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Precipitation and fire impacts on small mammals in shortgrass prairie[1]

Written by: Whitney J. Gann, Ph.D.

INTRODUCTION

The ecological value of shortgrass prairies in North America has become increasingly evident as populations of prairie dog (*Cynomys* spp.) and burrowing owl (*Athene cunicularia*) begin to decline. The native prairies found in the Great Plains were once the largest vegetation group across North America. However, introduction of agriculture to North America has led to decline in prairie ecosystems. Shortgrass prairie decline, in particular, ranges from 20% in Wyoming to 85% loss in Saskatchewan (Sampson and Knopf 1994). Today, the North American prairies are among the continent's most endangered ecosystems.

The diminished presence of fire in prairie ecosystems is believed to be responsible for shifts in the composition, structure, and diversity of grasslands, leading specifically to the rise of invasive species and invasion by less fire-tolerant species (D'Antonio 2000). Abundance of woody plants has increased substantially in grasslands worldwide (Briggs et al. 2002), and changes in the habitat structure resulting from encroaching woody plants have potential to change the distribution, abundance, and occurrence of many small mammal species in prairies (Sietman et al. 1994, Horncastle et al. 2005).

Rainfall may also effect small mammal productivity indirectly, or directly affect the physiological tolerance of animals (Wright 1983). This is particularly true in semiarid environments with variable environmental conditions (Coupland 1958), and where rainfall is arguably the principal cause of vegetative variability (Oesterheld et al. 2001).

Current management and restorative efforts in prairie ecosystems are centered around the use of periodic prescribed fires. Although the importance of fire in grasslands is evident, there remains uncertainty in methods needed by land managers to restore fire to the grasslands that have long gone unburned. Additionally, the effects of prescribed fire on mammalian species in semi-arid shortgrass prairies is not well understood (Sampson and Knopf 1994).

Using two fire return intervals and an unburned control, we assessed abundance, richness, and biomass of small mammal communities in a shortgrass prairie over seven years.

STUDY AREA

This study was conducted on the Cross Bar Cooperative Management Area (CB-CMA), 16 km north of Amarillo, Potter County, Texas. The CMA has 4,856 ha of shortgrass prairie managed by the Bureau of Land Management (BLM). A history of over grazing, fire suppression, and woody vegetation invasion makes the CB-CMA a good representation of the remaining shortgrass prairie along the Canadian River.

METHODS

Experimental Design: CB-CMA was divided into three fire return intervals (2-, 4-, 10-yr, and burned control) replicated three times, 120 ha each. The treatments were also partitioned into three blocks to control for environmental conditions and spatial variation. All burns took place during spring (March-April). Results described below were divided into dormant season (Oct–Mar) and growing season (Apr–Sep) time periods.

Beginning in 2004, small mammals were sampled within one week of the burn using two transects in each experimental plot. Sampling sessions were 2-weeks. Trapping sessions were three consecutive nights for a total of 1,620 trap nights per trapping session. 540 Sherman live traps were deployed at 18 transects. Animals were marked by clipping hair (Skinner and Chimimba 2005). Onsite precipitation was collected from August 2002 to August 2009.

Statistical Analysis: We compared mean abundance of all species combined, biomass, and richness with year, season, and frequency of burning (treatment) as main effects in a repeated measures analysis of variance (ANOVA). We tested normality using Shapiro-Wilks w-statistic followed by a least significant difference test.

We defined abundance as the total number of animals of

[1] *A summary of Priesmeyer, W. J, R. S. Matlack, and R. T. Kazmaier. 2014. Precipitation and Fire Impacts on Small Mammals in Shortgrass Prairie. The Prairie Naturalist 46:11–20.*

each species captured per transect and biomass as total weight of all animals. During each sampling period, we averaged abundance for both transects within a sampling plot. We averaged fall abundance within each burn plot for the dormant seasons. We examined the relationship between abundance and biomass of small mammals to precipitation levels by plotting means along a regression curve (Figure 2).

