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Effects of Gopher Disturbance on Plant Diversity in Prairie Ecosystems

Abstract:

Burrowing mammals can have a pronounced effect on vegetation growth and species diversity. Based on the intermediate-disturbance hypothesis, we estimate that the intermittent disturbances caused by burrowing pocket gophers (*Geomys bursarius*) encourages species diversity in prairie ecosystems. Mounds that result from burrowing displace vegetation and allow competition for establishment. Competition between colonizer species and competitive species reaches a coexistence maximum as vegetation compensates for this disturbance. We found that these spatially separated disturbances encouraged a higher species diversity compared to undisturbed areas.

Introduction:

Within ecosystems, animal behaviors can have effects on both the physical structure and biodiversity. Often, these animals can be important agents affecting plant diversity (Huntly & Inouye 1988). Levels of diversity have been shown to be important in the temporal stability of ecosystems as well as stability within plant communities. (Tilman et al. 2007).

The intermediate disturbance hypothesis first proposed by Connell (1978), explains how intermittent disturbances to an ecological community can encourage diversity. Frequent disturbances may prevent secondary succession from occurring, favoring rapid-growth species that can persist in an unstable environment. In contrast, an area with few disturbances will favor succession of a superior competitor and will lower overall diversity. An environment affected by consistent intermediate disturbances encourages competition between both extremes, allowing both to persist in the same community.

Burrowing of small mammals like pocket gophers (*Geomys bursarius*) provide an example of a disturbance. Found in prairie ecosystems, *G.bursariu*s form tunnels by displacing subterranean soil to the surface. The mounds created by this displacement remove established vegetation and mix soil and nutrients, allowing new vegetation to develop (Huntly & Inouye 1988). Based on the intermediate disturbance hypothesis, we hypothesize that the age of gopher mounds will affect the amount of plant diversity around the mounds. We predict that this disturbance will allow the most diversity around the old mounds compared to undisturbed prairie and newly constructed mounds. Disturbances on vegetation caused by this behavior may play a key role in regulating species diversity and is an important factor for understanding competition and species interaction within ecological communities.

Methods:

Our research was conducted at Frenchman's Bluff prairie in Norman County of Northern Minnesota. Data was collected on June 7, 2010 for later analysis. To minimize edge effects and ensure a large sample size, we chose an area of the prairie with a well-represented selection of gopher mound. We constructed a $50m^2$ test site organized into a grid with the southwest corner as the origin and four 25 x 25m quadrants. All gopher mounds within the site were flagged, given coordinates, and classified as new or old (figure 1).

The distinguishing characteristics of new mounds are areas of fresh dirt with little vegetation on top, whereas old mounds were obviously elevated, but typically covered by vegetation with evidence of gravel at plant bases. Control plots were determined by random number generation of X, Y coordinates within the bounds of our 50 x 50m dimensions. If a generated control overlapped a flagged mound site, another random location was generated until a total of 18 controls were achieved, with at least four in each quadrant. These points were randomly distributed, along with 15 new and 14 old mounds, among the fieldwork groups. Groups then evaluated their given sites for number of species and percent cover for each species within a $1m^2$ area centered on the coordinates.

Data Analysis:

Shannon-Weaver diversity indexes were calculated for control, new, and old mound data. In order to compensate for percent coverage estimates not adding up to 100%, we added .5 to the highest coverage value to use as a baseline in getting our proportional abundances. This was done to avoid a logarithmic output of zero in our Shannon-Weaver test. A single variable ANOVA test was run to verify overall significant variance, and further T-tests were done to compare the variability of results between each category.

Results:

Our Shannon-Weaver Diversity Index results revealed that old mounds had a mean diversity (H) of 5.3, the new mounds had a mean of 2.69 and the control plots had a mean of 1.34 (figure 2). A single factor ANOVA test with a P-value of .05 revealed a significant difference between the diversities of 3 treatments, $F_{2,42}=15.87$, $p<.0001$.

