The Effect of the Plains Pocket Gopher (*Geomys bursarius*) on Plant Species Diversity at Frenchman's Bluff, Minnesota

ANNA KOERNER, *Department of Fisheries, Wildlife and Conservation Biology, University of Minnesota, St. Paul, Minnesota 55108, USA*

BLAIR BOLLIG, *Department of Forestry Resources, University of Minnesota, St. Paul, Minnesota 55108, USA*

MACKENZIE LOCKHART, *Department of Fisheries, Wildlife and Conservation Biology, University of Minnesota, St. Paul, Minnesota 55108, USA*

COURTNEY FAEH, *Department of Plant Biology, University of Minnesota, St. Paul, Minnesota 55108, USA*

Abstract

In a prairie ecosystem, plains pocket gophers are a major cause of plant community disturbance. Based on the Intermediate Disturbance Hypothesis, we predicted that plant species diversity would be greater in the areas of pocket gopher mound disturbance. We also hypothesized that gopher mounds would result in a higher concentration of colonizing invasive species. We tested 1 m^2 plots at Frenchmen's Bluff, Minnesota: half containing gopher mounds and half without gopher mounds. The plots containing gopher mounds had significantly greater species richness and higher abundance of invasive species. However, the difference in diversity (quantified with the Shannon Weaver Index) between the two plots was marginally significant. These results are consistent with the Intermediate Disturbance Hypothesis, wherein the disturbance of the gopher mound provided a greater opportunity for a larger variety of species.

Introduction

Plant species diversity within prairie ecosystems relies on disturbances, which prevent succession in order for the community to remain stable. Fires and small mammal disturbances are two common disruptions that take place on the tall grass prairie. One mammal in particular, the plains pocket gopher (*Geomys bursarius*), is responsible for creating multiple disturbances throughout the grasslands of North America by burrowing extensive underground tunnels (Tilman, 1983). This fossorial mammal has been shown to increase the amount of moisture in the subsoil as well as the amount of plant species diversity due to the complex tunnel systems that they are capable of creating (Rezsutek and Cameron, 2000). While plains pocket gophers

are digging tunnels, they push a large amount of soil up and out to the surface, creating gopher mounds (Breckenridge, 1929). These newly created mounds can occupy over one square meter of space, with several occurring in close proximity to each other. The more gopher mounds that arise in a field, the higher the levels of incident light that will be absorbed by these newly created mounds. In northwestern Minnesota, where our study took place, the gopher mounds have a mixed clay hard pan with an overlying silt loam (Ross et al., 1968). These gopher mounds serve as important germination sites for grasses and forbs throughout the prairie (Schaal and Leverich, 1982). The disturbed soil generated by the mound building process creates a disturbance in the prairie vegetation which improves the growth of forbs, a plant that is a major part of a plains pocket gopher's diet (Mielke, 1977).

Our experiment focused on examining whether plant species diversity would be greater at a gopher mound disturbance sites compared to non-disturbed sites. The Intermediate Disturbance Theory states that the maximum species diversity occurs under conditions of intermediate disturbance rate and intensity (Huston, 1979). It has been shown that gopher mound building increases plant species diversity and spatial heterogeneity (Hobbs and Mooney, 1985). Therefore, we predicted to find similar results as gopher mounds are an important natural disturbance for maintaining plant community structure and diversity within a prairie ecosystem (Collins, 1987).

Methods/Materials

This study took place at the Frenchman's Bluff Prairie SNA, in northwest Minnesota. Before the study was conducted, a 50x50m plot was measured. Within this area, all gopher mounds were marked with a flag. If one mound fell within a meter of another already marked mound, it was not flagged to be observed. Random points within the 50x50m area were selected

to be sampled for control plots. Of these random points within the plot, any that were within one meter of a gopher mound were discarded without observation. At the remaining points, $1m^2$ plots were constructed and the percent coverage of the different plant species within the $1m^2$ plot was recorded. Plants were not identified by species, except for two invasive species: spotted knapweed (*Centaurea maculosa*) and yellow sweet clover (*Melilotus officinalis*); and a rare native plant: Frenchman's Bluff moonwort (*Botrychium gallicomontanum*).

