Are Extreme Precipitation Conditions Equally Likely Among Pastures in a Rotation System?

Haiyan Wei[1,2], Mitchel McClaran[2], D. Phillip Guertin[2]

[1] USDA-Agricultural Research Service, Southwest Watershed Research Center, Tucson, Arizona

[2] University of Arizona, School of Natural Resources and the Environment, Tucson , Arizona

Introduction

- *Seasonal rotation of livestock grazing is common on western rangelands*
- *Expected outcomes of rotation include improved animal performance and vegetation conditions*
- *Statistical analysis assumes homogeneity of precipitation conditions among rotated pastures to combine pastures into a single treatment unit*

Objectives and Approach

- *Evaluate the null hypothesis*

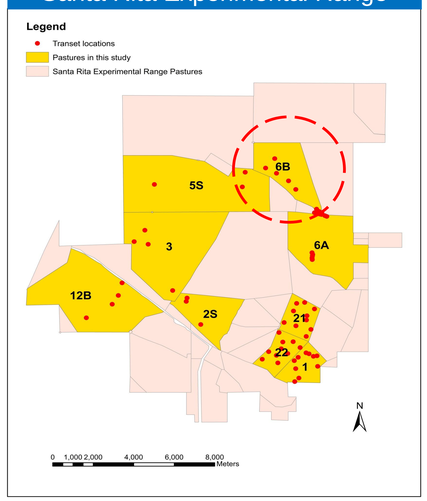
  H_o: No Difference in PPT among Pastures
- *Nine pastures rotated on Santa Rita Experimental Range (1972-1984)*
- *Rotation Schedule:*
  - *NO GRAZE PRIOR to grazing (12 months)*
  - *SUMMER GRAZE (8 months (MAR-OCT)*
  - *NO GRAZE POST grazing (12 months)*
  - *WINTER GRAZE (4 months NOV-FEB)*
- *Calculate monthly Palmer Drought Severity Index (PDSI) for each pasture based on soil at permanent transects and nearby rain gauges*
- *Use September PDSI for summer conditions*
- *Use average NOV-FEB PDSI for winter conditions*
- *Calculate probability of extreme PDSI ≤-2 (DRY) and PDSI ≥2 (WET)*

$$p = \frac{C_3^1 C_{33}^3}{C_{36}^4}$$

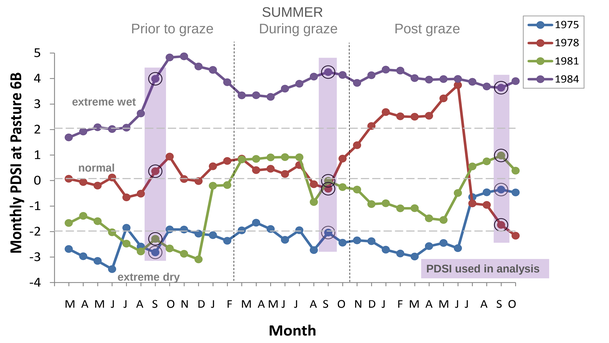
Probability (p) equation example

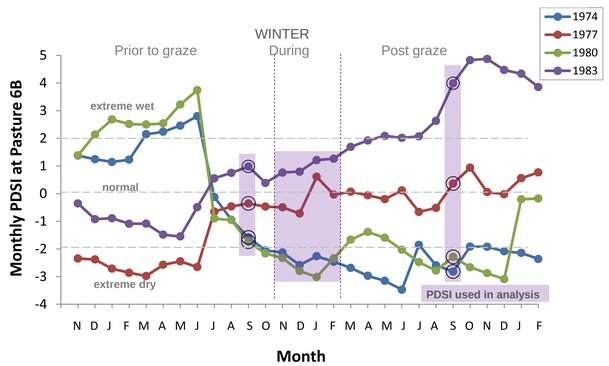
Probability of having 1 dry occurrence out of 36 when: a) 3 occurrences in 36 and b) select 4 at a time

Santa Rita Experimental Range



PDSI During 4 Grazing Rotations in Pasture 6B





PDSI Values by Pasture, Season, and Year

Pasture	Year	SUMMER PDSI Prior to graze	SUMMER PDSI During graze	SUMMER PDSI Post graze	WINTER PDSI Prior to graze	WINTER PDSI During graze	WINTER PDSI Post graze
21	1	-1.76	-1.83	1.10	1.10	-0.54	-0.13
	2	-0.13	0.24	0.19	0.19	0.08	-0.83
	3	-0.83	-0.80	-1.10	-1.10	-0.96	-0.86
	4	-0.86	-0.02	3.00	3.00	3.59	5.03
1	1	-1.98	0.99	-0.13	-0.13	-0.91	-0.67
	2	-0.67	-0.19	-0.84	-0.84	1.69	-0.82
	3	-0.82	-0.57	-0.52	-0.52	-1.26	-0.51
	4	-0.51	3.25	4.77	4.77	4.68	4.05
22	1	0.95	-0.12	-0.53	-1.91	-2.55	0.95
	2	-0.18	-0.83	-0.85	-0.53	-0.66	-0.18
	3	-1.17	-0.95	0.15	-0.85	-1.69	-1.17
	4	3.03	4.84	4.42	0.15	0.56	3.03
6A	1	-0.35	-1.66	-1.58	-1.58	-1.63	-1.62
	2	-1.62	-0.20	0.28	0.28	0.07	-0.99
	3	-0.99	-1.59	-2.05	-2.05	-1.24	-0.25
	4	-0.25	0.77	3.94	3.94	4.29	4.51
2S	1	-1.91	1.00	-0.85	-0.85	-1.63	-0.25
	2	-0.25	0.11	-0.20	-0.20	1.92	-0.90
	3	-0.90	-1.78	-0.82	-0.82	-1.30	0.31
	4	0.31	3.00	4.84	4.84	4.86	4.38
6B	1	-2.82	-2.04	-0.35	-1.59	-2.36	-2.82
	2	0.36	-0.32	-1.74	-0.35	-0.16	0.36
	3	-2.29	-0.01	0.98	-1.74	-2.62	-2.29
	4	3.99	4.25	3.64	0.98	1.01	3.99
5S	1	1.24	0.12	-2.52	-2.47	-1.51	-1.80
	2	-1.80	-2.46	0.09	0.30	0.61	0.84
	3	0.84	-1.12	-2.17	-2.17	-1.50	0.05
	4	0.05	0.54	2.54	2.54	3.65	4.04
3	1	-1.97	0.64	-1.64	0.22	1.42	-1.97
	2	-1.43	0.16	0.57	-1.64	-2.21	-1.43
	3	-0.94	-2.37	-0.53	0.57	2.27	-0.94
	4	0.24	2.80	4.69	-0.53	-1.19	0.24
12B	1	0.67	-1.81	-1.84	-2.80	-3.30	0.99
	2	0.11	-0.89	-0.97	-1.84	-0.91	0.11
	3	-2.69	-0.56	0.21	-0.97	-2.14	-2.69
	4	2.83	4.86	4.44	0.21	0.48	2.83

