# AN ABSTRACT OF THE THESIS OF

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Title: Two Management Regimes in the Tallgrass Prairie: Effects on Plants and Small Mammals

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In summer and late fall 1997 and 1998 I compared plant and small mammal communities in tallgrass prairie subject to two different management regimes: annual summer haying and spring burning with moderate grazing. The eight sites were located 11 km west of Mayetta, Kansas.

On each site I determined the number and cover of plant species present. Analysis of variance (ANOVA) was used to compare between the regimes for species richness, species diversity, cover, and for each guild, species richness and cover. Four sites were dropped for 1998; consequently analysis was done for 1997 and the two years pooled. Significantly more species were found on the hayed sites in 1997 and for pooled years (1997: P=0.04; pooled P=0.01), as were non-native species (1997 richness: P=0.04; pooled richness: P=0.004, and cover: P=0.03). In 1997, two guilds had significantly greater values on the hayed sites: early spring ephemeral forbs (richness: P=0.02; cover: P=0.02) and spring forbs (richness: P=0.05), as did three guilds in the pooled analysis: early spring ephemeral forbs (cover: P=0.01), spring forbs (richness: P=0.03), and summer/fall forbs (richness: P=0.02).

Small mammal communities were live-trapped in late fall. Six sites were trapped in 1997 and four in 1998. Comparisons were made with ANOVA for species richness, species diversity, and abundance for certain species. In 800 trapnights 101 individuals of eight species were captured. The deer mouse (Peromyscus maniculatus) was most abundant as 51% of all captures. Significantly more individuals of all species (P=0.01) were found on the burned, grazed sites in 1997, as was the deer mouse (P=0.02). Regression analysis showed mean height of the sampled vegetation on the sites explained 44% (P=0.07) and 86% (P=0.08) of the variation in numbers of individuals of small mammals captured in 1997 and 1998, respectively.

# TWO MANAGEMENT REGIMES IN THE TALLGRASS PRAIRIE: EFFECTS ON PLANTS AND SMALL MAMMALS

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# PREFACE

My thesis is divided into two chapters, which will be submitted to a scientific journal, the American Midland Naturalist. The chapters have been prepared for separate submission in the style appropriate to the journal. The running heading for Chapter 1 is RH: Witters et al.: Management Effects on Plants. Key words: burning, grazing, guild, haying, management, prairie, tallgrass. The running heading for Chapter 2 is RH: Witters and Finck: Small Mammals and Management. Key words: burning, grazing, haying, prairie, rodents, small mammals, tallgrass.

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# CHAPTER 1

## Two Management Regimes in the Tallgrass Prairie: Effects on Plants

ABSTRACT.-- Understanding the effects of management regimes on the constituent communities of the tallgrass prairie is crucial to the perpetuation of its remaining fragments. The purpose of my study was to examine differences in plant communities between late summer annual haying and spring burning in conjunction with grazing of tallgrass prairie in northeastern Kansas. One hundred fifty $1 m^2$ plots were sampled in each treatment with 142 species identified. I compared species richness and diversity between treatments, and, using a functional delineation for the native species -- the guild -- I compared species richness and cover for each guild between treatments. Results indicated annual haying was a management tool that maintains significantly greater species richness and benefits certain prairie forb guilds, particularly the early spring ephemeral forbs, spring forbs, and summer/fall forbs. Non-native species fared better under a haying regime. All guilds were found in both treatments and the remainder of the native species guilds showed no significant differences between the treatments for either species richness or cover, which indicated effective functional and compositional replacement between the two regimes. Annual haying is an effective management tool for maintaining overall richness in the tallgrass prairie plant community and, particularly, for maintaining many of the forb species.

# INTRODUCTION

The tallgrass prairie once covered over 575,000 square km of the midwestern United States (Knapp and Seasdedt, 1986). Unique ecosystem processes of the tallgrass prairie included large grazers and their predators and landscape-scale level fires. The tallgrass prairie is generally defined by the association of four dominant grasses: big bluestem (Andropogon gerardii), little bluestem (Andropogon scoparius), Indian grass (Sorghastrum nutans), and switchgrass (Panicum virgatum). Today what remains of the tallgrass prairie is found mostly in scattered fragments and in the Flint Hills region of Kansas and Oklahoma. The Flint Hills comprise the largest remaining landscape of tallgrass prairie, about 10,000 square km (Knapp and Seasdedt, 1986). However, these rocky, thin-soiled hills provide only a partial representation of the former expanse of tallgrass prairie.

Fertile soils and relatively gentle topography proved to be the demise of the tallgrass prairie. By the early 1900's much of what had historically been tallgrass prairie had abdicated to an agrarian landscape (Steiger, 1930). Long before the prairie itself was destroyed, the grazing and depredating megafauna was either pushed from the prairie region or was reduced to barely viable populations (Collins, 1987). In the ensuing decades, the prairie continued to be carved into ever-smaller pieces until most of what remains east of the Flint Hills today exists as small (<1-10 ha), often insular, intensively managed fragments (Hover and Bragg, 1981; Swengel, 1996).

Much of the remaining tallgrass prairie is used as forage for pastured cattle and has been reduced to depauperate native grass stands with decreased floristic diversity because of preferential grazing habits and unsustainable grazing intensities (Weaver, 1968). Grazing is certainly a necessary disturbance process in maintaining a prairie (Zimmerman and Kucera, 1977; Collins et al., 1998). Cattle grazing can be the functional replacement for historical grazing by bison (Bos bison) (Collins et al.,1998). However, the different intensity, duration, and forage preferences (Plumb and Dodd, 1993) have the potential to make traditional cattle grazing a destructive substitute in the prairie community.

Fire is the other landscape-scale disturbance process that can no longer be counted on to maintain a prairie community without intensive local-scale human intervention (Knapp and Seasdedt, 1986). Prior to settlement by Europeans there was little to impede a lightning- or human-started fire, and such a fire could have easily burned hundreds of square kilometers of prairie. Now, smaller-scale human-initiated burns are done every one to three years on many grazed prairies. However, some individuals do not perform prescribed burning on their grazed land, and many prairies maintained as hay meadows are not burned (Hover and Bragg, 1981; Kindscher, pers. comm.).

Oddly, the least "naturally" managed prairies, the hay meadows, have high plant species richness and diversity. Some suppose that the practice of summer haying increases dominance (Hover and Bragg, 1981) and diversity of cool season species (Hover and Bragg, 1981; Collins et al., 1998). Penfound (1964) found that a haying regime alone does not significantly alter plant species composition, but does increase total biomass in the subsequent growing season.

Under haying regimes species composition can remain the same while diversity is altered in the plant community, and biomass ratios between different constituent species change when light availability is altered (Van Auken et al., 1992). Overall, haying is either maintaining diversity by providing a non-selective, one-time "grazing", which reduces soil shading (Van Auken et al., 1992), or is not eroding diversity as quickly as other management practices such as spring burning, which favors the warm season dominant grasses (Zimmerman and Kucera, 1977; Collins et al., 1998), or heavy grazing by cattle (Van Auken et al., 1992).

Collins (1992) noted that grazing can increase vegetative heterogeneity by decreasing cover of dominants, thus increasing floristic diversity. Vertical vegetative structure does have an effect on prairie plants, both in shading of shorter plants by overtopping dominant plants and, when removed, as a possible factor for increasing diversity by allowing more light to the diminutive, low-frequency plants (Van Auken et al., 1992). Problems arise when considering intensity and duration of grazing because overgrazed prairie has low perennial forb diversity resulting from highgrading, which occurs when the grazers remove only the most-preferred and highest-quality foliage, and has an increase in weedy annuals (Weaver, 1968). Heavy grazing without burning can lead to succession to a shrubby dominance (Weaver, 1968). Collins (1992) found that fire, in conjunction with grazing, creates the greatest regional floristic heterogeneity, but did not include annual haying in his study. Increased fire frequency alone has been shown by others to decrease the diversity in plant communities (Johnson and Knapp, 1995) by decreasing forb diversity.

Some studies have been published on the effects of haying on prairie plant communities (Hover and Bragg, 1981; VanAuken et al., 1992; Kindscher and Wells, 1995; Collins et al., 1998). However, few have been published that incorporate the effects of both haying and burning, grazing management regimes Kindscher and Wells, 1995; Collins, et al., 1998). My objectives were to 1) to determine percent cover of all vascular plants on hayed and burned, grazed prairies, and 2) to determine species richness, diversity, and guild composition on those prairies.

# MATERIALS AND METHODS

Study area.--The study sites were located on the Prairie Band of the Potawatomi Nation Reservation (Reservation) 11 km west of Mayetta, Kansas. The Reservation is 240 $km^2$ situated immediately east of the boundary of the far northeastern edge of the Flint Hills in the glaciated region of Kansas. Its flora is typical of the post-native-American displacement eastern Great Plains where grazing and haying predominate the management of the remaining unplowed native grasslands.