In the second part of the study, observations were taken at forty of the marked gopher mounds. The same process of creating a $1m^2$ plot and recording the percent coverage of the different plant species present was repeated for the gopher mound plots.

Results

Plots containing gopher mounds had significantly greater species richness than control plots by a t-test ($t=3.68$, $p=0.0004$, $df=72$) (Fig 1.). In addition, gopher mound plots contained a significantly greater percent cover of the invasive species, yellow sweet clover ($t=3.29$, $p=0.0018$, $df= 53$) (Fig. 2). Neither the spotted knapweed nor the Frenchman's Bluff moonwort was observed in the study. The difference in diversity, as calculated from the Shannon Weaver Index, was determined marginally significant ($t=1.842$, $p=0.069$, $df=75$) (Fig. 3).

Discussion

The results of this study show that the existence of plains pocket gopher mounds in Frenchman's Bluff has a clear connection to the level of plant richness and diversity. The Intermediate Disturbance Hypothesis states that "a maximum of diversity is found in

communities experiencing intermediate disturbance regimes, or communities at an intermediate stage of development since the last major disturbance event" (Cordonnier et al. 2006). The effects of gopher mound disturbances are similar to that of the early stages of succession found when a major disturbance changes the prairie's structure but on a smaller scale (Inouye et al. 1987). In our study, a gopher mound represents an intermediate disturbance, which only affects parts of the community, not the entire ecosystem, as a fire would. The gopher mounds leave areas of disturbance between patches of undisturbed soil that has an impact on the plant diversity. We limited our study to only test gopher mounds that did not have freshly turned over soil nor completely covered by vegetation. In a future study it would be beneficial to see if the age of gopher mounds had a greater effect on the plant diversity. We would expect that the gopher mounds that were too old or too young to not significantly increase diversity.

Plots that contained gopher mounds had higher species richness than those plots that did not have mounds (Fig. 1). This richness suggests that the newly overturned soil allows for more species to take hold in the less competitive environment, at least in the short term (Jones et al. 2008). The increased species richness is an indication that the prairie environment thrives when there is occasional intermediate soil disturbance.

The results also showed a greater amount of the invasive species, yellow sweet clover, in the plots that had a gopher mound present than in those that did not (Fig. 2). The disturbance caused in the soil by the gophers allows for a surge of invasive species to outcompete the slower colonizing or stress intolerant native species (Cordonnier et al. 2006). The higher amount of yellow sweet clover in the plots with the gopher mounds suggests that this species has a high likelihood of colonizing freshly turned soil. The lack of this species in the control plots suggests that it is not able to get as strong of a hold as well when competitors already have a strong

presence in the soil. The invasive species spotted knapweed was not seen in our study, which suggests that the current management to remove species by the Minnesota DNR has been successful.

The diversity, as calculated by the Shannon Index, between the plots with gopher mounds and those without was found to be marginally significant (Fig. 3). However, the p-value of the t-test was 0.069, which was near our confidence level with a p value of 0.05. In addition, standard error showed the gopher mound treatment to have a significantly greater diversity (Fig 3). It may be necessary to sample a larger amount of plots to determine the significance of the treatments.

The results found in this study differ in some aspects to the results found in similar previous studies. The gophers of meadows in the western United States had such an effect on the plant diversity that it did not support the Intermediate Disturbance Hypothesis (Jones et al. 2008). It was found that the gophers reduced the richness of the plants in the areas they disturbed instead of increasing it, contrary to what was found in our study. In another case, the gophers present in abandoned oil-fields in the eastern part of Minnesota were found to increase the amount of species richness in areas that contained gopher mounds. The amount of disturbance and diversity due to each mound differed if the field was old or new, but there was a significant change in abundance if a mound was present (Inouye et al. 1987). These results were in agreement to the ones recorded in our study; although, we did not test if the age of the mound had an effect on species richness or diversity.

