Gopher Disturbance and Plant Community Dynamics in Montane Meadows

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Madelon Case

Advisors: Simon Levin[1], Charles Halpern[2]

1. Department of Ecology and Evolutionary Biology, Princeton University, 2. School of Forest Resources, University of Washington

Background

Pocket gophers (Geomyidae) are a major agent of disturbance in grassland plant communities throughout North America. By depositing excavated soil on the ground surface, they bury existing plants and restart succession on a local scale. This can increase habitat heterogeneity and potentially influence community structure and diversity by providing opportunities for less competitive species to persist. Gopher disturbance often gives forbs an advantage relative to graminoids [1].

While gopher effects on vegetation are well-studied in lowland prairies, study of gopher-plant interactions in higher-altitude systems has been limited. Gopher disturbance in montane meadows occurs in two distinct forms:

Mounds

Mounds are piles of excavated soil that gophers push out onto the ground surface. Created during summer and fall (Figure 1).

Figure 1. Gopher mound >1 year old.

Castings

During winter, gophers tunnel through the deep snow and fill the tunnels with soil that settles on the ground surface after snow melt (Figure 2). The impact of castings on plants has not been studied before.

Figure 2. Gopher castings. Scale is 20 cm x 50 cm.

Objectives

This study sought to investigate the effects of gopher disturbance on plant community structure in montane meadows at Bunchgrass Ridge, a high-altitude plateau in the Oregon Cascade Range. Two primary goals were:

1. To explore relationships between disturbance and vegetation at larger spatial scales than previously studied in this system [2].

2. To assess the contributions of the two main forms of disturbance—mounds and castings—to these relationships.

Methods

I established four plots in different meadows, and sampled 20 five-meter transects in each plot for percent cover of plant species and different types of gopher disturbance (Figure 3).

I used mixed-effects models to assess relationships between disturbance and: total plant cover, forb cover, graminoid cover, ratio of forb/graminoid cover, species richness (# of species per transect), and heterogeneity of species composition (mean Bray-Curtis dissimilarity between pairs of quadrats).

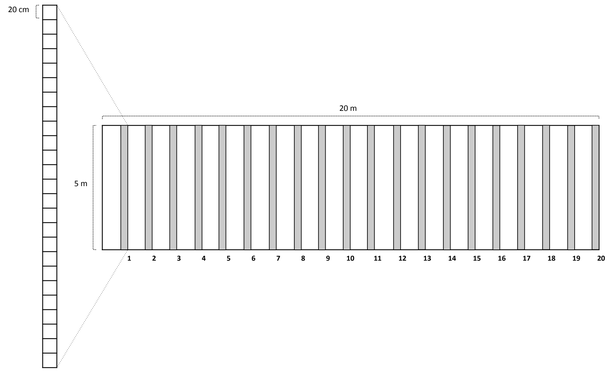
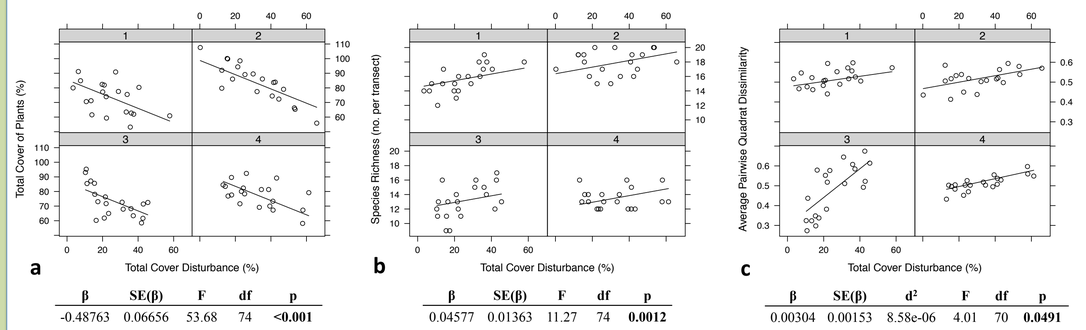


Figure 3. Plot layout. Transects crossed the 20 m x 5 m plot at 1-m intervals and were sampled with 20 cm x 20 cm quadrats.

