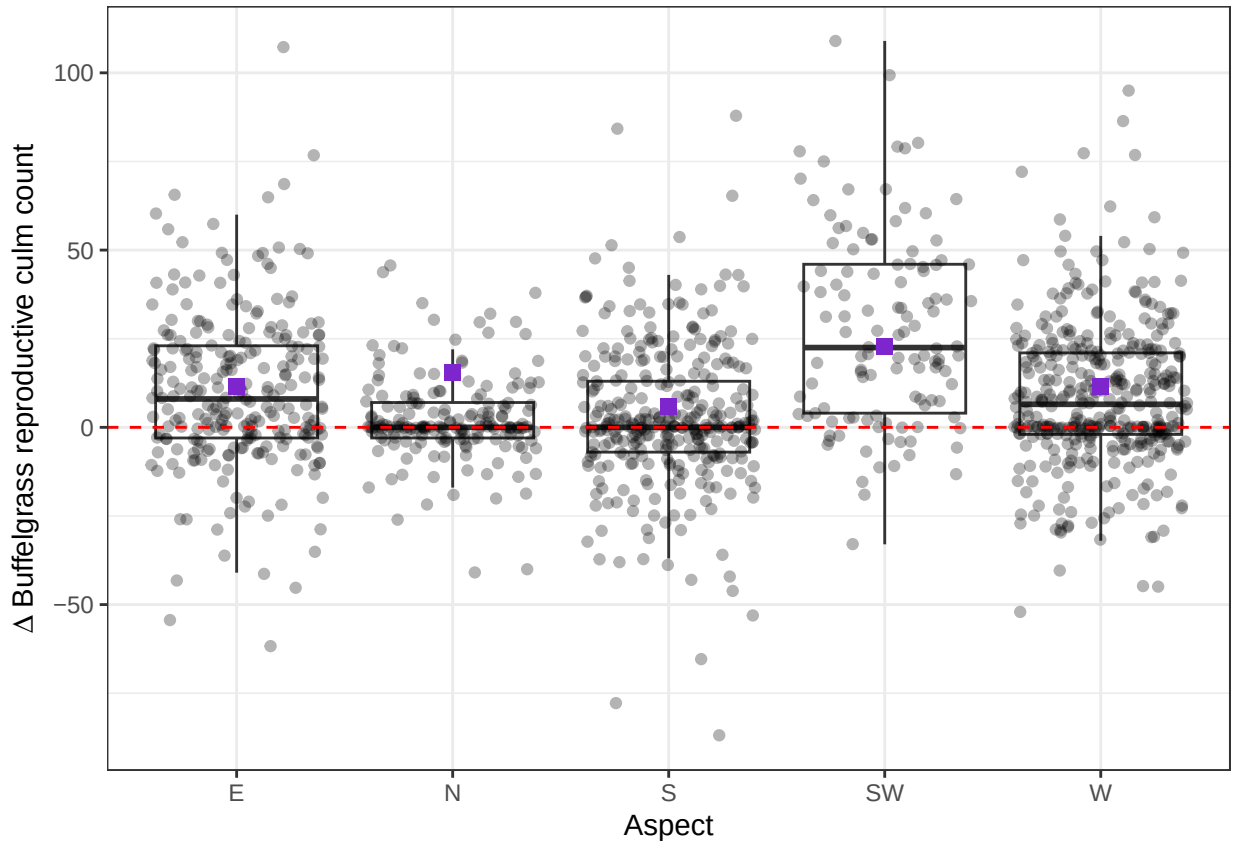

Fig. S7. Effects of aspect on year-to-year change in buffelgrass reproductive culm count. Purple squares represent model-predicted averages. Horizontal red dashed line indicates no change in the number of reproductive buffelgrass culms.