I located candidate sites by using information from the Kansas Biological Survey's (KBS) Kansas Natural Heritage Inventory. I then sought to locate good quality grazed sites nearby that were burned the previous spring. More grazed sites were available than were selected for the study; however, most had very depauperate plant communities. I chose sites within a half-section (0.6 km) of each other in an attempt to minimize physiographic differences between sites in a pair. Burned, grazed sites were selected at year-of-burn to avoid differences within that treatment resulting from sites being on differing fire chronologies. Eight sites were chosen as pairs -- grazed/burned sites paired to hayed sites -- to facilitate statistical analysis by compensating for inherent confounding differences between samples of the community. As much as possible, transects on each site were located on similar topographic conditions. In 1998, four of the eight sites were sampled because conditions changed for a site in each of the other two pairs (herbicide spraying on one and haying on another that had been burned and grazed).

Field methods.--Sampling was done in early summer (24 June - 11 July 1997 and 17 - 20 June 1998) to sample both spring ephemerals and vegetative late-summer and fall-flowering plants (Kindscher and Wells, 1995) by using a 1 $m^2$ quadrat in a belt transect at 4 m intervals for a total sample of 25 quadrats per site. Plant community data were gathered by recording species composition for each quadrat and by determining aerial percent cover of a plant's maximum spread of foliage (percent cover) for each constituent species (after Daubenmire, 1959). Permanent transect endpoint coordinates were determined by triangulation from landmarks, e.g., fenceposts, distinctive trees, and were marked by driving 0.25 m steel rebar into the ground. See Appendix 1 for transect coordinates.

Analysis.--One-way analysis of variance (ANOVA) was done for all comparisons by using SAS (SAS Institute, 1985). Species richness was considered the total number of species for a site, treatment, or guild. Nomenclature for all plants follows the Great Plains Flora Association (1991). Percent cover by species, guild, site, and treatment was summed. I calculated the Shannon-Weaver Diversity Index (Magurran, 1988; Zar, 1996) for each site and all native prairie species were assigned to guilds. I used the guild classifications based on multivariate analysis techniques for assigning the species to functional groups described by Kindscher and Wells (1995; Kindscher, pers. comm). The guilds are: annual and biennial forbs (ANN); $C_3$ graminoids (C3), which include the $C_3$ photosynthetic pathway grasses as well as the sedges (Carex spp.), spikerushes (Eleocharis spp.), and other grass-like plants; $C_4$

grasses (C4), which use the $C_4$ photosynthetic pathway; ephemeral spring forbs (ESP); legumes (LEG); spring forbs (SPR); summer/fall forbs (SFF); and woody shrubs (SHR). Two additional non-guild classifications (Kindscher and Wells, 1995) were used: non-native species (INT), which are not native to North America; and tree species (TRE), defined as any native woody species not considered members of the prairie plant community. See Appendix 2.

Sampling was done earlier in 1998, relative to 1997, in an attempt to sample under similar phenological conditions to 1997. In 1998, April, May, and June were substantially warmer than the corresponding months in 1997 (pers. obs.), likely causing a shift in growth curves for the plant community from 1997 to 1998. Substantial change in the experimental design occurred from 1997 to 1998 through the loss of study sites. The reduction of the sample size by half in 1998 precluded its analysis alone. Therefore results are given first for 1997 and then for the pooled data from both years.

# RESULTS

Overall plant species richness for hayed sites in 1997 was significantly higher (F=11.97, d.f.=1, P=0.04) than the burned, grazed sites with a total for all sites of 126 plant species. Total cover was not significantly different (F=1.02, d.f.=1, P=0.39). There was no significant difference between treatments for trees for either species richness (F=2.45, d.f.=1, P=0.22) or percent cover (F=1.80, d.f.=1, P=0.27). For non-native species there was significantly greater species richness (F=13.36, d.f.=1, P=0.04) on the hayed sites, but no significant difference for percent cover (F=5.29, d.f.=1, P=0.10). I selected four species beforehand to use for comparison between the treatments. Western ironweed (Vernonia baldwinii) and ragweed (Ambrosia spp.) were selected based on my expectation that as weedy species (Weaver, 1968) they would have a greater percent cover on the burned, grazed sites than on the hayed sites. Two Bromus species, smooth brome (B. inermis) and Japanese brome (B. japonicus), were selected with the expectation that as non-native $C_3$ species they would have greater percent cover on the hayed sites. Because they were found in sporadically low amounts within the treatments the two Bromus species were lumped for analysis. No significant differences were found for any of the three genera: Vernonia (F=4.16, d.f.=1, P=0.13); Ambrosia (F=2.27, d.f.=1, P=0.23); Bromus (F=2.50, d.f.=1, P=0.21) . See Table 1.

The mean of site diversities (H') was greater for the hayed treatment in 1997 than for the burned, grazed treatment (Table 1). The difference was not statistically significant (F=1.58, d.f.=1, P=0.30).

**Table 1.** Treatment means and ANOVA for 1997 plant data, trees and non-native forbs by species richness and cover, and three genera for cover. H=hayed, B/G=burned, grazed.

| **Richness** | | **H** | **B/G** | **F-value** | **P-value** |
|---|---|---|---|---|---|
| | **total** | 57.50 | 38.50 | 11.97 | 0.04 * |
| | **trees** | 1.00 | 0.25 | 2.45 | 0.22 |
| | **non-native forbs** | 2.75 | 1.00 | 13.36 | 0.04 * |
| **H'** | | 2.62 | 2.38 | 1.58 | 0.30 |
| **% Cover** | | | | | |
| | **total** | 1.59 | 1.44 | 1.02 | 0.39 |
| | **trees** | 0.01 | ** | 1.80 | 0.27 |
| | **non-native forbs** | 0.02 | ** | 5.29 | 0.10 |
| | **Ambrosia** | ** | 0.11 | 2.27 | 0.23 |
| | **Bromus** | 0.034 | 0.01 | 2.50 | 0.21 |
| | **Vernonia** | ** | 0.01 | 4.16 | 0.13 |

* $P \leq 0.05$

** <0.01

The species were grouped by guilds (see Appendix 2) and analyzed for differences between treatments. No comparison was made for total number of guilds between treatments because all guilds were found in both treatments, so comparisons were made between treatments for each guild for species richness (Table 2) and percent cover (Table 3). Ephemeral spring forbs (F=25.00, d.f.=1, P=0.02) and spring forbs (F=10.24, d.f.=1, P=0.05) had significantly higher species richness on the hayed sites. The summer/fall forbs showed a non-significant trend (F=6.85, d.f.=1, P=0.08) toward higher species richness on the hayed sites. Ephemeral spring forbs had significantly higher percent cover (F=20.21, d.f.=1, P=0.02) on the hayed sites. Summer/fall forbs showed a non-significant trend (F=7.19, d.f.=1, P=0.07) toward higher percent cover on the hayed sites. All other guilds showed no significant differences between treatments for either species richness: annuals and biennials (F=0.82, d.f.=1, P=0.43); $C_3$ graminoids (F=0.16, d.f.=1, P=0.72); $C_4$ grasses (F=3.01, d.f.=1, P=0.18); legumes (F=1.42, d.f.=1, P=0.32); and woody shrubs (F=0.00, d.f.=1, P=1.00), or percent cover: annuals and biennials (F=2.25, d.f.=1, P=0.23); $C_3$ graminoids (F=0.73, d.f.=1, P=0.46); $C_4$ grasses (F=3.23, d.f.=1, P=0.17); legumes (F=3.15, d.f.=1, P=0.17); spring forbs (F=0.00, d.f.=1, P=0.96); and woody shrubs (F=1.92, d.f.=1, P=0.26); (Table 1).

