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Bison selectivity and grazing response of little bluestem in tallgrass prairie

KENT E. PFEIFFER AND DAVID C. HARTNETT

Authors are graduate research assistant; and Associate Professor, Division of Biology, Kansas State University, Manhattan, Kan. 66506.

Abstract

The perennial bunchgrass little bluestem (*Schizachyrium scoparium* [Michx.] Nash) was examined in a 5-yr study on tallgrass prairie to determine how fire influences its use by bison and its responses to grazing. On unburned prairie, bison grazed only 5% of the available little bluestem, selecting it only 30% as frequently as big bluestem, the dominant co-occurring species. On burned prairie, grazing frequency of little bluestem was over 3-fold greater and equal to that of its dominant neighbor. Grazing frequency of little bluestem was affected by plant size (basal area). On burned sites, plants of intermediate size classes were least abundant (<10% of total) but were grazed most frequently (>50%). Small plants were most abundant but were grazed least frequently. Density, tiller numbers, and basal area of little bluestem were significantly greater in annually burned compared to infrequently burned sites but were decreased by > 50% in grazed compared to ungrazed sites. Grazing shifted the population size distribution toward higher frequencies of smaller individuals (< 50 cm² basal area), whereas burning increased the frequency of large (> 200 cm² basal area) individuals. In unburned prairie, little bluestem accumulates a persistent clump of standing dead tillers that appear to serve as a physical deterrent to grazing. Although burning enhances its growth, it also removes its canopy of dead tillers exposing the plant to grazers. The shift in population structure toward a high frequency of smaller (and perhaps less drought- or grazing-tolerant) individuals may contribute to the decline of little bluestem populations under persistent grazing. Thus, plant growth form, population size structure, and fire interact to influence bison grazing patterns and responses of little bluestem to grazing on tallgrass prairie.

Key Words: bison, grazing, fire, bunchgrass, *Schizachyrium scoparium*

Studies of plant-grazer interactions have shown that numerous characteristics of the plant and the grazer may influence both the probability of a given plant being grazed and its response to herbivory (Dirzo 1984). Plant traits that reduce the probability of a plant being grazed (grazing avoidance) or those that increase its ability to recover following grazing (grazing tolerance) are 2 primary mechanisms by which plants cope with herbivory (Briske 1991). Plant characteristics such as growth form, size, morphology and nutritional status, and environmental factors such as resource availability, plant competition and fire may all be important in determining both the selection of species, plants, or plant parts by grazers and the subsequent growth, tillering, and reproductive responses of grasses following herbivory (e.g. Mueggler 1972, Archer and Detling 1984, Coppock and Detling 1986, Hartnett 1989, Ganskopp and Rose 1992, Ganskopp et al. 1992, Vinton et al. 1993). The spatial and species selectivity of grazers and plant responses to grazing patterns have important implications for the management of rangeland ecosystems.

In tallgrass prairie and other grassland communities, variation in growth form and size among co-occurring plants, and the occurrence of fire, may significantly influence grazing patterns and plant responses. For example, in tallgrass prairie little bluestem is an important bunchgrass and produces a high ratio of reproductive stems to vegetative tillers. Although it has a comparatively low tolerance to grazing (Butler and Briske 1988, Mullahey et al. 1990), its development of a persistent clump of dead reproductive tillers may be an effective grazing avoidance mechanism (Ruyle and Rice 1991, Brummer et al. 1993). Fire in tallgrass prairie removes this physical barrier and exposes the plants to grazers. This may significantly increase the frequency at which little bluestem is grazed relative to other dominant forage grasses such as big bluestem. Thus, the patterns of grazing of little bluestem, and its responses to grazing, may differ considerably between burned and unburned prairie.

Furthermore, recent studies indicate that, within monotypic pastures, cattle selectively graze bunchgrasses based on plant basal area (Ganskopp and Rose 1992). Whether such selectivity based on plant size occurs in diverse, multi-species grasslands such as tallgrass prairie is unknown.