Results



	β	SE(β)	F	df	p
a	-0.48763	0.06656	53.68	74	**<0.001**
b	0.04577	0.01363	11.27	74	**0.0012**
c	0.00304	0.00153	8.58e-06	4.01	70 **0.0491**

Figure 4. Relationships between total cover of disturbance and (a) total plant cover, (b) species richness, and (c) compositional heterogeneity, across the four plots sampled. Regression lines for plots in (a) and (b) have different random-effects intercepts but a common slope (β). For (c), slopes vary by the variance d^2 about the common slope (β). P-values assess the null hypothesis that $\beta = 0$.

Total disturbance appeared to reduce plant cover while encouraging diversity. Total plant cover decreased with total disturbance across all four plots, while species richness and spatial heterogeneity in species composition (mean pairwise quadrat dissimilarity) were positively correlated with total cover of disturbance (Figure 4).

Mounds and castings both had a significant impact on plant cover. They varied, however, in their relationships with major growth forms (forbs and graminoids). The significant relationships between mound cover, graminoids, and the forb/graminoid ratio agreed with expectations from the literature [1, 2]. Relationships between castings and growth forms varied across plots.

Effects of Mounds

- ↓ Total plant cover ($p<0.001$)
- ↓ Total graminoid cover ($p<0.001$)
- N/S effects on forb cover ($p=0.9973$)
- ↑ Forb/graminoid ratio ($p=0.0029$)

Effects of Castings

- ↓ Total plant cover ($p<0.001$)
- N/S effects on graminoid cover ($p=0.3391$)
- N/S effects on forb cover ($p=0.8535$)
- N/S effects on forb/graminoid ratio ($p=0.6651$)

Simulation Model

My analyses suggested a high degree of variability among plots in the relationship between disturbance and graminoids. In Plot 3, unexpectedly, graminoid cover appeared to increase with total disturbance. I proposed that this might be due to the influence of *Phlox diffusa*, a highly competitive dominant sub-shrub in Plot 3.

I illustrated this hypothesis with a grid-based simulation model. The model includes a disturbance module (gophers disturb the grid at a certain rate per time step) and a plant population dynamics module (plants reproduce and compete) [3]. I first found a set of parameters representing Species A (forb) as the better colonizer and Species B (graminoid) as the better long-term competitor, so Species B was most successful at low levels of disturbance. I then introduced *Phlox*, which was a very poor colonizer and an excellent long-term competitor. *Phlox* dominated the meadow unless gopher disturbance created openings, so Species B showed a general trend of increasing with rate of disturbance – opposite to the relationship between Species B and disturbance without *Phlox* present (Figure 5).

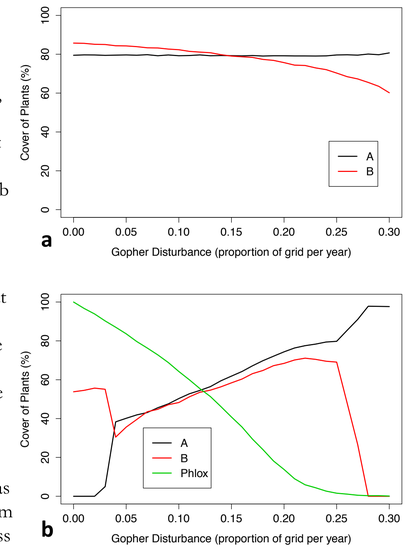


Figure 5. Cover of (a) Species A and B in a two-species system, and (b) Species A, B and *Phlox* in a three-species system, for a range of gopher disturbance. Cover data are recorded after 100 time steps of the simulation and averaged over 10 simulation trials.

Conclusions

- Gopher disturbance plays an important role in shaping plant communities at Bunchgrass Ridge. Through creating a dynamic, heterogeneous mosaic of disturbed and undisturbed patches, gopher activity helps maintain species diversity and increases spatial heterogeneity in community composition.

- Gopher castings, previously ignored in the literature, clearly have a negative impact on plant cover. They have less consistent effects than mounds do, however, on relative abundances of forbs and graminoids. This may be due to physical differences (mounds are larger and last longer) or age differences (castings were recent, whereas all mounds in this study were at least 1 year old).

- As my simulation model shows, a highly competitive dominant species can alter the relationship between disturbance and other species such as graminoids.

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