A total of 107 plant species was recorded in 1998, including sixteen species not found in 1997 (see Appendix 2), for a total of 141 species over the two years. The pooled data from both years again showed significantly higher species richness for the hayed sites (F=14.35, d.f.=1, P=0.01) than the burned, grazed

**Table 2.** Treatment means and ANOVA for 1997 treatments by guild (species richness). H=hayed, B/G=burned, grazed.

| **Guilds (richness)** | **H** | **B/G** | **F-value** | **P-value** |
|---|---|---|---|---|
| annuals & biennials | 4.75 | 3.00 | 0.82 | 0.43 |
| $C_3$ graminoids | 8.75 | 7.50 | 0.16 | 0.72 |
| $C_4$ grasses | 6.25 | 5.75 | 3.01 | 0.18 |
| ephemeral spring forbs | 3.25 | 2.00 | 25.00 | 0.02 * |
| legumes | 4.50 | 3.75 | 1.42 | 0.32 |
| spring forbs | 10.75 | 5.00 | 10.24 | 0.05 * |
| summer/fall forbs | 12.50 | 7.00 | 6.85 | 0.08 |
| woody shrubs | 1.75 | 1.75 | 0.01 | 1.00 |

* $P \leq 0.05$

**Table 3.** Treatment means and ANOVA for 1997 treatments by guild (percent cover). H=hayed, B/G=burned, grazed.

| **Guilds (% cover)** | **H** | **B/G** | **F-value** | **P-value** |
|---|---|---|---|---|
| annuals & biennials | ** | 0.08 | 2.25 | 0.23 |
| $C_3$ graminoids | 0.14 | 0.21 | 0.73 | 0.46 |
| $C_4$ grasses | 0.63 | 0.56 | 3.23 | 0.17 |
| ephemeral spring forbs | 0.01 | ** | 20.21 | 0.02 * |
| legumes | 0.10 | 0.04 | 3.15 | 0.17 |
| spring forbs | 0.02 | 0.05 | 0.02 | 0.96 |
| summer/fall forbs | 0.08 | 0.04 | 7.19 | 0.07 |
| woody shrubs | 0.01 | 0.02 | 1.92 | 0.26 |

* $P \leq 0.05$

** <0.01

sites. Total cover was not significantly different between treatments (F=0.07, d.f.=1, P=0.80).

There was no significant difference between treatments for trees for either species richness (F=1.00, d.f.=1, P=0.36) or percent cover (F=0.14, d.f.=1, P=0.72). However, non-native species had significantly higher values on the hayed sites for both species richness (F=25.00, d.f.=1, P=0.004) and percent cover (F=9.46, d.f.=1, P=0.03). The analyses of the pooled data revealed no significant difference between the treatments for any of the three selected genera, Ambrosia, Bromus, and Vernonia (Table 3). However, the two Bromus species did show a non-significant trend (F=4.80, d.f.=1, P=0.08) toward greater cover on the hayed sites (Table 4).

The mean of site diversities (H') for the pooled years was again higher for the hayed treatment than for the burned, grazed treatment. The difference was not statistically significant (F=3.66, d.f.=1, P=0.11).

All guilds were found in both treatments in 1998, so no comparison was made in the pooled data for differing numbers of guilds. Species richness was significantly higher on the hayed sites for the spring forbs (F=8.86, d.f.=1, P=0.03) and the summer/fall forbs (F=10.21, d.f.=1, P=0.02). The spring ephemeral forbs did not show a significant difference for species richness (F=3.05, d.f.=1, P=0.14), but was the only guild to show a significant difference for percent cover, with significantly higher values (F=15.56, d.f.=1, P=0.01) on the hayed sites.

The remainder of the guilds in the pooled data showed no significant

**Table 4.** Treatment means and ANOVA for pooled plant data, trees, and non-native forbs by species richness and percent cover, and three genera for percent cover. H=hayed, B/G=burned, grazed.

| **Richness** | | **H** | **B/G** | **F-value** | **P-value** |
|---|---|---|---|---|---|
| | **total** | 57.67 | 42.50 | 14.35 | 0.01 * |
| | **trees** | 0.83 | 0.33 | 1.00 | 0.36 |
| | **non-native forbs** | 4.00 | 1.50 | 25.00 | 0.004 * |
| **H'** | | 2.58 | 2.35 | 3.66 | 0.11 |
| **% Cover** | | | | | |
| | **total** | 1.68 | 1.75 | 0.07 | 0.80 |
| | **trees** | ** | ** | 0.14 | 0.72 |
| | **non-native forbs** | 0.03 | 0.01 | 9.46 | 0.03 * |
| | **Ambrosia** | ** | 0.09 | 3.68 | 0.11 |
| | **Bromus** | 0.03 | ** | 4.80 | 0.08 |
| | **Vernonia** | ** | 0.01 | 3.96 | 0.10 |

* $P \leq 0.05$

** <0.01

differences between treatments for species richness (Table 5): annuals and biennials (F=0.22, d.f.=1, P=0.66); $C_3$ graminoids (F=0.00, d.f.=1, P=1.00); $C_4$ grasses (F=1.00, d.f.=1, P=0.36); legumes (F=3.18, d.f.=1, P=0.13); and woody shrubs (F=1.36, d.f.=1, P=0.30), or percent cover (Table 6): annuals and biennials (F=1.64, d.f.=1, P=0.26); $C_3$ graminoids (F=3.72, d.f.=1, P=0.11); $C_4$ grasses (F=0.06, d.f.=1, P=0.82); legumes (F=3.54, d.f.=1, P=0.12); spring forbs (F=0.05, d.f.=1, P=0.83); summer/fall forbs (F=0.90, d.f.=1, P=0.39); and woody shrubs (F=1.62, d.f.=1, P=0.85).

**Table 5.** Treatment means and ANOVA for pooled treatments by guild (species richness). H=hayed, B/G=burned, grazed.

| **Guilds (richness)** | H | B/G | F-value | P-value |
|---|---|---|---|---|
| annuals & biennials | 5.17 | 4.50 | 0.22 | 0.66 |
| $C_3$ graminoids | 8.50 | 8.00 | 0.00 | 1.00 |
| $C_4$ grasses | 6.33 | 6.00 | 1.00 | 0.36 |
| ephemeral spring forbs | 3.17 | 2.33 | 3.05 | 0.14 |
| legumes | 5.00 | 3.83 | 3.18 | 0.13 |
| spring forbs | 9.83 | 5.50 | 8.86 | 0.03 * |
| summer/fall forbs | 12.00 | 7.67 | 10.21 | 0.02 * |
| woody shrubs | 2.00 | 1.83 | 1.36 | 0.30 |

* $P \leq 0.05$

**Table 6.** Treatment means and ANOVA for pooled treatments by guild (percent cover). H=hayed, B/G=burned, grazed.

| **Guilds (% cover)** | **H** | **B/G** | **F-value** | **P-value** |
|---|---|---|---|---|
| annuals & biennials | 0.01 | 0.04 | 1.64 | 0.26 |
| $C_3$ graminoids | 0.11 | 0.23 | 3.72 | 0.11 |
| $C_4$ grasses | 0.66 | 0.60 | 0.06 | 0.82 |
| ephemeral spring forbs | 0.01 | ** | 15.56 | 0.01 * |
| legumes | 0.11 | 0.03 | 3.54 | 0.12 |
| spring forbs | 0.02 | 0.04 | 0.05 | 0.83 |
| summer/fall forbs | 0.07 | 0.04 | 0.90 | 0.39 |
| woody shrubs | 0.01 | 0.01 | 1.62 | 0.85 |

* $P \leq 0.05$

** <0.01

# DISCUSSION

The physical characteristics of the sites, such as soil type and depth, slope, and aspect, may have influenced the observed results (Kaufman et al., 1988; Kindscher and Tieszen, 1998). However, the experimental design precludes determining any such differentiation from the effects of the management regimes. In addition, the physical characteristics of the sites may also have a strong role in the histories of the sites, i. e., why is a site grazed rather than hayed? So the observed differences between management regimes must be assumed to be differences produced by the regimes as well as the possible intrinsic differences in physical characteristics and histories.

The significantly greater number of plant species found on the hayed sites was expected because of the apparently slower loss of species from them relative to sites subject to burning and grazing. The richness values for the hayed sites were in the range reported for other prairies in northeastern Kansas (Kindscher and Wells, 1995; Kindscher and Tieszen, 1998). The lack of a significant difference for total percent cover is also expected because most of the plant species found in the tallgrass prairie community occupy very little of the space in the community. More species of non-native species may be better able to invade tallgrass prairie in the hay meadows because of the absence of fire. The change from the non-significant difference for the total percent cover values for non-native species in 1997 to a significant difference in the pooled data is most likely because of the increase in the sample size. Non-native species, such as Bromus inermis, appear to fare better under a haying regime than under burning and grazing. Some non-native species may be more poorly adapted to fire (Glenn-Lewin et al., 1990) and they may be well adapted to the competitive environment of a hay meadow as most come from the Eurasian continent, where haying has been practiced for millennia. Many hay meadows on the Reservation have much greater levels of non-native species than did the sites I selected because of the practice of overseeding of non-native clovers (Trifolium spp.) and smooth brome (pers. obs.).

From the literature (Johnson and Knapp, 1995; Kindscher and Wells, 1995) I expected the lack of a statistically significant difference for diversity between the treatments. The P-value for the difference did decrease substantially from the 1997 analysis to the pooled analysis. The move toward significance could simply be the effect of increasing the sample size. If so, then further investigation with larger sample size could reveal a difference or might show the trend to be an artifact of the study. Plant diversity is generally expected to be lowest at year-of-burn, after which it gradually increases again (Collins, 1990). On my study sites, diversity decreased as time increased since burning. However, caution must be used in interpreting anomalous results from two burned, grazed pastures.