The objectives of this study were to: 1) assess patterns of bison grazing of little bluestem in tallgrass prairie by quantifying both its grazing frequency (percentage of available plants grazed) and its selection by bison (use relative to its most abundant neighboring plant species), 2) assess the influence of plant size on the selection of plants by bison, and 3) assess the effects of fire on the relative grazing frequency of little bluestem and its responses

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to grazing. Previous studies in tallgrass prairie have examined the growth and tillering dynamics of some of the rhizomatous tall grasses (e.g. Peet et al. 1975, Knapp and Hulbert 1986, Forwood and Magai 1992, Vinton and Hartnett 1992), but the growth and dynamics of the bunchgrass little bluestem in relation to fire and grazing in tallgrass prairie have not been studied.

Materials and Methods

This study was conducted on the Konza Prairie Research Natural Area, a 3,487 hectare tallgrass prairie site located in the northern Flint Hills region of northeastern Kansas (39°05'N, 96°35'W). Average monthly temperature ranges from a January low of -2.7° C to a July high of 26.6° C and average annual total precipitation is 835 mm. The vegetation of Konza Prairie is predominantly tallgrass prairie, dominated by the C_4 grasses big bluestem (*Andropogon gerardii* Vitman), little bluestem [*Schizachyrium scoparium* (Michx.) Nash], Indiangrass [*Sorghastrum nutans* (L.) Nash], and switchgrass (*Panicum virgatum* L.), with numerous subdominant grasses, composites, legumes, and other forbs (Kuchler 1967, Freeman and Hulbert 1985). A few woody species, such as leadplant (*Amorpha canascens* Pursh) and New Jersey tea (*Ceanothus herbaceous* Raf.), are locally common. The vascular flora of Konza includes over 500 species representing over 60 families (Freeman and Hulbert 1985). The soils are Chase silty clay loams: fine, montmorillonitic, mesic Aquic Arguidolls. Bison were introduced onto a 1,000 ha portion of Konza Prairie in October 1987 at a stocking rate of 9 ha au^{-1}. The stocking rate was gradually increased to 5 ha au^{-1} by 1992. The animals are free to move among 10 watersheds (avg. size = 100 ha) that are subjected to prescribed April burning annually or at 2-yr, 4-yr or 20-yr intervals. For this study, we sampled in an annually burned watershed and a watershed burned at 4-yr intervals that had been grazed by bison since 1987, and nearby annually burned and 4-yr burn interval watersheds that were ungrazed. The 4-yr burn interval watersheds were last burned in 1990 and thus had not burned within 2 years of our sampling. For simplicity, these sites and the annually burned sites will hereafter be referred to as "unburned" and "burned" sites respectively.

Soil types, slopes, aspects, and previous land-use histories are similar among the watersheds studied. Prior to the introduction of bison in 1987, all watersheds sampled in this study had been ungrazed and similarly managed for approximately 20 yrs. The various prescribed burning frequency treatments were initiated on Konza Prairie in 1970. In addition, the Konza Prairie Long-Term Ecological Research Program plant community data (Data Set PVC-081, unpublished) indicate that there were no significant initial differences in botanical composition among the study sites.

Plants were marked at the beginning of the 1992 growing season, the fifth season after the initiation of the grazing treatments on the watersheds. Five 50-m transects were established in each of the treatment areas. At 1-m intervals along each transect, the nearest little bluestem bunch and big bluestem tiller was marked and mapped, for a total of 250 plants of each species in each watershed and 2,000 plants overall. Bunch size (for little bluestem) and distance from the transect sampling point were recorded. Basal area was determined by measuring the greatest basal diameter and a second diameter perpendicular to the first, and solving for the area of the ellipse. Little bluestem plants were stratified into 6 size classes based on basal area, ranging from less than 25 cm^2 to greater than 200 cm^2. All plants were censused every 2 weeks beginning 1 June and continuing until 15 August in 1992 and 1993 to determine grazing frequency. Also, during the first week of August, an additional 1,000 plants of each species were randomly sampled along the transects to determine whether they had been grazed or not during the season. Grazing frequency of big bluestem (*Andropogon gerardii* Vitman) was measured to provide a reference or comparison for assessing bison selection or avoidance of little bluestem and because it is the most abundant co-occurring species in these tallgrass prairie communities (accounting for >50 % of the total plant cover) and the most frequent nearest-neighbor of little bluestem.