Figure S8

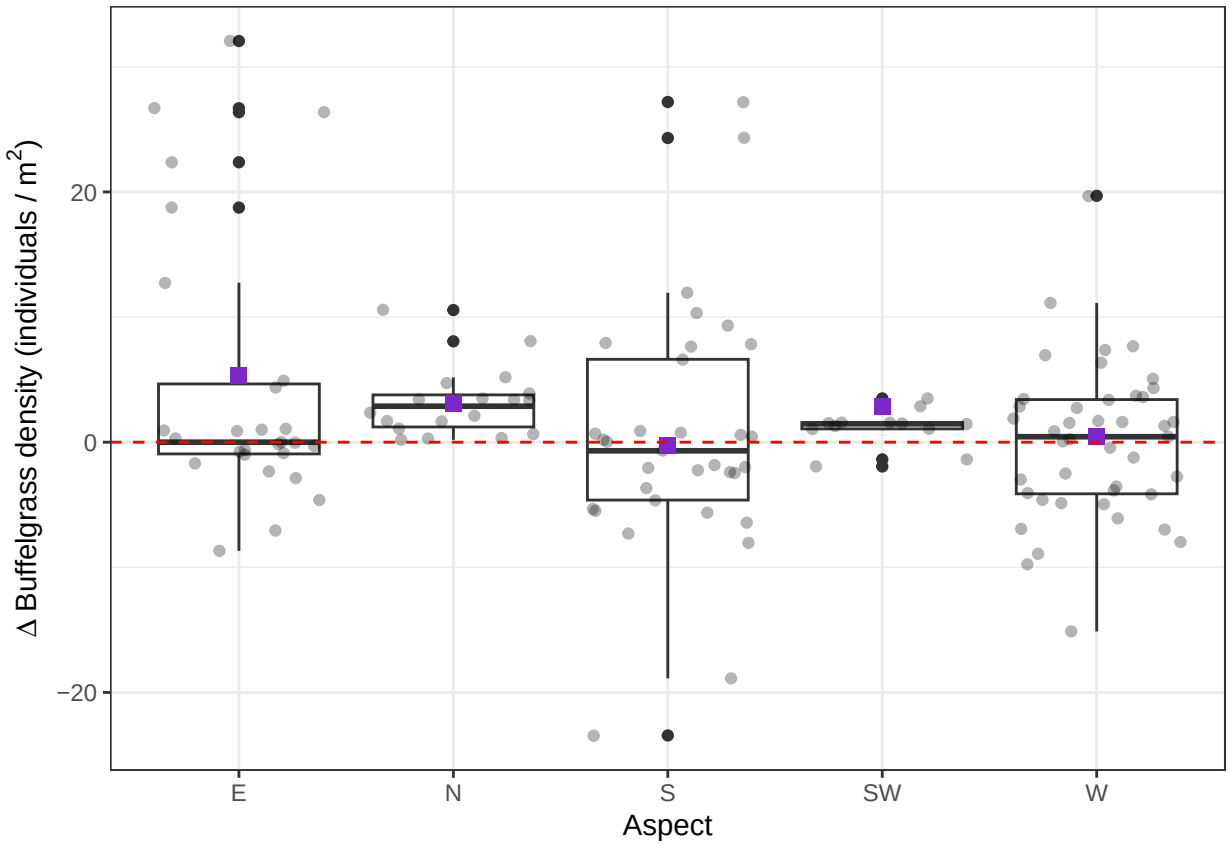

Fig. S8. Effects of aspect on year-to-year change in buffelgrass plot density. Purple squares represent model-predicted averages. Horizontal red dashed line indicates no change in buffelgrass density.