Based on the large differences between treatment means in 1997, I expected to find significant differences for the trees for percent cover and for the three selected genera, Vernonia, Ambrosia, and Bromus. Analysis of the pooled data for the three genera reiterated the results from 1997. The notable difference between the two sets of results is that the P-values for the three genera in the analysis of the pooled data moved closer to significance. This is most likely a function of the increase in sample size within the treatment and underscores the likelihood of a substantially larger sample revealing significant differences between the two management regimes for the three genera.

When the treatments were compared by using individual guilds the general pattern showed that most of the guilds occupied approximately the same amount of space in both treatments. This agrees with Kindscher and Wells (1995), who compared a hay meadow and a grazed prairie for cover by guilds. The notable exception to the agreement with my study was the spring ephemeral forbs. However, Kindscher and Wells (1995) did not look at species richness within individual guilds, as I did. I found differences between regimes for spring ephemeral forbs, spring forbs, and summer/fall forbs. In 1997 the burned, grazed sites were at the year-of-burn for their burn regime. Hence, the number of species observed in the spring ephemeral and spring forb guilds perhaps were affected more than other guilds by the early spring fires. However, cover of the spring forbs showed a compensatory effect with fewer species on the burned, grazed sites still occupying an equivalent space in the community because the ephemeral spring forbs showed a significant difference in cover as well as richness. A stronger effect on that guild for the burning, grazing regime was shown. Analysis from 1997 also indicated the possibility that the summer/fall forb guild was affected by some facet of the burning, grazing regime. The growing season after a spring burn the prairie plant community is at one of the low points in the fire cycle for plant species richness (Collins, 1990). In the subsequent growing seasons richness increases, steadily diminishing the difference in richness between the two regimes -- assuming the only difference to be the presence or absence of periodic fire.

My hayed sites were not on a burning regime and one could therefore expect the difference between the two regimes to be greatest in the year-of-burn and diminishing in subsequent years. However, analysis of the pooled data from 1997 and 1998 showed by inference the regimes to be maintaining significant differences from year-of-burn to year-after-burn, with the exception of richness for ephemeral spring forbs. The apparent anomaly of the ephemeral spring forbs in the pooled analysis is explained by the addition of one species in that guild to each of the two burned, grazed sites in 1998. The large effect is a simple function of their paucity in the community. The ephemeral spring forb guild is not speciose, so while a small numeric difference in species richness is not likely to produce a meaningful difference in cover, it is likely to produce a meaningful difference in species richness. The increase in sample size is the most likely reason for the summer/fall forb guild's change from a non-significant trend to a significant difference, indicating a likely "on the ground" difference for both years. Because haying is done in mid- to late July, it is possible that an annual haying regime roughly emulates a summer burn. The effect of a summer removal of vegetation has been shown to increase the dominance of cool season species, such as the prairie forbs (Hover and Bragg 1981; Howe, 1994).

The results in my study clearly indicated that on the tallgrass prairie remnants the practice of annual haying is somehow retaining more species of plants than the practice of periodic spring burning and moderate grazing. In particular, early spring ephemeral forbs, spring forbs, and summer/fall forbs appeared to benefit from an annual haying regime. However, annual haying also provided an environment more conducive to the success of non-native plants than spring burning and grazing. Many others have demonstrated the ill effects of too many grazers on the tallgrass prairie. My study demonstrated that while a burned and grazed prairie may look substantially different than a hayed prairie, the two have much in common compositionally.

Certainly more work needs to be done to further our understanding of one of the continent's most imperilled ecosystems and the effects of the disturbances crucial to its perpetuation. With my study as a starting point, future research could include similar studies that have greater site replication or studies that investigate other combinations of disturbance, i. e., burned, ungrazed or burned, hayed. The functional grouping of prairie plant species into guilds (Kindscher and Wells, 1995) provides another way to investigate the effects of disturbance on prairie plant communities, and the guilds could be used in future research for quantitative analysis as well as for qualitative assessment.

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# Appendix 1. Endpoint coordinates for plant transects.

Hay meadow on Road K (0.6 km S of Road 134 on W side):

East end -- From the 11th metal fencepost from the NE corner of the property go 32 m bearing 220 degrees SW. From the 13th metal fencepost go 25 m bearing 178 degrees SSE.

West end -- From the 2nd metal pole after the 1st big dogwood (Cornus drummondii) thicket as one goes W along the N fence go 53 m bearing 202 degrees SSW. From the small double-trunked cedar (Juniperus virginiana) on the W side of the 2nd thicket go 24.35 m bearing 171 degrees SSE.

Shoot transect at 254 degrees WSW.

Burned, grazed site on Road K (0.75 km S of Road 134 on E side):

East end -- From the 20th metal post from the gate at 0.6 km S of Road 134 go 27.5 m bearing 59 degrees NE. From the 15th metal post go 23.8 m bearing 109 degrees ESE.

Shoot transect at 87 degrees E.

Hay meadow on Road J (0.6 km N of Road 158):

On S end of meadow go to the 7th metal fencepost E of gate in the middle of the fence. From there go 20 m bearing 328 degrees NNW. From the 3rd metal fencepost go 18.15 m bearing 20 degrees NNE.

Shoot transect at 4 degrees NNE. (immediately E of Tripsacum dactyloides clumps as looking **N**)

Burned, grazed site on Road J (0.5 km N of Road 158):

At same fence as for hay meadow on Road J, go E 1 metal fencepost from the gate. From there go 37 m bearing 157 degrees SSE. From the 7th metal fencepost go 35.4 m bearing 190 degrees S.

Shoot transect at 187 degrees S.

Hay meadow on Road I4 (0.6 km N of Road 142):

No permanent endpoints because there were NO places from which to triangulate transect endpoints. Transect runs about 30 m from treeline along Road I4, parallel, from about 0.6-1.6 km from the corner of Road I4 and Road 142.

Burned, grazed site on Road I4 (0.6 km E of cemetery on Road I4, across the valley in hay meadow):

From the fence corner at the SW corner of the property go E along fence.

At the 5th metal fencepost go 40.75 m bearing 336 degrees NW.

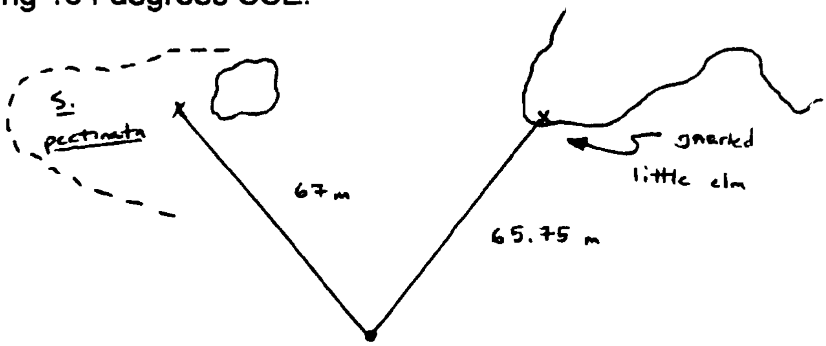
From the 3rd metal fencepost go 36.85 m bearing 4 degrees NNE.

Shoot transect at 256 degrees N.

Hay meadow on Road 158 (S side between Roads H &G):

Along the N edge of the native part of the hay meadow, there is a peninsula of _Spartina pectinata_ projecting W into the brome. On the NE corner of that there is an island of dogwood with a single (2 m) dead tree. From the base of that tree go 67 m bearing 138 degrees SE. From the base of the elm (_Ulmus_ spp.; see drawing) go 65.75 m bearing 296 degrees SSW.

Shoot transect bearing 164 degrees SSE.



Burned, grazed site on Road 158 (N side between Roads H & G):

Park at 2nd pole telephone pole from bridge as coming from the E. At about here the fenceposts change from green (new) to orange.

From the 3rd green post E of orange go 54.2 m bearing 330 degrees NW. From the 5th post W of green go 47.05 m bearing 12 degrees NNE.

Shoot transect at 335 degrees NW.