Differences between grazing frequencies of big and little bluestem were determined using the 2-way analysis of variance procedure, and Fisher's Protected L.S.D. ($P < 0.05$) was used to separate means. Chi-square analysis ($P < 0.05$) was used to examine the hypothesis that the number of plants grazed was independent of the number available within each size class. Degree of association between class rankings based on the number of plants grazed and number of plants occurring within size classes was indexed with Spearman's rank correlation coefficient.

In early September, a total of approximately 300 little bluestem plants were randomly selected along the 50-m transects and harvested: 50 plants in each of the ungrazed watersheds, 50 grazed plants in each of the grazed watersheds, and 50 ungrazed plants in each of the grazed watersheds. The plants were oven-dried at 75° C for at least 3 days. The plants were separated into reproductive tiller and vegetative tiller components, counted, and weighed to the nearest mg.

The influence of fire and grazing on plant response variables was analyzed using 2-way analysis of variance procedures. Differences between means were tested with Fisher's Protected L.S.D. at a significance level of $P < 0.05$.

Results

Bison Selectivity

In unburned prairie, little bluestem was grazed far less frequently than its dominant neighbor, but the 2 species were grazed at equal frequencies on burned prairie (Fig. 1). Bison grazed little bluestem 3.3 times more frequently on burned prairie (26.5% of plants grazed) than on unburned prairie (6.9% of plants grazed) (Fig. 1).

The grazing frequency of little bluestem was also significantly affected by plant size (freq. of plants grazed in each size class was significantly different than freq. available [Chi-square significant at the $p < 0.05$ level]) (Fig. 2). In the burned watershed, plants in the 2 smallest size classes occurred most frequently but were grazed least frequently, while intermediate sized plants in the 100 cm^2 and 150 cm^2 size classes occurred least frequently and were grazed most frequently (Fig. 2). Bison grazed plants in the 50 to 200 cm^2 size classes most frequently. Spearman's rank correlation showed that the number of plants grazed within each size class was significantly inversely related to the relative number of plants available within each size class. In the unburned sites, the low grazing frequency of the plants precluded statistical comparisons of grazing frequency among size classes.

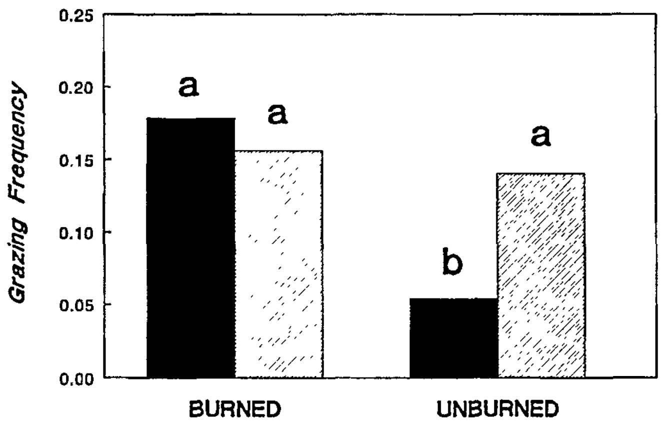

Fig. 1. Mean grazing frequencies of little bluestem (solid bars) and big bluestem (cross hatched bars) in burned and unburned prairie. Similar letters above bars indicates no significant difference in grazing frequency at the $p < 0.05$ level (ANOVA, LSD).

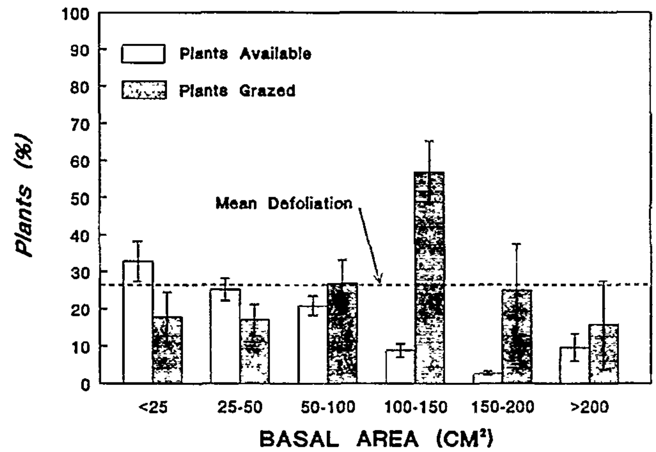

Fig. 2. Availability and percent of little bluestem plants grazed (mean + 1 SE) in 7 basal area size classes in annually burned tallgrass prairie. Dashed line indicates the mean percent of all plants defoliated.