Figure S9

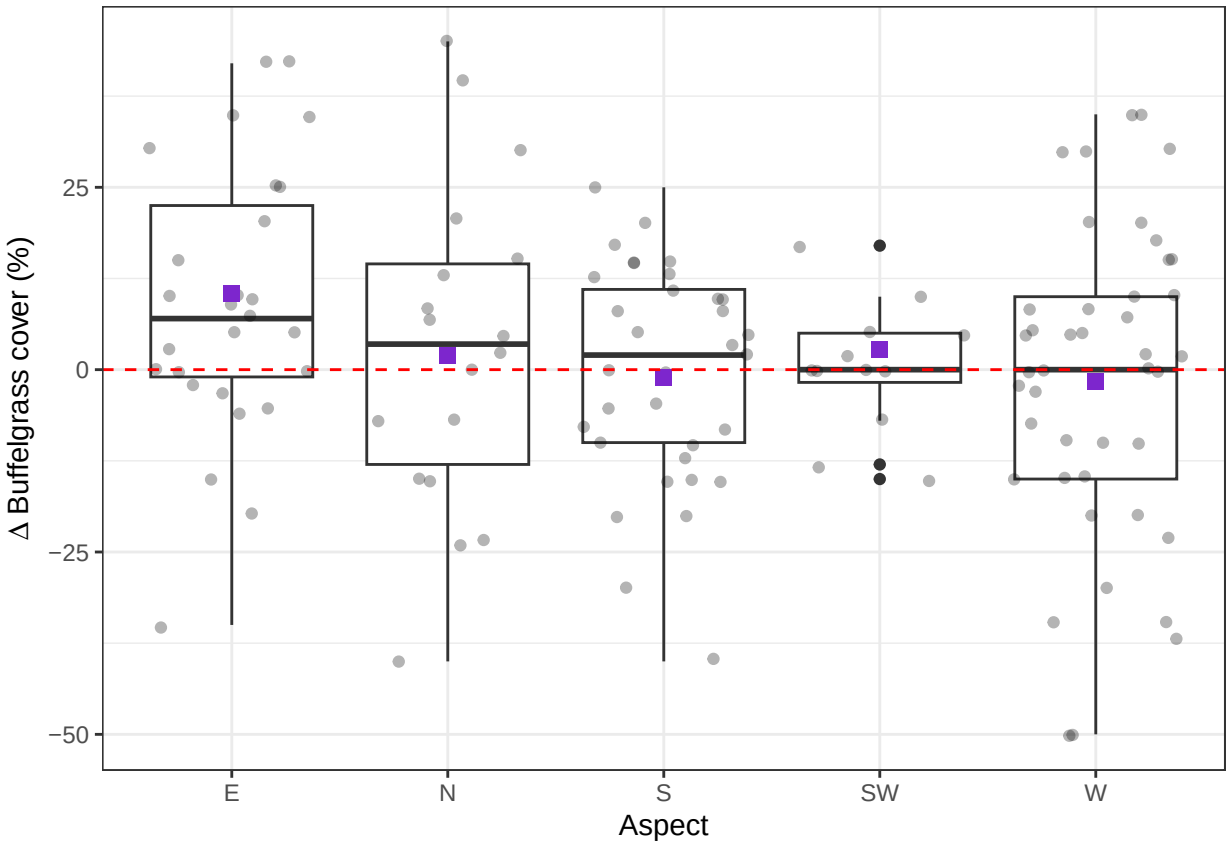

Fig. S9. Effects of aspect on year-to-year change in buffelgrass plot cover. Purple squares represent model-predicted averages. Horizontal red dashed line indicates no change in buffelgrass cover.