Appendix 2. Plant species and their guild assignments. Guild codes: **ANN** = annual/biennial; **C3** = $C_3$ photosynthetic pathway graminoid (grass or grasslike plant); **C4** = $C_4$ photosynthetic pathway grass; **ESP** = early spring ephemeral forb; **LEG** = legume; **SFF** = summer/fall forb; **SHR** = woody shrub; and **SPR** = spring forb. Additional non-guild classifications are coded: **INT** = non-native species; **TRE** = tree species. Guild classifications after Kindscher and Wells (1995) and Kindscher (pers. comm.). Plant species with “*” were found only in 1998. Plant names after Great Plains Flora Association (1991).

| | | | |
|---|---|---|---|
| *Achillea millefolium* | SPR | *Carduus nutans* | INT |
| *Agrostis hyemalis* | C3 | *Carex bushii* * | C3 |
| *Agrostis stolonifera* | INT | *Carex meadii* | C3 |
| *Ambrosia artemisiifolia* | ANN | *Carex spp.* | C3 |
| *Ambrosia psilostachya* | SFF | *Ceanothus americanus* * | SHR |
| *Amorpha canescens* | LEG | *Ceanothus herbaceus* | SHR |
| *Andropogon gerardii* | C4 | *Cerastium brachypodum* | ANN |
| *Andropogon scoparius* | C4 | *Cirsium altissimum* * | SFF |
| *Antennaria neglecta* | SPR | *Cirsium undulatum* | SFF |
| *Apocynum cannabinum* | SFF | *Cornus drummondii* | SHR |
| *Asclepias tuberosa* | SPR | *Croton capitatus* | ANN |
| *Asclepias verticillata* | SFF | *Croton glandulosus* * | ANN |
| *Asclepias viridiflora* | SPR | *Dalea candida* | LEG |
| *Asclepias viridis* | SPR | *Dalea multiflora* | LEG |
| *Aster ericoides* | SFF | *Dalea purpurea* | LEG |
| *Aster oolentangiensis* | SFF | *Delphinium virescens* | SPR |
| *Astragalus crassicarpus* | LEG | *Desmanthus illinoensis* | LEG |
| *Baptisia bracteata* | LEG | *Desmodium illinoense* | LEG |
| *Bouteloua curtipendula* | C4 | *Desmodium sessilifolium* | LEG |
| *Bromus inermis* | INT | *Dianthus armeria* | INT |
| *Bromus japonicus* | INT | *Dichanthelium acuminatum* | C3 |
| *Cacalia plantaginea* | CFF | *Dichanthelium liebergii* * | C3 |
| *Calystegia sepium* * | ANN | *Dichanthelium linearifolium* | C3 |

| | |
|---|---|
| *Dichanthelium oligosanthes* | C3 |
| *Dichanthelium sphaerocarpon* | C3 |
| *Echinacea angustifolia* | SPR |
| *Eleocharis spp.* | C3 |
| *Elymus canadensis* | C3 |
| *Elymus virginicus* | C3 |
| *Erigeron annuus* | ANN |
| *Erigeron strigosus* | ANN |
| *Euphorbia corollata* | SPR |
| *Euphorbia marginata* | ANN |
| *Euphorbia nutans* | ANN |
| *Euthamia gymnospermoides* | SFF |
| *Festuca octoflora* * | C3 |
| *Fragaria virginiana* | SPR |
| *Gaura longiflora* | ANN |
| *Gentiana puberulenta* | SFF |
| *Geranium carolinianum* | ANN |
| *Gleditsia triacanthos* | TRE |
| *Hedeoma hispidum* | ANN |
| *Hedyotis nigricans* | ANN |
| *Helianthus annuus* | ANN |
| *Helianthus rigidus* | SFF |
| *Hieracium longipilum* | SFF |
| *Hordeum jubatum* | C3 |
| *Hypericum punctatum* | INT |
| *Juncus interior* | C3 |
| *Juniperus virginiana* | SHR |
| *Koeleria pyramidata* | C3 |
| *Kuhnia eupatorioides* | SFF |
| *Lactuca ludoviciana* | SPR |
| *Lespedeza capitata* | LEG |
| *Lespedeza violacea* | LEG |
| *Liatris aspera* | SFF |
| *Liatris punctata* | SFF |
| *Liatris pycnostachya* | SFF |
| *Linum sulcatum* | ANN |
| *Lithospermum incisum* | SPR |
| *Lobelia spicata* | SPR |
| *Lomatium foeniculaceum* | ESP |
| *Medicago lupulina* | INT |
| *Medicago sativa* * | INT |
| *Melilotus alba* | INT |
| *Melilotus officinalis* | INT |
| *Mirabilis linearis* | SFF |
| *Myosotis verna* | ANN |
| *Oenothera speciosa* | SPR |
| *Oxalis dillenii* | SPR |
| *Oxalis violacea* * | SPR |
| *Panicum virgatum* | C4 |
| *Physalis pumila* | SFF |
| *Physalis virginiana* * | SFF |
| *Physalis viscosa* | SFF |
| *Poa pratensis* | C3 |
| *Polygala verticillata* * | ANN |
| *Polytaenia nuttalii* | SPR |
| *Potentilla recta* | INT |
| *Psoralea esculenta* | LEG |
| *Psoralea tenuiflora* | LEG |
| *Rosa arkansana* | SHR |
| *Rudbeckia hirta* | SFF |
| *Ruellia humilis* | SPR |
| *Rumex altissimus* | SPR |
| *Salvia azurea* | SFF |
| *Schrankia nuttallii* | LEG |
| *Scutellaria parvula* | SPR |
| *Senecio plattensis* | SPR |
| *Silphium integrifolium* * | SFF |
| *Sisyrinchium campestre* | ESP |
| *Solanum carolinense* | SFF |
| *Solidago canadensis* | SFF |
| *Solidago missouriensis* | SFF |
| *Solidago rigida* | SFF |

| | |
|---|---|
| *Sorghastrum nutans* | C4 |
| *Spartina pectinata* | C4 |
| *Spermolepis divaricata* | ANN |
| *Sporobolus asper* | C4 |
| *Sporobolus heterolepis* | C4 |
| *Stipa spartea* | C3 |
| *Strophostyles leiosperma* * | LEG |
| *Symphoricarpos orbiculatus* | SHR |
| *Taraxacum officinale* | INT |
| *Tradescantia bracteata* | SPR |
| *Tragopogon dubius* | INT |
| *Tridens flavus* | C3 |
| *Trifolium repens* | INT |
| *Triodanis leptocarpa* * | ANN |
| *Triodanis perfoliata* * | ANN |
| *Tripsacum dactyloides* | C4 |
| *Ulmus americana* | TRE |
| *Ulmus pumila* | TRE |
| *Ulmus rubra* * | TRE |
| *Valerianella radiata* | ANN |
| *Vernonia baldwinii* | SFF |
| *Viola pedatifida* | ESP |
| *Viola pratincola* | ESP |

# CHAPTER 2

# Two Management Regimes in the Tallgrass Prairie: Effects on Small Mammals

ABSTRACT.--Most of the remaining tallgrass prairie is under the ownership of private landowners, who manage the prairie with two predominant practices: annual haying, and spring burning in conjunction with grazing. The goal of my study was to determine if there were any differences between small mammal communities under the two regimes in northeastern Kansas. During 1997 and 1998 eight species of small mammals and 101 individuals were trapped within 800 trapnights. No difference was found for species richness or diversity (H') in 1997 or in the pooled data, but significantly more individuals of all species and of the deer mouse (Peromyscus maniculatus) were found on the burned, grazed sites in 1997. The western harvest mouse (Reithrodontomys megalotis) was the only other species with enough captured individuals to analyze, but I found no significant difference between treatments. The selection of the burned, grazed sites by P. maniculatus is contrary to my expectation based on the literature, which suggests that the species would choose the hayed sites, which have substantially less cover. However, it is possible that there is a threshold amount of cover necessary for finding P. maniculatus. From the vegetation analysis "height" -- the mean height of all vegetation for the site -- was selected as the variable to regress against total individuals captured per site. Both regressions for 1997 and 1998 showed a trend toward significance. The independent variable representing vegetation height explained 44.24% of the variation in total individuals captured per site in 1997 and 85.45% of the variation in 1998.

# INTRODUCTION

The grasslands of central North America are a product of climate, soils, and disturbance in the form of periodic fire and grazing by large herbivores (Collins, 1987; Kaufman *et al*., 1988; Collins *et al*. 1998). Within the last several centuries the tallgrass prairie has been drastically reduced in geographic extent so that approximately 4% remains (Samson and Knopf, 1994) and the formerly landscape-scales disturbances must now be carried out on a site-specific basis. Much of that small remainder is under the ownership of private individuals and is thus often managed for the economic benefit of the landowners, rather than explicitly for the benefit of the prairie community. The most common management practices employed on such remnant tallgrass prairies in northeastern Kansas are either late summer, annual haying or periodic spring burning in conjunction with grazing by cattle.

The tallgrass prairie is often defined by the association of four dominant matrix-forming grasses: big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), Indian grass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*). The community is maintained by disturbance at large and small scales (Gibson, 1989; Collins *et al*., 1998; Risser, 1990), such as periodic fire, large and small grazing animals (Gibson *et al*., 1990), and burrowing animals.