Plant Responses to Grazing

Little bluestem plant (bunch) density was reduced by grazing and increased by annual burning (Fig. 3a). The average density of plants was 0.5 plants m^{-2} in grazed prairie and 0.9 plants m^{-2} in ungrazed prairie. On both grazed and ungrazed sites, little bluestem densities were nearly double on annually burned compared to infrequently burned sites (Fig. 3a). Mean basal area was reduced by grazing in both burned and unburned prairie. Burning alone increased mean basal area relative to that of unburned prairie and the largest mean bunch size was found in the ungrazed annually burned site (Fig. 3b). In general, grazing had a larger effect on average bunch size than did burning.

In addition to altering mean basal area, 5 years of burning and grazing shifted the size class distribution of little bluestem (Fig. 4). Annual burning resulted in a population with high frequency of large individuals (> 200 cm^2), while grazing by bison shifted the distribution towards the smaller size classes (Fig. 4). In the grazed watersheds, mean basal area was 72.6 cm^2 and 76.5 cm^2 in burned and unburned prairie, respectively. In grazed prairie, plants in the <25 to 100 cm^2 size classes occurred the most frequently, while those in the large (100 to >200) size classes were the least frequent in both burned and unburned sites (Fig. 4). In the ungrazed watersheds, mean basal area was 225.5 cm^2 and 168.6 cm^2 in burned and unburned prairie, respectively. Small individuals (<50 cm^2) were generally much less frequent and large individuals (> 200cm^2) were more frequent in ungrazed than in grazed sites (Fig. 4).

Table. 1. Mean biomass and densities of vegetative and reproductive tillers of little bluestem in burned/grazed (BU/GR), burned/ungrazed (BU/UNGR), unburned/grazed (UNBU/GR), and unburned/ungrazed (UNBU/UNGR) tallgrass prairie.

	BU/GR	BU/UNGR	UNBU/GR	UNBU/UNGR
Tillers plant^{-1}				
Vegetative	44.2a	73.5b	48.3a	55.9a
Reproductive	2.8a	11.3b	4.5a	7.8c
Tillers cm^{-2} Basal Area				
Vegetative	0.57a	0.66a	0.49a	0.55a
Reproductive	0.05ab	0.09c	0.03a	0.08bc
Tillers m^{-2}				
Vegetative	27.3a	79.0b	22.6a	34.7a
Reproductive	2.3a	12.3b	2.5a	4.9c
Total	29.5a	91.3b	25.1a	39.6a
Grams tiller^{-1}				
Vegetative	0.13a	0.19b	0.08c	0.14a
Reproductive	0.39a	0.43a	0.60b	0.81c
Grams m^{-2}				
Vegetative	3.6a	12.7b	2.8a	4.9a
Reproductive	1.3a	5.8b	1.7a	4.0c
Total	4.9a	18.5b	4.4a	9.0c

Values within a row with the same lowercase letter do not differ ($p < 0.05$).

Grazing reduced the number of little bluestem vegetative tillers per plant in annually burned prairie, but not in unburned prairie (Table 1). In the grazed watersheds, burning decreased the number of reproductive tillers per plant, while burning increased reproductive tillers in ungrazed areas. No significant differences were detected in tiller density within clumps (vegetative tillers cm^{-2} of basal area) among any treatments, but the number of reproductive tiller cm^{-2} of plant basal area was decreased by grazing in both burned and unburned prairie (Table 1). Grazing reduced the number of vegetative tillers m^{-2} and reproductive tillers m^{-2} in the burned areas, but not in the unburned areas (Table 1). Burning increased vegetative tiller biomass and reduced reproductive tiller biomass in grazed and ungrazed prairie. Grazing reduced biomass of all tillers except reproductive tillers in burned prairie. Grazing reduced both vegetative and reproductive tiller production (g m^{-2}) in the burned sites, but not in the unburned sites. Overall, little bluestem standing crop was dramatically increased by burning in ungrazed prairie but not in grazed prairie.