Figure S10

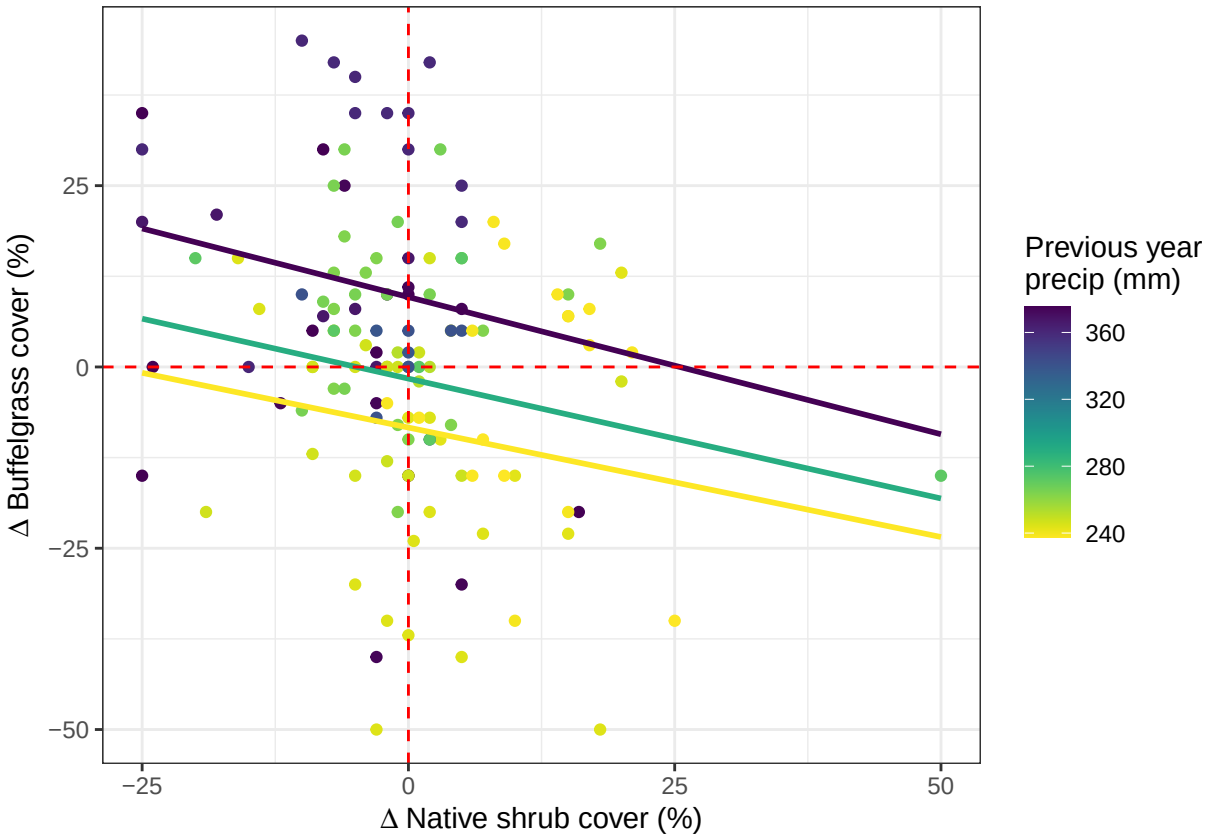

Figure S10. Relationship between year-to-year change in native shrub cover and year-to-year change in buffelgrass plot cover, moderated by precipitation. Colored lines represent model-predicted values under the wettest precipitation conditions experienced (purple line), the driest conditions (yellow line), and average conditions (green line). Vertical red dashed line indicates no change in shrub cover while horizontal line indicates no change in buffelgrass cover.