Collins (1992) noted that grazing can increase vegetative heterogeneity by decreasing cover of dominants, thus increasing floristic diversity. Clark *et al*. (1989) attributed increased small mammalian diversity to the greater spatial heterogeneity in vegetative structure caused by moderate grazing by cattle. Vegetative structure is one of the primary habitat variables for small mammals. When vegetative cover is removed, by either burning or mowing, vole (*Microtus*) populations experience steep declines (Lemen and Clausen, 1984). Birney *et al*. (1976) found that the vegetative cover is necessary for multi-year cycles in the populations, but Bowles and Copsey (1992) found *Microtus* populations to be affected by vertical stratification to a lesser extent. However, under similar regimes of vegetative cover removal, populations of deer mouse (*Peromyscus maniculatus*) increased (Snyder and Best, 1988; Clark *et al*., 1989; Clark *et al*., 1998) or were about the same (Sietman *et al*., 1994). Similar to the preferences of *Microtus*, the hispid cotton rat (*Sigmodon hispidus*) selected habitat with high vegetative cover and a heavy mulch layer (Fleharty and Mares, 1973; Clark *et al*., 1998). The western harvest mouse (*Reithrodontomys megalotis*) usually selects less-recently-burned habitat over more-recently-burned habitat. However, the expected pattern of a decrease in numbers in the year following a burn may be offset by fall grass seed production, which encourages recolonization (Kaufman *et al*., 1988). Sietman *et al*. (1994) found an overall decrease in total relative abundance of small mammals in a hay meadow -- a logical consequence of the annual removal of vegetation and consequent homogenization of structural habitat diversity.

Burning, grazing, and haying all have marked effects on the prairie small mammal community. If one is seeking to understand small mammals in relation to prairie, then structural and spatial considerations of vegetation under those regimes take precedence (Bowles and Copsey, 1992; McMillan and Kaufman, 1994; Bixler and Kaufman, 1995). To at least some extent the vegetative components then become quantifiable habitat in summation of its functional components, e.g., height, density, mulch depth, and grass vs. forb. Dormant season prairie hay meadows are a unique situation among the various forms, which a dormant season prairie may assume. When there is less than 20 cm of relatively uniformly cut prairie vegetation (excluding sparsely spaced mature grass inflorescences), the nuances of discrimination between degrees of habitat suitability for various species may be largely lost. A hayed prairie may be equated with a very large grazing lawn without the attendant nearby cover found in the heterogeneous habitat of grazed prairie.

Few studies have been published on the effect of haying on small mammal communities (Lemen and Clausen, 1984) or hayed prairie compared to differently managed prairies (Sietman et al., 1994; Clark et al., 1998). My study compared small mammal communities in annually hayed prairie and in grazed prairie subject to periodic burning. My objectives were to 1) to determine the small mammal community composition, and 2) to quantify habitat variables for a measure of macrohabitat.

## MATERIALS AND METHODS

Study area.--My study was done on the Prairie Band of the Potawatomi Nation Reservation (Reservation) in northeastern Kansas, 11 km west of Mayetta, Kansas. The remaining unplowed native grasslands on the Reservation are predominantly managed by either grazing and periodic spring burning or annual haying.

To avoid problems arising from the small mammal communities being on different fire chronologies (Kaufman et al., 1990), all burned, grazed sites were chosen at year-of-burn upon initiation of my study and were paired with a hayed site. I located the small mammal transects as near the plant transects (see Chapter 1) as was feasible. See Chapter 1 for further details concerning the study area and selection of study sites.

Field methods.--Eight sites were trapped in 1997 and four were trapped in 1998. Small mammal sampling was conducted on 25-26 October and 1-2 November 1997 and 20-21 October 1998, for a total of 800 trapnights over the two years. Trapping was done during late fall for two primary reasons. First, trappability increases dramatically as natural food abundance decreases with the cessation of the growing season (Johnson and Gaines, 1988). Second, I was not sampling fecundity or other breeding season measurements so the best time for simple abundance measures is in the late fall. Choice of trapping dates was constrained by consideration of the lunar cycle for conditions most conducive to trapping; i.e., no trapping during the full moon. Trapping was done by using large Sherman live traps (7.6 by 8.9 by 22.9 cm), baited with peanut butter and rolled oats wrapped in wax paper and suspended from the back door to keep excessive moisture out (Stout and Sonenshine, 1973). Polyfil was used for bedding. Traps were placed in pairs at 15 m intervals on a 300 m transect at least 50 m from the nearest edge of the treatment, for a total of 40 traps per transect and a potential total of 640 trapnights. Permanent marking of individuals was by toe-clipping (Ad hoc committee on acceptable field methods in mammalogy, 1987). The toes are coded so that by clipping a maximum of one toe on each foot a unique identification number is generated for each individual.

Habitat analysis.--Habitat features were measured on 8 November 1997 and 6 November 1998, immediately following the trapping period, rather than during summer because habitat features change from summer to the fall season. Habitat features were quantified for the two treatments by following the protocol described in Kaufman et al. (1988). Of the twenty trapping stations, ten were randomly selected for habitat analysis because I was quantifying macrohabitat rather than microhabitat. A steel pipe (17 mm diameter) was used to determine presence or absence of vegetation, litter, and bare ground, for twelve points at each station. Height classes were marked on the steel pipe for measuring vegetation height and litter depth.

One-way analysis of variance (ANOVA) was done to test for significant differences between the treatments by using the SAS (SAS Institute, Inc., 1985). Shannon-Weaver Diversity Index (Zar, 1996; H') was used to calculate species diversity for sites within the treatments. Regression analysis was done on the small mammal community data and the vegetation analysis data by using SAS (SAS Institute, Inc., 1985).

## RESULTS

In late September 1997 one of the burned, grazed sites was hayed. It was trapped in the fall, but was dropped with its paired hay meadow for analysis of the small mammal community data because the pair no longer conformed to the experimental design, which resulted in 480 trapnights for 1997. However, it was included in the regression analysis because the analysis had no assumptions about the regimes producing the independent vegetation variable. In the summer of 1998 another pair of sites was dropped because the burned, grazed site in the pair had been sprayed with a broadleaf herbicide, the implications of which were uncertain but questionable. Thus there were only 320 trapnights in 1998. The reduction of sites within treatments in 1998 precluded their analysis alone, so results of analysis are given for 1997 and for data pooled from both years.

Trapping results.--Small mammal species richness in 1997 was not significantly different between treatments (F=4.00, d.f.=1, P=0.18), but the difference between treatments for the total number of individuals was highly significant (F=243.00, d.f.=1, P=0.004), with more individuals found on the burned, grazed sites than on the hayed sites. Eight species of small mammals were trapped in 1997 -- six rodents: prairie vole (Microtus ochrogaster), house mouse (Mus musculus), Peromyscus maniculatus, Reithrodontomys megalotis, plains harvest mouse (Reithrodontomys montanus), Sigmodon hispidus, and two insectivores: Elliot's short-tailed shrew (Blarina hylophaga) and least shrew (Cryptotis parva). Of these, three species were captured only once and four species were captured in both treatments for a total of 75 individuals (Table 1).

In 1998 four species of small mammals were trapped -- three rodents: Peromyscus maniculatus, Reithrodontomys megalotis, Sigmodon hispidus, and one insectivore, Cryptotis parva. Of these, one species was captured once and the remainder were captured in both treatments. Notably, one site produced no captures in 1998. A total of 26 individuals were captured in 1998 (Table 2). Eight species were captured over the two years for a total of 101 individuals.

Over the two years, Peromyscus maniculatus comprised 51% of all captures, while Reithrodontomys megalotis comprised 25%. The third most commonly captured mammal was Microtus ochrogaster, which comprised 11% of all captures despite its complete absence in 1998. The remaining five species summed to 14% of all captures.

Mean species diversity (Zar, 1996; H') in 1997 for hayed sites and burned, grazed sites, respectively, was 0.37 and 0.49, but was not significantly different (F=5.61, d.f.=1, P=0.14). The pooled data likewise showed no difference (F=1.89, d.f.=1, P=0.24) for the hayed sites and burned, grazed sites (mean H' values -- hayed: 0.28, burned, grazed: 0.43). Peromyscus maniculatus was by far the most common species trapped in 1997 and was the only species to show a significant difference between treatments for total individuals (F=57.14, d.f.=1, P=0.02) with more individuals found on the burned, grazed sites than the hayed sites. All other species captured in 1997 had too few individuals to do any meaningful statistical analysis (Table 1).