Discussion

The results reported here demonstrate that fire in tallgrass prairie alters grazing frequency of the bunchgrass little bluestem and its selection relative to the dominant co-occurring species. In addition, little bluestem plant size (bunch basal area) is an important basis for selection among conspecific plants. Previous studies have shown that fire frequency alters the spatial patterns of bison grazing at the landscape scale in grasslands (Coppock and

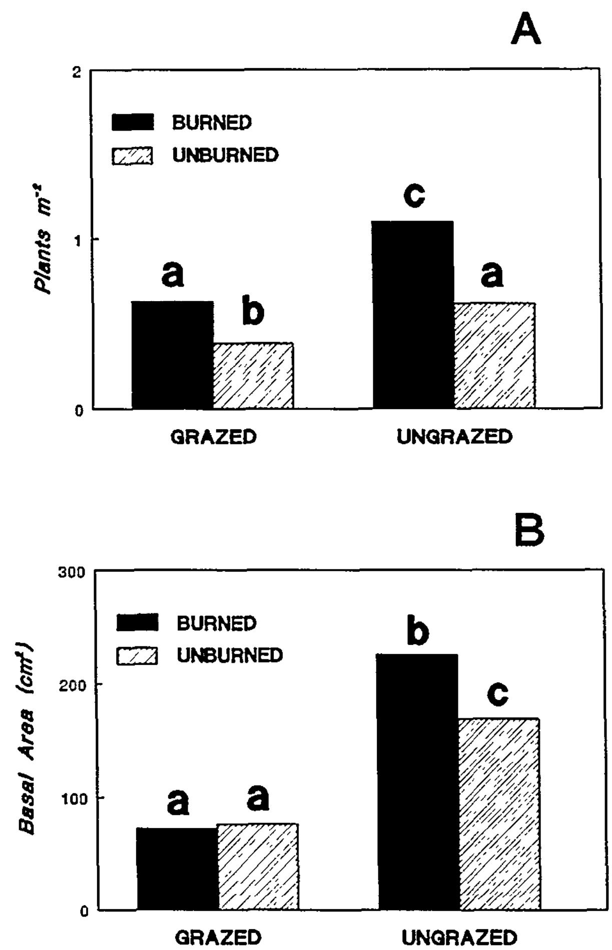

Fig. 3. a) Mean plant density of little bluestem plants (bunches) by treatment. b) Mean plant basal area of little bluestem plants by treatment. Similar letters above bars indicate no significant difference between treatments at the