The mean species richness for each treatment was calculated as well. The control mounds had a richness mean of 9.41, while both the new and old mounds had a mean richness of 9.29 (figure 3).

Cross treatment two sample with equal variance T-tests were performed to isolate the differences between treatments. All treatments were found to differ significantly from each other using a p-value of .05. The new mounds were found to be significantly more diverse than the control mounds $T_{29}=3.22$, $p= .00312$. The old mounds were found to be significantly more diverse compared to the control mounds and the new mounds; $T_{29}=5.17$, $p<.0001$ and $T_{26}=2.84$, $p= .0087$ respectively.

Discussion:

Our results support our hypothesis that the old gopher mounds will be more diverse compared to new mounds and control plots without mounds. These results add support to the intermediate disturbance hypothesis, which would suggest that because control plots have too little disturbance and new mounds have recent disturbance, the intermediate stage (old mounds) should have the most diversity.

The Shannon-Weaver diversity index incorporates both richness and evenness (species distribution). Figure 2 reveals that the species richness between treatments was very similar; therefore the major differences in diversity can be attributed to the distribution of species. The control plots tended to have a distribution that was dominated by 1 main species giving it a low diversity index. The new mounds tended to have to be dominated by unearthed dirt with relatively little plant coverage. The old mounds had more evenly distributed species compared to both new and control plots making them more diverse.

Although control plots clearly had a higher density of plant biomass, the new mounds were shown to have significantly more diversity than the control. It has been documented that although the new mounds have large dirt areas removed from production, the regions immediately around the dirt mounds compensate with increased production (Grant et al. 1980).

This is consistent with other research suggesting that gopher mounds overall, increase diversity compared to the undisturbed areas no matter the age class of the mound (Huntly & Inouye 1988).

The exact mechanism that allows for more plant diversity within the older mounds is not yet known. However, gopher mound soil has been shown to differ in many ways compared to undisturbed plots, which may affect plant growth. This includes soil texture, water-holding capabilities, and soil nitrogen, phosphorus and potassium levels (Huntly & Inouye 1988).

Our data collection methods were the main source of possible errors. Plant covers were estimated by eye, so different groups may have had different opinions on percent covered. This could lead to misrepresentation of species cover. Another source of error would be missing a plant species during counts. In the thicker vegetation, it is possible that smaller plants could be hidden under the other plants. Should we repeat this experiment in the future, it should be done over a larger area and plant species identification should be done.

These results reveal that gophers and their mound building behavior are important agents encouraging plant diversity and thus ecosystem stability within prairie systems. This offers insight into the complex ecological interactions, showing that a seemingly simple behavior has repercussions for an entire ecosystem.