**Table 1.** Treatment means, totals (per 100 trapnights), and ANOVA for 1997 small mammal data. H=hayed, B/G= burned, grazed.

| | H | B/G | F-value | P-value |
|---|---|---|---|---|
| Mean richness | 3.0 | 4.3 | 4.00 | 0.18 |
| Total individuals | 5.0 | 10.6 | 243.00 | 0.01 * |
| Microtus ochrogaster | 0.8 | 1.5 | nt | nt |
| Mus musculus | 0.2 | 0.0 | nt | nt |
| Peromyscus maniculatus | 2.1 | 6.3 | 57.14 | 0.02 * |
| Reithrodontomys megalotis | 1.5 | 1.5 | nt | nt |
| Reithrodontomys montanus | 0.2 | 0.0 | nt | nt |
| Sigmodon hispidus | 0.0 | 0.6 | nt | nt |
| Blarina hylophaga | 0.0 | 0.2 | nt | nt |
| Cryptotis parva | 0.2 | 0.6 | nt | nt |

* $P \leq 0.05$
nt = not tested

**Table 2.** Summary of 1998 small mammal data. Totals are per 100 trapnights. H=hayed, B/G= burned, grazed.

| | H | B/G |
|---|---|---|
| Mean richness | 1.5 | 3.0 |
| Total individuals | 2.5 | 5.6 |
| *Peromyscus maniculatus* | 1.9 | 1.7 |
| *Reithrodontomys megalotis* | 0.3 | 3.1 |
| *Sigmodon hispidus* | 0.3 | 0.6 |
| *Cryptotis parva* | 0.0 | 0.3 |

Reithrodontomys megalotis was the most common species trapped in 1998, but showed no significant difference (F=1.33, d.f=1, P=0.31) in number of individuals between treatments in analysis of the pooled data. In the pooled analysis Peromyscus maniculatus showed no significant difference between treatments (F=3.18, d.f.=1, P=0.15). All other species had too few individuals to do analysis (Table 3).

Habitat analysis.--Habitat features were measured on 8 November 1997 and 6 November 1998. Vegetation height was the variable selected for the habitat analysis as the most likely of the variables measured to predict the occurrence of small mammals because of the gross difference in vegetation height between treatments. A mean height for the twelve points at each station for each of the ten sampled stations was obtained. A mean of the station means was then obtained to yield a site mean. Mean heights varied considerably between sites, (F=1.51, d.f.=1, P=0.34) in 1997. The site means provided a simplified but meaningful data set for the regression. High values and low values for the means were produced by relatively uniformly high or low vegetation, respectively. Mid-range values were the result of either uniformly medium-height vegetation or a fairly balanced mix of all heights. The regression for 1997 showed marginally significant prediction (F=4.76, d.f.=7, P=0.07, Y=0.23x+4.00; see Fig. 1) with less than half of the variation in individuals caught explained by the regression ($R^2$=0.44). In 1998 the regression again showed a marginally significant prediction (F=11.75, d.f.=3, P=0.08, Y=0.15x+1.05; see Fig. 2) with much more of the variation explained by the regression ($R^2$=0.86).

**Table 3.** Treatment means, totals (per 100 trapnights), and ANOVA for pooled small mammal data. H=hayed, B/G= burned grazed.

| | H | B/G | F-value | P-value |
|---|---|---|---|---|
| Mean richness | 2.4 | 3.8 | 2.58 | 0.18 |
| Total individuals | 4.0 | 8.6 | 5.79 | 0.07 |
| Microtus ochrogaster | 0.5 | 0.9 | nt | nt |
| Mus musculus | 0.1 | 0.0 | nt | nt |
| Peromyscus maniculatus | 2.0 | 4.4 | 3.18 | 0.15 |
| Reithrodontomys megalotis | 1.0 | 2.1 | nt | nt |
| Reithrodontomys montanus | 0.1 | 0.0 | nt | nt |
| Sigmodon hispidus | 0.1 | 0.6 | nt | nt |
| Blarina hylophaga | 0.0 | 0.1 | nt | nt |
| Cryptotis parva | 0.1 | 0.5 | nt | nt |

nt = not tested

Vegetation on the sites in 1998 was substantially taller than in 1997, with the exception of a hayed site, which was even shorter than in 1997 probably because of a later haying date. Thus, the pooled regression was not significant ($F=0.86$, d.f.=11, $P=0.38$, $Y=0.08x+6.36$; see Fig. 3) and $R^2= 0.08$.

Fig. 1. Total individuals captured per site regressed against mean vegetation height for each site in 1997 ($R^2$=0.44, F=4.76, 1,7 d.f., P=0.07).

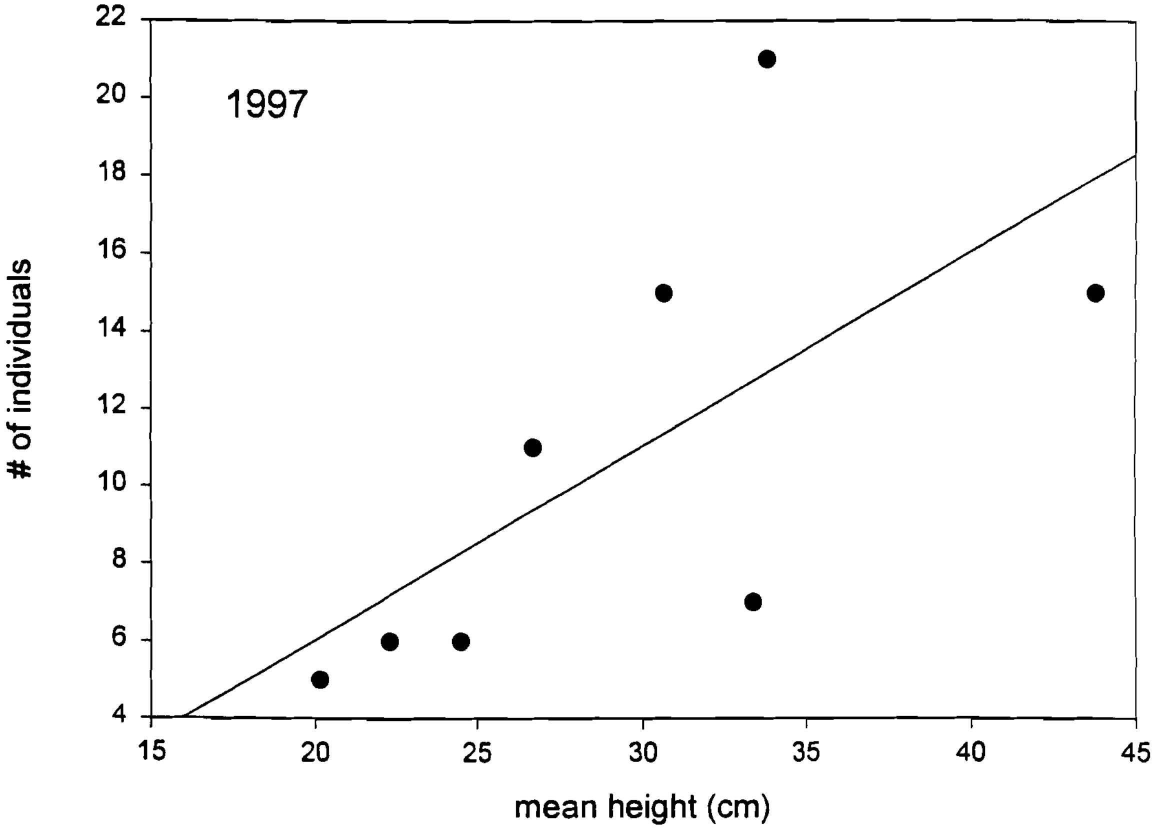

1997
# of individuals
mean height (cm)
4
6
8
10
12
14
16
18
20
22
15
20
25
30
35
40
45

Fig. 2. Total individuals captured per site regressed against mean vegetation height for each site in 1998 ($R^2=0.86$, $F=11.75$, 1,3 d.f., $P=0.08$).

