

BIODIVERSITY AND FIRE IN SHORTGRASS STEPPE

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Abstract

Effects of fire at two levels of intensity on beetle diversity in shortgrass steppe were examined. The experimental design was completely randomized, with 3 treatments and 4 replicates per treatment. Treatments were two levels of fire 1) dormant-season fire (relatively hot), and 2) growing-season fire (relatively cool), and unburned plots. The response variables were arthropod species richness and abundance. The intermediate disturbance hypothesis predicts that maximum species richness occurs at intermediate levels of disturbance. Data obtained in this study support that prediction. Species richness was higher on plots of intermediate fire intensity than the more intensely burned plots, and almost twice as high as unburned plots. Abundance did not significantly differ among treatments.

Keywords: Fire, disturbance, shortgrass steppe, biodiversity, arthropod, Coleoptera, beetles

Introduction

In ecological terms fire is a disturbance. A disturbance is an event that may, directly or indirectly, disrupt a community and change resource availability (White and Pickett, 1985). Disturbance can increase species richness by increasing spatial heterogeneity within an area, and by creating gaps in communities that allow recolonization of the gaps by individuals of the same or different species. Even though infrequent to moderately frequent disturbances enhance diversity, extremely frequent disturbances can be so destructive that they operate in the reverse to reduce diversity; therefore, diversity is predicted to peak at intermediate levels of disturbance (Connell, 1978; Pianka, 1994).

The order Coleoptera (beetles) contains a third of all known insects- 300,000 species worldwide and ~30,000 species in North America (Milne and Milne, 1996). Beetles are conspicuous components of the terrestrial invertebrate fauna of arid and semi-arid ecosystems of North America (Allsopp, 1980). They have an important role in the functioning of the shortgrass steppe ecosystem, serving as predators, prey, scavengers and parasites. In addition, many plant-feeding species attack plants and stored foods, while others pollinate flowers and eat plant pests. My experimental research examined the effect of fire at two levels of intensity on beetle diversity in shortgrass steppe.

Material and Methods

The study site was in shortgrass steppe of the southern Great Plains on the Kiowa National Grassland (36° 30'N, 103° 7'W) in northeastern New Mexico. Almost all of the grassland on the plains in the Southwest is composed of mixed or shortgrass communities (Brown, 1994). While these

communities have been considerably altered by grazing and the results of this practice (fire suppression followed by shrub invasion), much of the grassland remains an uncluttered perennial grass dominated landscape (Brown, 1994).

It is estimated that less than 23% of true shortgrass steppe in the United States still exists in native vegetation (National Grasslands Management Review Team, 1995). My study site, located in the far northeastern corner of New Mexico, is one such area. My site consists of approximately 160 ha of shortgrass steppe that has never been plowed, though it was grazed by livestock until 1990. The site is relatively homogeneous and nearly flat. Elevation ranges from 1,455 m at the southwest corner to 1,472 m at the northwest corner of the site. Mean annual precipitation is 391 mm. The majority of precipitation occurs from May through September, with peak rainfall in July. Overall, the deep, well-drained loam soils on the site support and almost shrubless grassland with a relatively tight sod of buffalograss (*Buchloe dactyloides* (Nutt.) Engelm.) and blue grama (*Bouteloua gracilis* (H.B.K.) Lag.) These species average 85% of the cover through out the site.

The research experimental design was completely randomized, with 3 treatments and 4 replicates per treatment. Treatments were two levels of fire 1) dormant-season fire, and 2) growing-season fire, and unburned plots. The response variables were arthropod species richness and abundance. Treatments were randomly assigned to 12 2-ha plots. Treatments were applied in 1997. Dormant-season fire (level 1) occurred in April, when moisture was low and fine fuel was cured. Growing-season fire (level 2) occurred in July when vegetation was green and moisture was high. Pre-treatment sampling took place in March, post-burn sampling began two weeks after fire treatment.