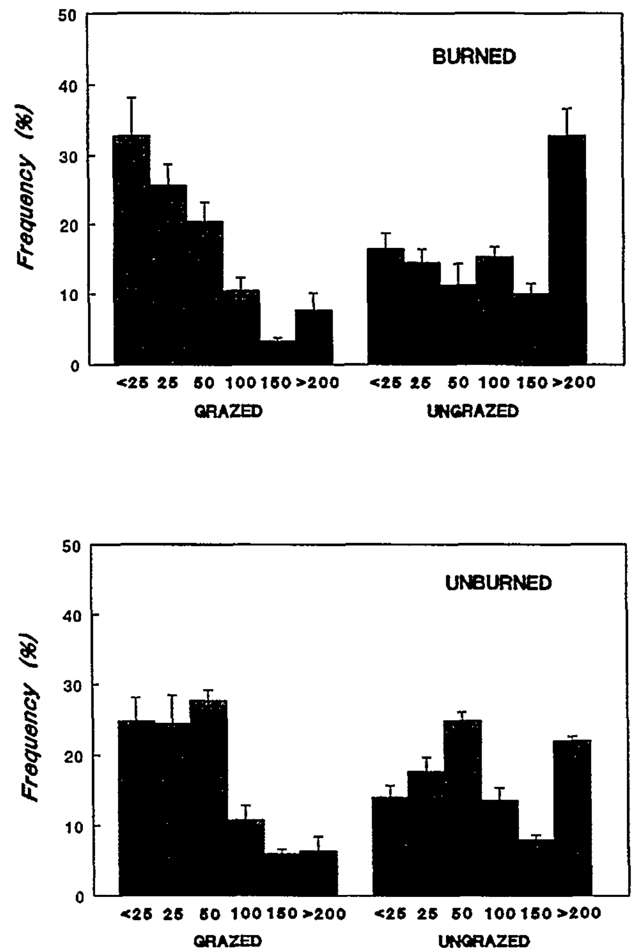

Fig. 4. Mean ± 1 SE) percent of little bluestem individuals in each of 6 size (basal area) classes in burned/grazed, burned/grazed, unburned/grazed, and unburned/ungrazed tallgrass prairie. Numbers on the x-axis indicate lower limit of each size class.

Detling 1986, Vinton et al. 1993). Thus, in addition to the documented direct effects of fire in tallgrass prairie (e.g. Hulbert 1986, Collins and Wallace 1990), fire may also influence these plant communities indirectly by altering patterns of large ungulate grazing at several scales.

In prairie that had not been recently burned, bison avoided little bluestem relative to its dominant neighbor, big bluestem, but this pattern of selectivity was eliminated by burning. The increased grazing frequency on little bluestem in the annually burned prairie compared to the site that had not burned for 2 years is most likely the result of the removal of its persistent standing dead tillers by burning. Recent studies have shown that the presence of standing dead stems deters grazing by cattle (Ganskopp et al. 1992, Brummer et al. 1993). The frequency at which neighboring big bluestem plants were grazed (a plant lacking persistent standing dead tillers) was unaffected by burning. With longer intervals between fires, bison might display even greater avoidance of little bluestem in favor of other co-occurring grasses, but only up to a point. The increase in standing dead biomass within bunches, and its deterrent effect on grazers, would be expected to reach an asymptote due to the gradual decomposition of dead tillers and reproductive culms.

An alternate hypothesis explaining the increased grazing frequency of little bluestem during the season after fire is that burning may alter its nutrient content or some other aspect of its forage quality, increasing its acceptability to bison. However, although burning generally increases the productivity of little bluestem (Towne and Owensby 1984, Svejcar and Christiansen 1986), it is unlikely that a change in plant tissue nutrient content alone could account for a 3-fold increase in its use after fire and such a large increase in its use relative to other co-occurring C_4 grasses.

Bison selectively grazed intermediate sized little bluestem plants and they avoided individuals in large and small size classes although they were available in greater numbers. This selectivity is most likely related to animal bite width and the efficiency with which animals harvest forage from bunchgrasses. Plants with diameters between 11 and 14 cm were grazed most frequently. Although we found no published data on the bite width of bison, Ganskopp and Rose (1992) reported that the mean bite width of 4+ year old Hereford X Angus cattle was 9 cm. Bison can be expected to have similar, or slightly larger, bite widths compared to cattle and the effective bite width is expanded somewhat by the use of the tongue. Ganskopp and Rose (1992) showed that cattle grazing monotypic stands of the caespitose grass *Agropyron* *desertorum* exhibited strong size preferences. Our results show that such size-based preferences also are evident in bison grazing and in mixed composition as well as monotypic communities.

Burning and herbivory acted to modify demographic characteristics of little bluestem at the plant and at the population level. Over the 5-yr period, bison grazing resulted in the shift in the little bluestem population size structure towards a high frequency of smaller plants. This shift is most likely caused by the fragmentation of intermediate and large plants (Briske and Anderson 1990). This change in population size distribution may result in greater mortality rates because smaller individuals of little bluestem may be less tolerant of drought conditions than large individuals (Butler and Briske 1988, Briske and Anderson 1990). This change in size structure may also result in reduced reproductive success because both seed production and vegetative reproduction are generally plant size-dependent in herbaceous perennials (e.g. Hartnett 1990). Thus, a grazing-induced shift to smaller size classes and resulting decrease in reproduction and/or survivorship may explain why little bluestem declines under persistent grazing, particularly in burned prairie, where it is more vulnerable to large grazers and more frequently grazed..

