Livestock exclusion increases the spatial heterogeneity of vegetation in the shortgrass steppe

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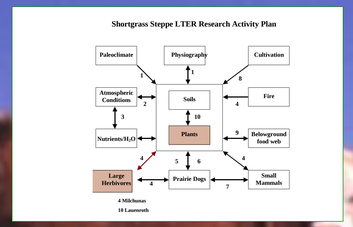


Introduction

• Ecologists have collected extensive information on how various factors affect the MEAN values of key response variables, but typically ignore how spatial distribution is affected.

• Describing spatial heterogeneity is important because 1) pattern may affect process and 2) the identification of previously unrecognized patterns generates new hypotheses.

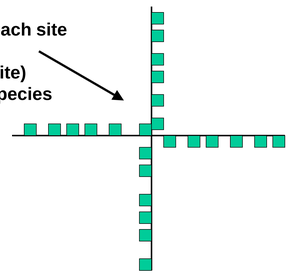
Objectives

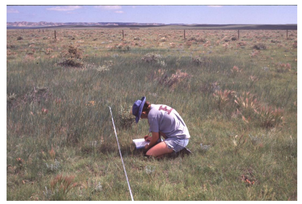
• Describe how the presence or absence of grazing alters the spatial heterogeneity of dominant plant species
• Generate hypotheses for mechanisms that may produce these spatial patterns

Methods

Vegetation sampling

•Paired grazed-ungrazed sites
•2 perpendicular transects of 40m at each site
•25 x 25cm quadrats located randomly within each meter (80 quadrats/site)
•cover and density of dominant plant species





Statistical analysis

•I used autocorrelation as a measure of spatial heterogeneity
•Moran's I measures the intensity of autocorrelation
+1 indicates positive autocorrelation
0 indicates random patterns
-1 indicates negative autocorrelation
•I used Moran's I in two forms:
The "global" Moran's I is a single coefficient based on all measurements within a plot, weighted by inverse distance.
"Autocorrelograms" are constructed by calculating Moran's I for subsets of the data separated by specific lag distances.

Results

Differences in grazed (n = 8) and ungrazed (n = 8) vegetation using paired t-tests.
Variables measured as percent cover (%) and density (#).

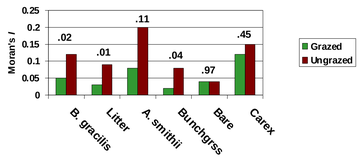
Variable	Mean Grazed	Mean Ungrazed	t	p
Litter (%)	17.4	27.8	-5.1	.00
A. smithii (#)	1.9	5.9	-4.6	.00
B. gracilis (%)	37.0	25.7	3.7	.01
Bare (%)	20.6	15.7	3.28	.01
Bunchgrass (%)	7.2	9.2	-0.9	.41

Mean Moran's *I* for *B. gracilis* and number of sites with significant autocorrelation (p<.05)

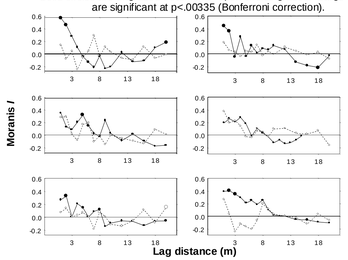
Treatment	mean *I*	significant/total
grazed	.05 [a]	3/8
8 yr. exclosure	.07 [a]	4/6
60 yr. exclosure	.12 [b]	7/8

Superscript letters indicate LSD comparisons in a one-way ANOVA

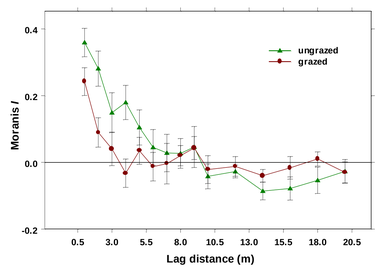
Differences in Moran's *I* between grazed (n = 8) and ungrazed (n = 8) sites using paired t-tests (p-values shown above bars).



Autocorrelograms for *B. gracilis* in 6 sites.
Solid circles are ungrazed treatments, open circles grazed. Large circles are significant at p<.00335 (Bonferroni correction).



"Average" autocorrelograms from grazed (n=8) and ungrazed (n=8) treatments.



Discussion

Pattern description:

•Vegetation shows greater spatial structure or "patchiness" in the long-term exclosures than in grazed areas.
•The lack of similar spatial structure in the short-term (8 year) exclosures suggests that these patterns form slowly.
•Inside the exclosures, patches of C_3 grasses appear to suppress *B. gracilis*.
•Simulations (not shown) demonstrate that reducing cover of *B. gracilis* in randomly selected quadrats of grazed sites does not increase spatial autocorrelation, while reducing *B. gracilis* cover in groups of contiguous quadrats does produce patterns similar to those observed within the exclosures.

What process could create this pattern?

1) Small scale variations in soil texture could favor C_3 grasses in the absence of grazing.
Evidence: Negative. At one site I sampled soil texture in each quadrat. I did find small scale variation in soil texture, but it was not correlated with cover or density of C_3 grasses.
2) Successional pathways following patch-disturbance may depend on grazing.
Evidence: Positive but indirect. Work by Coffin and Lauenroth showed that recovery of *B. gracilis* following mortality caused by belowground herbivory was faster in grazed than ungrazed sites.
3) In the absence of grazing, plant competition involves spatial processes such as vegetative reproduction or "preemption" of limiting resources, favoring the established species.
Evidence: Untested.

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