The results of this study could have been affected by errors that occurred during sampling. The plots were sampled by groups that would have had different ways of calculating the percent cover of the plot. Also, few of the groups had an extensive background in plant identification and this could have led to misidentification of the plants. The location of the

50x50m plot was at the foot of a hill and all the gopher mounds found were in the lower portion of the grid, not spread throughout the entire study site. Future studies could standardize the plots of individuals groups, as well as sampling multiple sites with differing slopes to determine its effect on gopher mound presence.

Overall, our study supported the Intermediate Disturbance Hypothesis, in which the gopher mounds studied were found to be a disturbance which increased the species richness and diversity of the local plant community in Frenchman's Bluff. Our results suggest that the plains pocket gopher has a significant role in maintaining plant diversity in prairie ecosystems. Disturbances in the prairie ecosystem, as created by plains pocket gophers, help maintain a stable community in the face of ecological succession.

References

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Figures

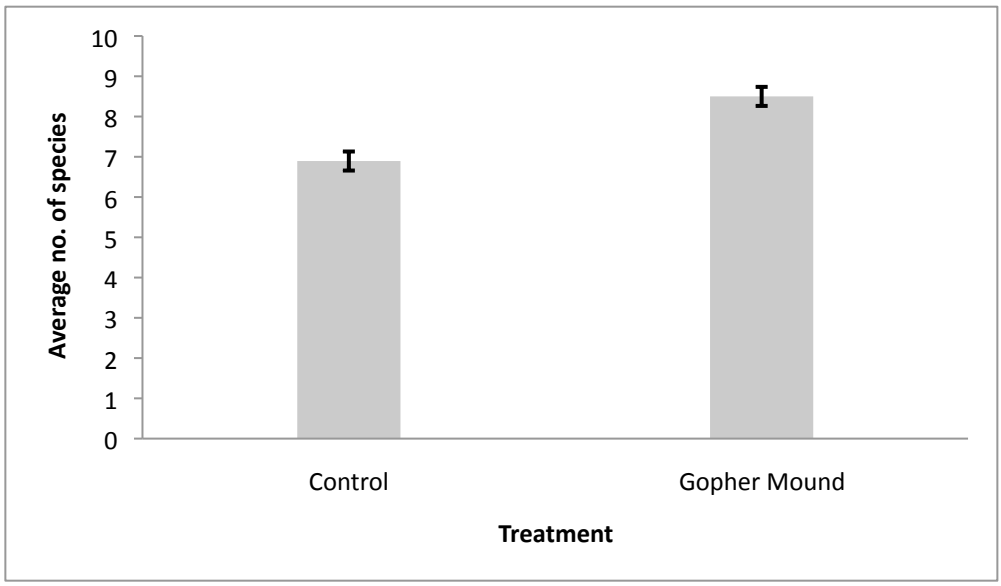

Figure 1. Comparison of species richness between control plots and gopher mound plots. Error bars indicate ± 1 standard error. Difference between treatments was found significant by a t-test (t=3.68, p=0.0004, df=72).