RESULTS

Small Mammal Community: We captured 835 individuals of 15 species of small mammals during 17,010 trap-nights. Species captured included the hispid cotton rat (*Sigmodon hispidus*; *n* 171 = 158), white-footed mouse (*Peromyscus leucopus*; *n* = 156), plains harvest mouse (*Reithrodontomys montanus*; *n* = 124), hispid pocket mouse (*Chaetodipus hispidus*; *n* = 112), northern grasshopper mouse (*Onychomys leucogaster*; *n* = 86), southern plains woodrat (*Neotoma micropus*; *n* = 76), northern pygmy mouse (*Baiomys taylori*; *n* = 43), western harvest mouse (*Reithrodontomys megalotis*; *n* = 24), silky pocket mouse (*Perognathus flavus*; *n* = 22), deer mouse (*P. maniculatus*; *n* = 21), Ord's kangaroo rat (*Dipodomys ordii*; *n* = 5), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*; *n* = 3), spotted ground squirrel (*S. spilosoma*; *n* 178 = 2), house mouse (*Mus musculus*; *n* = 2), and white-toothed woodrat (*N. leucodon*; *n* = 1).

Precipitation: Seasonal rainfall varied from 42.84 cm to 0.0 cm. Average annual rainfall over the course of the study (fall 2004–fall 2009) was 20.87 cm, 50% of the regional long-term average.

DISCUSSION

The effect of drought in the Great Plains outweighs fire (Albertson and Tomanek 1965, Wright and Bailey 1980). On the CB-CMA, periods of increased precipitation in fall 2004, resulted in greater capture success in the 2005 dormant season. Capture success during the dormant season of 2005 was 13.8 times greater than success during dormant season 2008 (following prolonged drought). Additionally, abundance of small mammals declined from fall 2005 to spring 2009 with decreasing precipitation.

Unlike current research which has detected a response of small mammal communities to fire (Clark and Kaufman 1990, Zwolak 2009, Fontaine and Kennedy 2012, Raybuck et al. 2012), we did not observe the same results. Instead, for most species there were no differences in total small mammal captures between burn plots, suggesting that prescribed fire had little effect (Bock and Bock 1978, Fitzgerald et al. 2001). However, similar to Fitzgerald et al. (2001), a few species varied across treatments, but this was only apparent in the years that received the greatest levels of precipitation. In this system, it appears that fire may not lead to changes which alter structure to the point that different species preferences are triggered.

Small mammal species richness decreased following periods of drought but remained high following periods of average precipitation because an increase in forage productivity, resulting from precipitation, may have increased richness of herbivorous and insectivorous small mammal species (Reed 2006)

The results of our research were consistent with the majority of studies on fire response of small mammals in semi-arid environments (Letnic and Dickman 2010, Kelly et al. 2012),

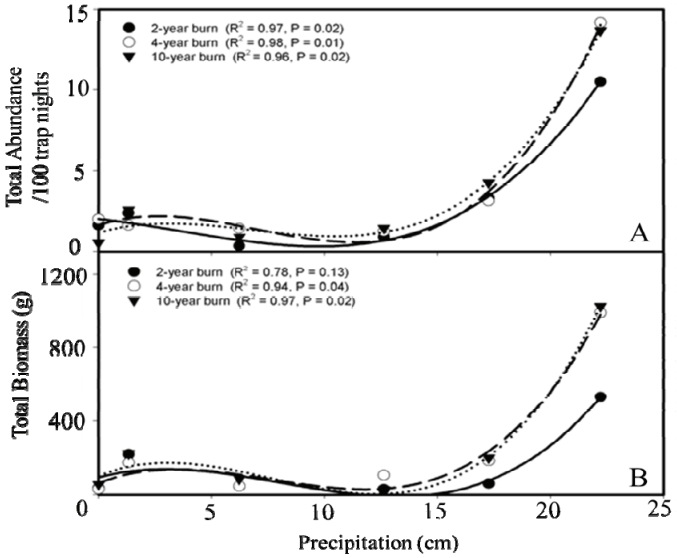

Figure 2. Relationship between previous dormant season precipitation and fall abundance (A) and biomass (B) of all small mammals in 2-, 4-, 10-year burn plots on the Cross Bar CMA, Texas, 2004–2009.

but differed from other grassland systems in the Great Plains. Furthermore, because a response was only detected following years of high precipitation, it is difficult to determine the specific response to burn treatment. The shortgrass prairie appears to be unique in its response to fire as a management practice because of the low density of small mammals and the habitat response to precipitation.

The shortgrass prairie evolved with fire as a vital and important component of the ecosystem. It is not surprising the small mammals of the prairie appear to be generally resilient to fire (Kaufman et al. 1988, Ford 2001).

Climatic changes have the potential to affect productivity and alter the frequency and intensity of management- (Weddell 1996). Future research in the Southern Great Plains that establishes connections between climatic change and disturbance (precipitation and fire) will be of great value.

**References for citations can be found in the journal article.