Results and Discussion

- *Reject null hypothesis for Dry Extremes*

  ~~H_o: No Difference in DRY conditions among Pastures~~
  - *3 pastures experienced multiple dry periods*
  - *Two WINTER dry periods very unlikely ($p \leq 0.11$)*
  - *Two SUMMER dry periods very unlikely ($p \leq 0.03$)*
- *Do Not Reject null hypothesis for Wet Extremes*

  H_o: No Difference in WET conditions among Pastures
  - *No pastures experienced multiple wet periods*
- *Results consistent with general pattern of greater spatial variability during dry conditions than during wet conditions*

Implications

- *Statistical analysis of grazing systems studies can not assume homogeneity among rotated pastures*
- *Analytical Framework should account unique gradient of conditions experience among pastures*
- *Covariate or regression-type frameworks may be more appropriate than ANOVA appropriate*

Occurrence and Probability of DRY & WET Conditions

SUMMER DRY — # of PDSI<-2 and probability

Pasture	Prior to graze	During graze	Post graze
21	0 P=0.69	0 P=0.69	0 P=0.69
1	0 P=0.69	0 P=0.69	0 P=0.69
22	0 P=0.69	0 P=0.69	0 P=0.69
6A	0 P=0.69	0 P=0.69	1 P=0.28
2S	0 P=0.69	0 P=0.69	0 P=0.69
6B	2 P=0.03	1 P=0.28	0 P=0.69
5S	0 P=0.69	1 P=0.28	2 P=0.03
3	0 P=0.69	1 P=0.28	0 P=0.69
12B	1 P=0.28	0 P=0.69	0 P=0.69
Total	3 out of 36	3 out of 36	3 out of 36

SUMMER WET — # of PDSI>2 and probability

Pasture	Prior to graze	During graze	Post graze
21	0 P=0.69	0 P=0.47	1 P=0.45
1	0 P=0.69	1 P=0.41	1 P=0.45
22	1 P=0.28	1 P=0.41	1 P=0.45
6A	0 P=0.69	0 P=0.47	1 P=0.45
2S	0 P=0.69	1 P=0.41	1 P=0.45
6B	1 P=0.28	1 P=0.41	1 P=0.45
5S	0 P=0.69	0 P=0.47	1 P=0.45
3	0 P=0.69	1 P=0.41	1 P=0.45
12B	1 P=0.28	1 P=0.41	1 P=0.45
Total	3 out of 36	6 out of 36	9 out of 36

WINTER DRY — # of PDSI<-2 and probability

Pasture	Prior to graze	During graze	Post graze
21	0 P=0.61	0 P=0.47	0 P=0.69
1	0 P=0.61	0 P=0.47	0 P=0.69
22	0 P=0.61	1 P=0.41	0 P=0.69
6A	1 P=0.34	0 P=0.47	0 P=0.69
2S	0 P=0.61	0 P=0.47	0 P=0.69
6B	0 P=0.34	2 P=0.11	2 P=0.03
5S	2 P=0.05	0 P=0.47	0 P=0.69
3	0 P=0.61	1 P=0.41	0 P=0.69
12B	1 P=0.34	2 P=0.11	1 P=0.28
Total	4 out of 36	6 out of 36	3 out of 36

WINTER WET — # of PDSI>2 and probability

Pasture	Prior to graze	During graze	Post graze
21	1 P=0.38	1 P=0.41	1 P=0.44
1	1 P=0.38	1 P=0.41	1 P=0.44
22	0 P=0.53	0 P=0.47	1 P=0.44
6A	1 P=0.38	1 P=0.41	1 P=0.44
2S	1 P=0.38	1 P=0.41	1 P=0.44
6B	0 P=0.53	0 P=0.47	1 P=0.44
5S	1 P=0.38	1 P=0.41	1 P=0.44
3	0 P=0.53	1 P=0.41	0 P=0.35
12B	0 P=0.53	0 P=0.47	1 P=0.44
Total	5 out of 36	6 out of 36	8 out of 36

Future Work

- *Complete probability analysis with permutation and probability of joint events (PRIOR-GRAZE-POST)*
- *Account for DRY conditions in analysis of vegetation response with Covariate and regression frameworks.*

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