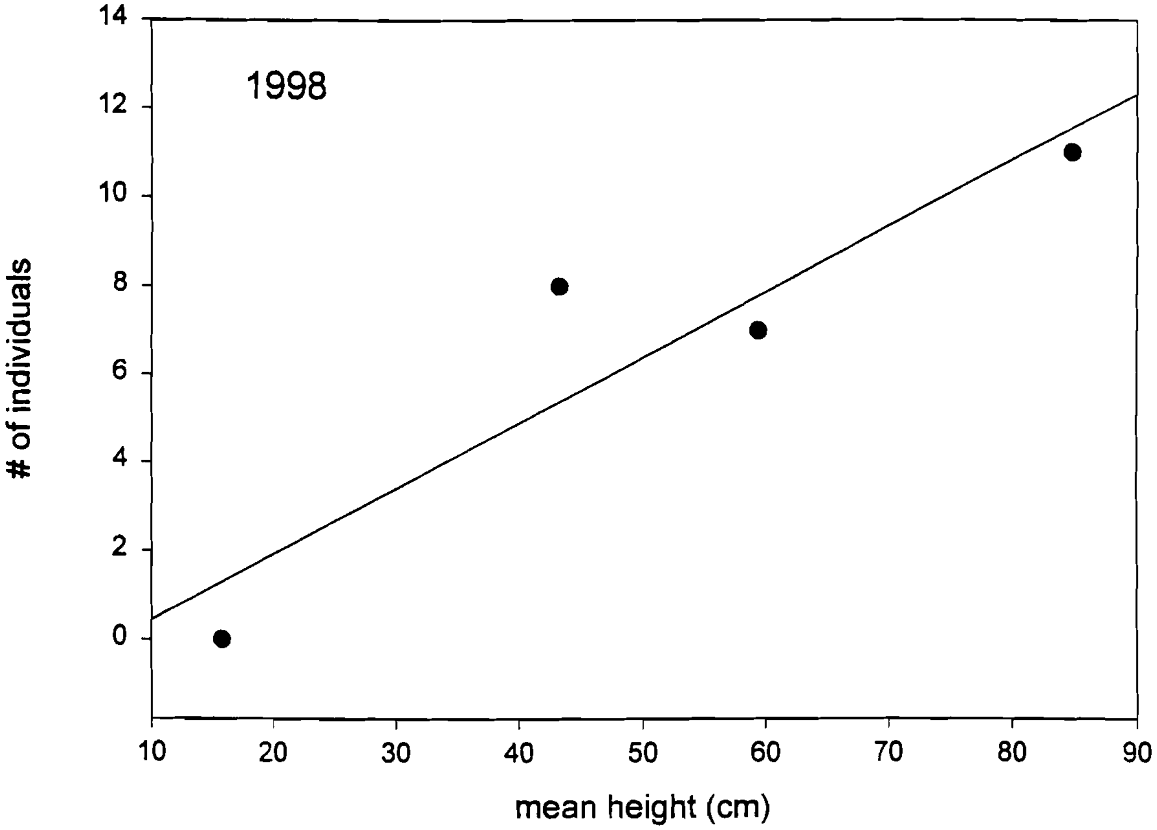
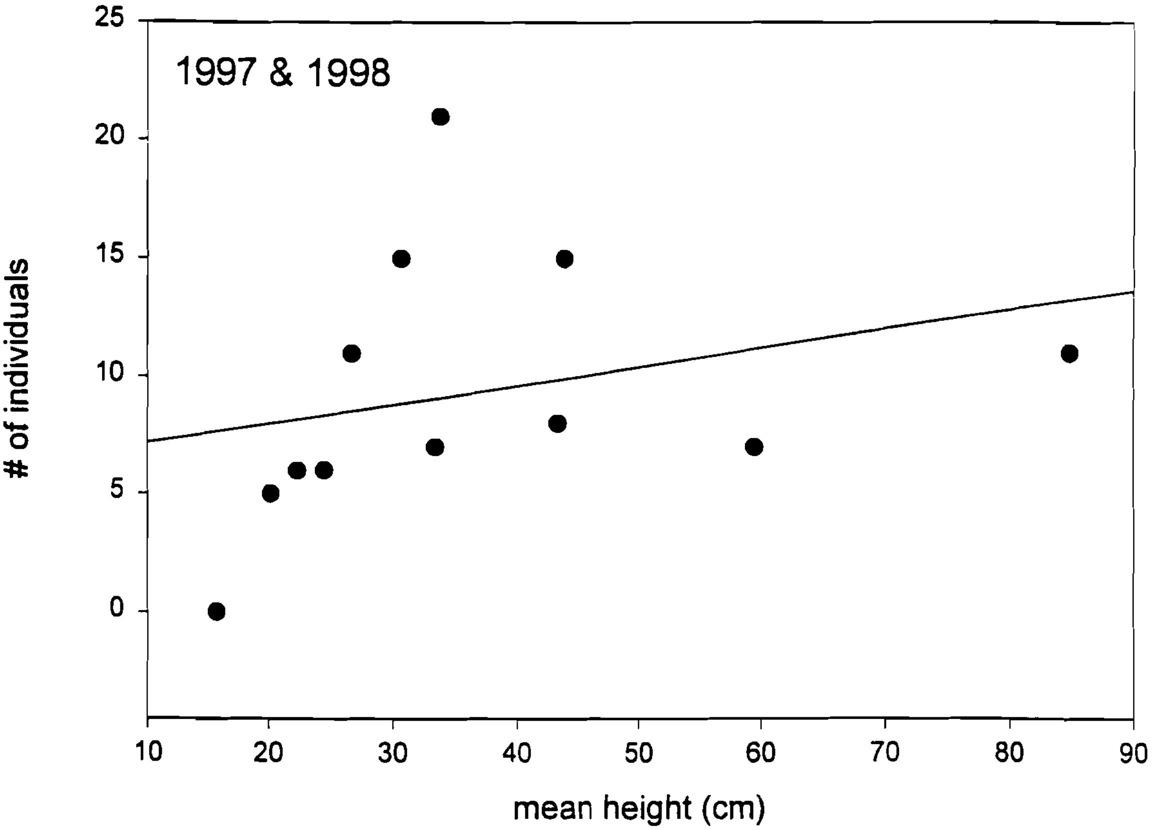

1998
# of individuals
14
12
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
mean height (cm)

Fig. 3. Total individuals captured per site regressed against mean vegetation height for each site in pooled years ($R^2$=0.08, F=0.86, 1,11 d.f., P=0.38).


1997 & 1998
25
20
15
10
5
0
# of individuals
10
20
30
40
50
60
70
80
90
mean height (cm)

# DISCUSSION

Trapping results.--Clark et al. (1989) found the diversity of small mammal assemblages and total numbers to be unaffected by grazing or burning. However, Sietman et al. (1994) found the nuances of habitat selection differences between various species of small mammals became far less important when compared to their general preference for more heterogeneous habitat over the more homogeneous habitat and largely absent complex vertical vegetative structure of a hayed site, with the exception of Peromyscus maniculatus, which was captured in similar numbers between the hayed site and the site with more heterogeneous habitat. Overall, Sietman et al. (1994) captured fewer individuals of all species on the hay meadow, which accords with my results. Only one species, P. maniculatus, in my study showed a pronounced affinity for the burned, grazed sites, which had greater cover than the hayed sites, and was in direct contrast to other studies showing the species to prefer less cover and simpler vegetative structure (Kaufman et al., 1988; Snyder and Best, 1988; Sietman et al., 1994; Clark et al., 1998). Despite the variability between sites, the differences in species composition of the small mammal community were not great enough to deviate from an overall uniformity in species composition. However, the significant affinity of total individuals of the small mammal community in 1997 for the burned, grazed sites shows the influence of the large number of individuals of P. maniculatus and also agrees with Sietman et al., (1994).

Diversity values for both treatments fell between low to comparable with other published values (Grant *et al*., 1982; Clark *et al*., 1998). However, Clark *et al*. (1998) urged caution in comparing diversity values, as well as other results, because of the influences on the results such factors as site history and areal extent may have among different studies.

The percent captures for each species were similar to Clark *et al*. (1989) for *Microtus ochrogaster* and *Peromyscus maniculatus*, because the majority of the species comprised less than 15% of total captures. However, *Blarina hylophaga* and *Reithrodontomys megalotis* comprised, respectively, 1% and 25% of my total captures, whereas Clark *et al*. (1989) report 22% and 2%, respectively, for these species. This simply illustrates the dynamic nature inherent in small mammal populations and in relatively small samples.

*Habitat analysis*.--The primary purpose of the habitat analysis was to quantitatively demonstrate the gross difference in the habitat resulting from the two different management regimes. After the first trapping season there appeared to be a simple relationship between the vegetation height and the number of individuals captured, and a regression on that basis appeared warranted. The lack of significance for the regressions for the separate years is likely a product of the inherent variability in small mammal populations censused in a one-time sample during the season. However, the P-values for the separate years did approach significance and explained 44.24% and 85.45% of the observed variation in captures relative to vegetation height, respectively. Other studies have generally found relationships between vegetation height and abundance of small mammals (Birney *et al*., 1976; Snyder and Best, 1988) and I conclude from my results that there is a strong possibility for a simple linear relationship between vegetation height and small mammal abundance.

A short-term investigation of small mammals such as my study highlights the need for caution when interpreting the results relative to longer term studies or similarly short-term studies with a greater trapping effort. I conclude that the late fall habitat resulting from spring burning and moderate grazing of the tallgrass prairie is preferred over hayed prairie by the small mammal communities in my study, and that the communities were similar to other reported tallgrass prairie small mammal communities.

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Two Management Regimes in the Tallgrass Prairie: Effects on Plants and Small Mammals

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