Surface-active beetles were captured with pitfall traps, 1-pint paint cans set into the ground with the opening flush with the ground surface. Pitfalls were placed 30 m apart. Propylene glycol

was used as the preservative. Twenty pitfalls per plot, for a total of 240 pitfalls, were open two weeks, once a month for 6 months in 1997 (March - October) and from July-October 1998. Pitfalls are biased toward the capture of solitary wandering species and against those with low mobility (Uetz and Unzicker, 1976; Baars, 1979; Halsall and Wratten, 1988) or that live in colonies (Marsh, 1984). Therefore, this collecting method by itself does not account for all of the site's diversity, even of surface-dwelling species. Beetles were identified to species, and number of individuals for each species was tallied.

Permutation methods in SAS PROC MULTTEST (SAS Institute Inc., 1989-1996) were used for sets of three pairwise comparisons among treatments and across sample periods for pre-treatment data (March 1997) and post-treatment data from July-October 1998.

Results and Discussion

Beetle samples were composed of 29 families, 115 species, and 4,608 individuals. Ten species from six families, made up 90% of the individuals (Table 1). Pre-treatment measures of species richness and abundance revealed no significant differences among the 12 experimental plots (Table 2).

Approximately one year and six months after dormant-season fire (level 1), and one year and three months after growing-season fire (level 2) species richness significantly differed among treatments; growing-season fire treated plots had a significantly higher number of beetle species than unburned plots. Species richness was also higher on growing-season plots versus dormant-season plots, but the difference was not significant. Abundance did not significantly differ among treatments (Table 2).

The intermediate disturbance hypothesis predicts that maximum species richness occurs at intermediate levels of disturbance because 1) high disturbance levels allow persistence of those species that are disturbance-adapted or in this case fire adapted, and 2) low disturbance levels allow competitive dominance by some species, causing local extinctions of others. However, many species can coexist and persist at intermediate levels of disturbance. My data support that prediction. Fires during the dormant-season (level 1), when fuel was cured and moisture was low, appeared to burn hotter and faster, and more completely than growing-season fires. Growing-season fires appeared to burn unevenly in a patchy manner, slow, smoky, and cool because of the green vegetation and high soil moisture content. Level 1 represented a higher level of disturbance than level 2, which represented an intermediate level of disturbance. Unburned plots represented a low level of disturbance. Species richness was higher on plots of intermediate fire intensity than the more intensely burned plots, and almost twice as high as unburned plots.

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Table 1 - Beetle relative abundance (%): total number of individuals per species compared to the total number of individuals of all other beetles species combined.

Family	Species	Relative Abundance (%)
Carabidae	<i>Cicindela obsoleta</i>	3
	<i>Pasimachus californicus</i>	4
	<i>Pasimachus obsoletus</i>	1
Curculionidae	undetermined	1
Elateridae	<i>Agrypnus rectangularis</i>	9
Nitidulidae	<i>Carpophilus lugubris</i>	66
Scarabaeidae	<i>Euphoria kerni</i>	1
	<i>Neopsammodius interruptus</i>	3
	<i>Phyllophaga glabricula</i>	2
Tenebrionidae	<i>Eusattus convexus</i>	2
Other		8
Total		100

Table 2 - Results of MULTTEST analysis of beetle (Coleoptera) abundance and richness in which fire season (dormant-season, growing-season) or unburned were treated as the independent variables, and number of beetle individuals and species as the dependent variables. $\alpha = 0.05$.

Abundance				
Period ¹	Treatment (N)	Abundance Mean (SD)	CONTRAST ²	P Value
Period 1	Unburned (4)	42(28)	U vs D	0.83
	Dormant-season (4)	73(56)	U vs G	0.98
	Growing-season (3)	60(26)	D vs G	0.99
Period 2	Unburned (4)	297(80)	U vs D	1.00
	Dormant-season (4)	317(76)	U vs G	0.91
	Growing –season(3)	376(189)	D vs G	0.97
Richness				
	Treatment (N)	Abundance Mean (SD)	CONTRAST	P Value
Period 1	Unburned (4)	7(1)	U vs D	0.99
	Dormant-season (4)	8(1)	U vs G	0.55
	Growing-season (3)	10 (4)	D vs G	0.68
Period 2	Unburned (4)	16(3)	U vs D	0.75
	Dormant-season (4)	20 (3)	U vs G	0.04
	Growing-season (4)	25 (5)	D vs G	0.34

¹Period 1 = pre-treatment, March 1997. Period 2 = July-October 1998.

²U = unburned, D = dormant-season fire treatment, G = growing – season treatment.