Figure S11

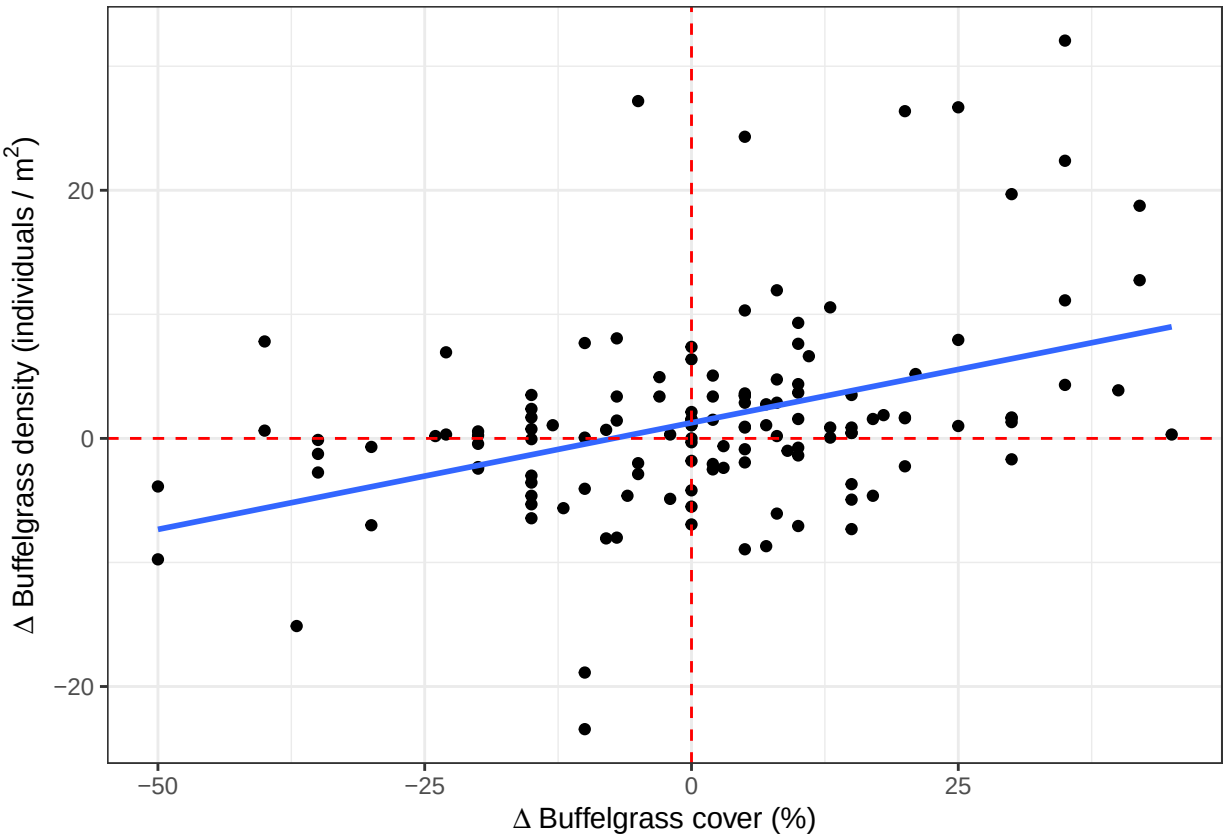

Figure S11. Simple linear regression of year-to-year change in buffelgrass plot density as a function of year-to-year change in buffelgrass plot cover, pooling all sampling locations and times. Vertical red dashed line indicates no change in buffelgrass cover while horizontal line indicates no change in buffelgrass density.

Figure S12

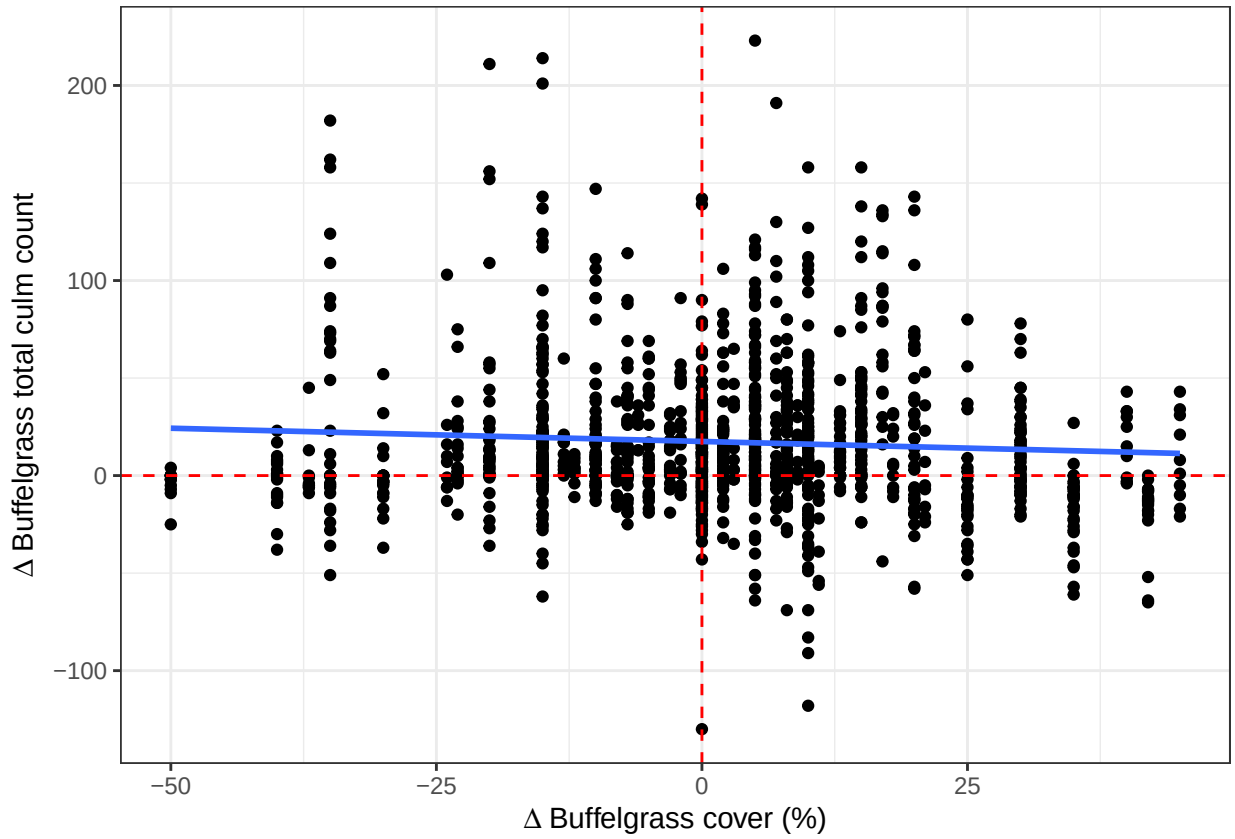

Figure S12. Simple linear regression of year-to-year change in buffelgrass total culm count as a function of year-to-year change in buffelgrass plot cover, pooling all sampling locations and times. Vertical red dashed line indicates no change in buffelgrass cover while horizontal line indicates no change in buffelgrass total culm count.