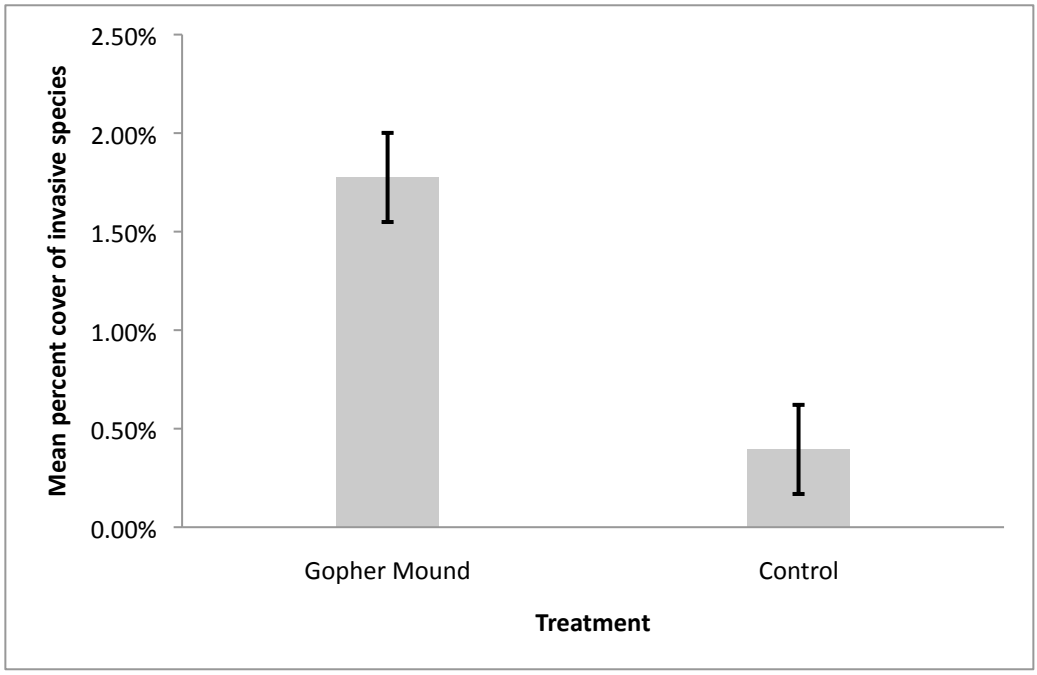

Figure 2. Comparison of percent cover of invasive species yellow sweet clover between control and gopher mound plots. Error bars indicate ± 1 standard error. Difference between treatments was shown significant by a t-test (t=3.29, p=0.0018, df=53).

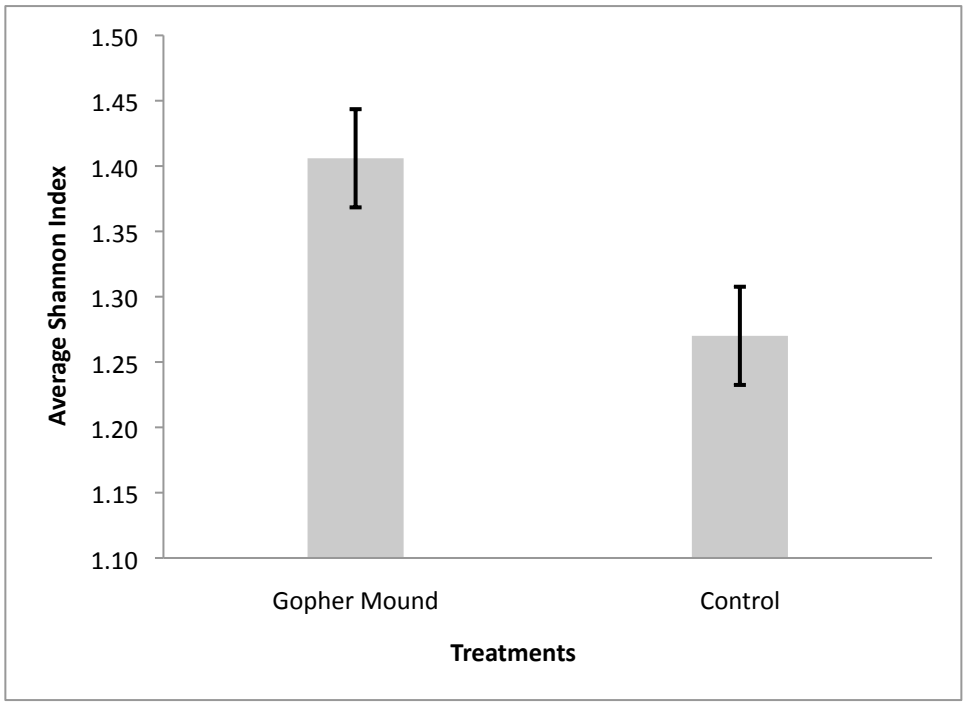

Figure 3. Comparison of diversity between gopher mound and control plots. Diversity was calculated using the Shannon Index. Error bars indicate ± 1 standard error. Difference between treatments was determined to be insignificant by a t-test (t=1.842, p=0.069, df=75).