Figures

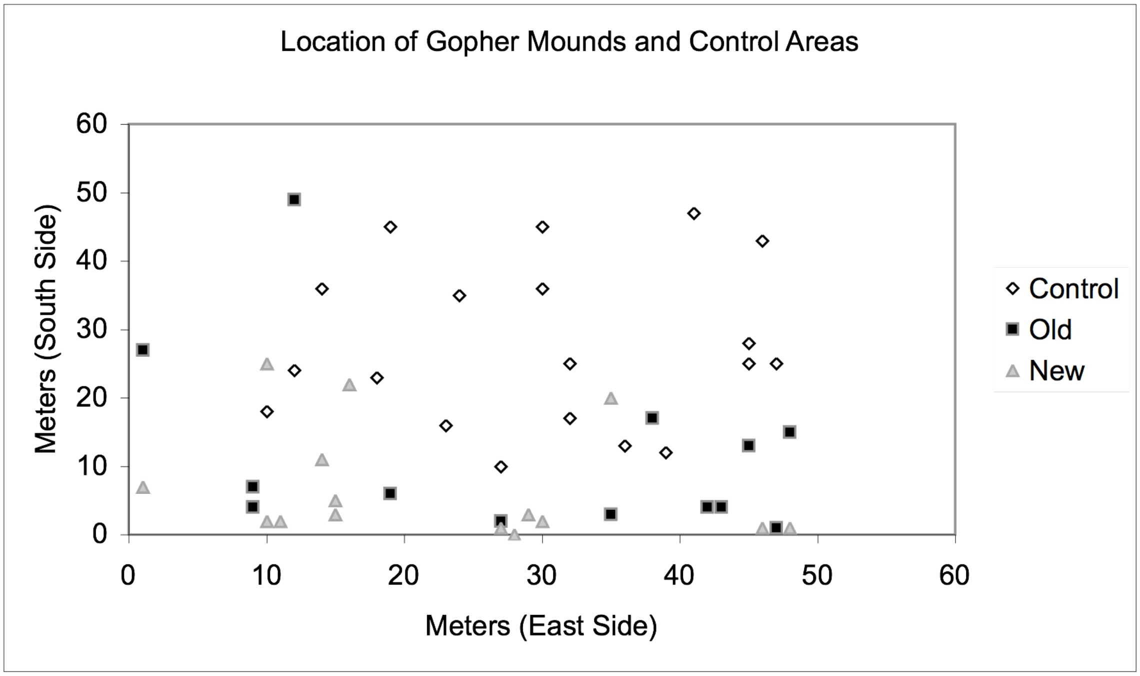
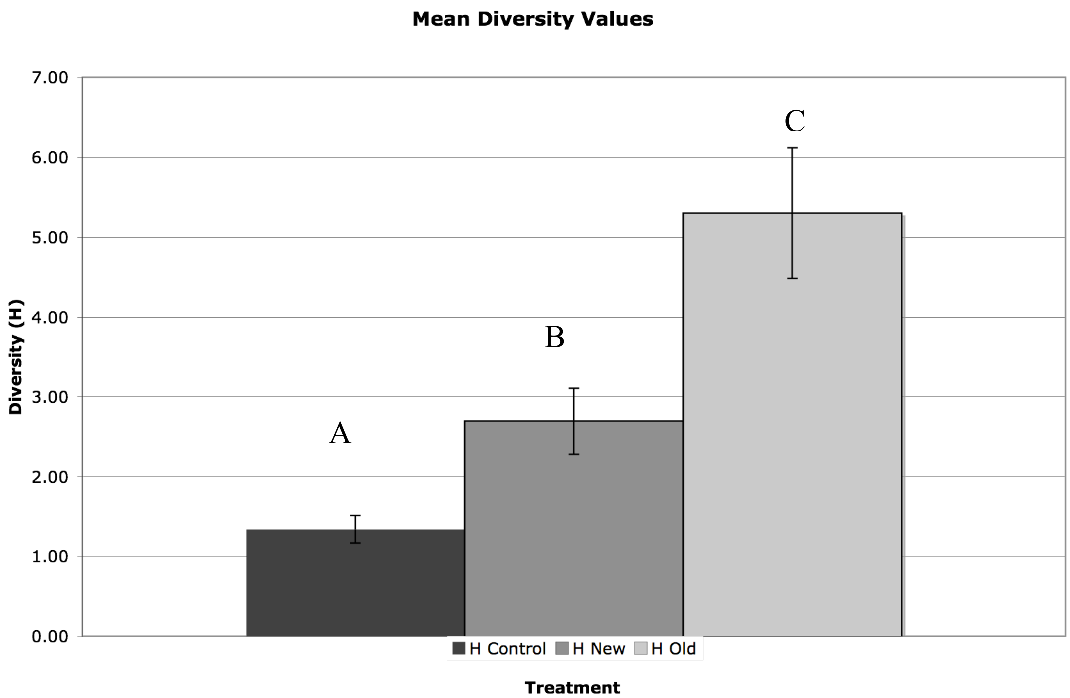
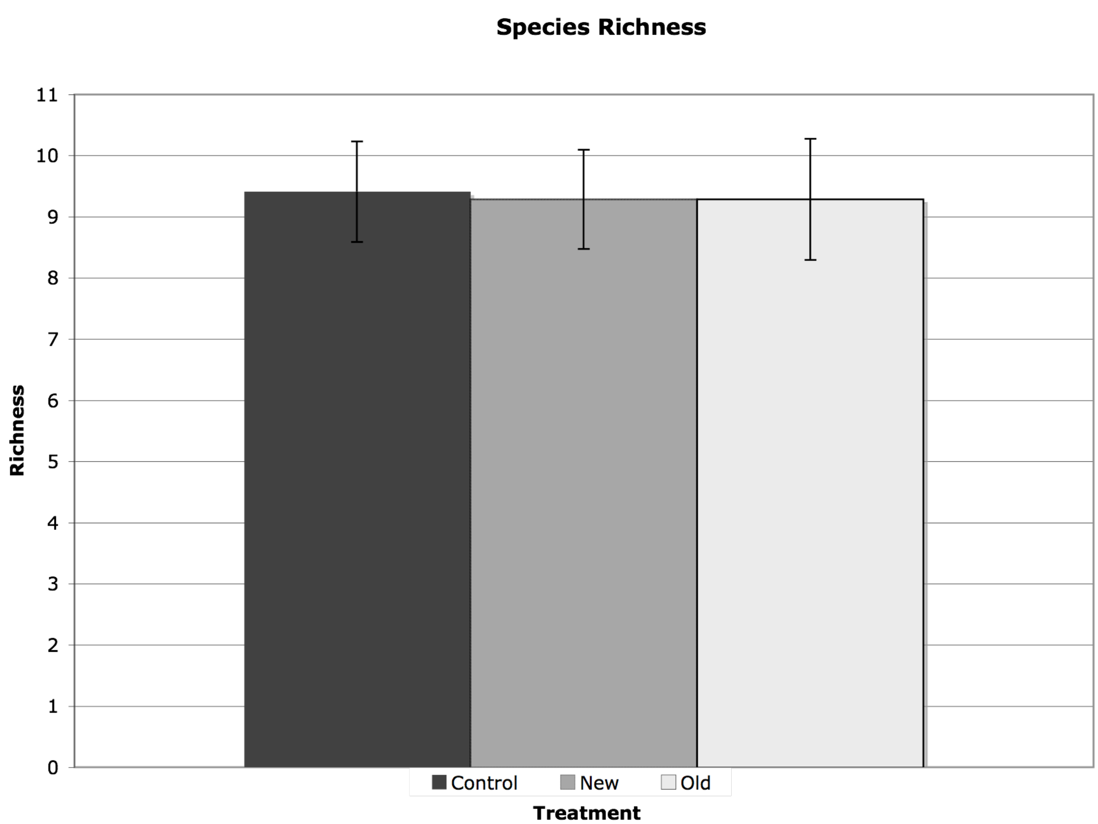


Figure 1: Gopher mound and control site locations in Frenchman's Bluff prairie.

Left: an example of a typical new gopher mound with unearthed dirt. Right: an example of a typical slightly elevated old gopher mound



Mean diversity values (H) for each treatment. The old mound mean= 5.3 (SE=.82), new mound mean=2.69 (SE=.413) and control mean=1.34(SE=.174). The A, B, C notation indicate the T-tests significant differences between treatments. The control mounds and the new mounds differed significantly from each other T_{29}=3.22, p= .00312. The old mounds were found to be significantly more diverse compared to control plots and new mounds: T_{29}=5.17, p<.0001; T_{26}=2.84, p= .0087.



Mean species richness (number of species) values for each treatment. The Control mean=9.41 (SE.82), the new mound mean=9.29 (SE=.81) and the old mound mean=9.29 (SE=.99). The ranges of these results show that the control plots differ from the old and new mounds by .12 species.

References

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