Density of little bluestem plants (bunches) was uniformly higher on burned prairie, but was significantly reduced by grazing. In contrast, Butler and Briske (1988) reported that herbivory results in increased plant density by fragmenting large individuals into a larger number of small individuals. In our study, we also observed the apparent fragmentation of large plants, but total plant density was reduced by grazing. This may be the result of significant mortality among the smaller plants due to more intense grazing, or higher levels of interspecific plant competition in our study site where little bluestem occurs in mixed stands with tall grasses (Butler and Briske conducted their study in monospecific stands of little bluestem). Grazing reduced vegetative tillers per plant by 39.9% and 13.6% in burned and unburned prairie, respectively, and reproductive tillers by 75% and 42.3% in burned and unburned prairie, respectively. The more pronounced effect of grazing in burned than in unburned prairie is most likely explained by the higher grazing intensity on little bluestem in the burned prairie relative to unburned sites. The larger effects of grazing on reproductive tiller numbers than on vegetative tiller numbers is consistent with earlier studies showing that reproductive responses are more sensitive to grazing stress than vegetative growth responses in big bluestem and switchgrass (*Panicum virgatum* L.) on tallgrass prairie (Vinton and Hartnett 1992). Plants in the grazed areas that were ungrazed during the current season had tiller numbers similar to grazed plants and had tiller weights similar to plants in the ungrazed areas. Thus, tiller number per plant appears to be related to previous seasons' grazing history, whereas tiller weight is influenced by current season's grazing. Intraclonal tiller densities (tillers cm^{-2} of plant basal area) were not different among any treatments. This is not unexpected given that bunchgrasses are characterized by the compact spatial arrangements of tillers within clones with strongly regulated intraclonal tiller densities (Williams and Briske 1991).

Previous work has indicated that bunchgrasses of the Great Plains are more poorly adapted to large herbivore grazing than are rhizomatous species (Mack and Thompson 1982, Mullahey et al. 1991). Bunchgrasses are known to decline in grassland communities as a result of long-term grazing. Although burning favors little bluestem in ungrazed tallgrass prairie, it also removes its protective canopy of standing dead tillers resulting in increased vulnerability to large grazers. Thus, even though burning apparently improves growth conditions for little bluestem, the increased grazing intensity it experiences and resulting suppression is enough to offset any fire induced increase in population growth potential. Thus, little bluestem (and likely other C_4 bunchgrasses) can be expected to exhibit opposite responses to burning in grazed compared to ungrazed prairie.

Literature Cited

Archer, S., and J.K. Detling. 1984. The effects of defoliation and competition on regrowth of tillers of two North American mixed-grass prairie graminoids. Oikos 43:351-357.

Briske, D.D. 1991. Developmental morphology and physiology of grasses. *In:* R.K. Heitschmidt, and J.W. Stuth (ed.), Grazing management: an ecological perspective. Timber Press, Portland, Ore.

Briske, D.D., and V.J. Anderson. 1990. Tiller dispersion in populations of the bunchgrass Schizachyrium scoparium: implications for herbivory tolerance. Oikos 59:50-56.

Brummer, J.E., J.T. Nichols, R.K. Engle, and P.E. Reece. 1993. Effect of standing dead herbage on utilization of little bluestem under different grazing strategies in the Nebraska Sandhills. Abstr. Anu. Mtg. Soc. Range Manage. 46:52.

Butler, J.L., and D.D. Briske. 1988. Population structure and tiller demography of the bunchgrass *Schizachyrium scoparium* in response to herbivory. Oikos 51:306-312.

Collins, S.L., and L.L. Wallace. 1990. Fire in North American tallgrass prairies. Univ. Oklahoma Press, Norman, Okla.

Coppock, D.L., and J.K. Detling. 1986. Alteration of bison and black-tailed prairie dog grazing interaction by prescribed burning. J. Wildlife Manage. 50:452-455.

Dirzo, R. 1984. Herbivory: a phytocentric overview. *In:* R. Dirzo and J. Sarukhan (ed.), Perspectives on plant population biology. Sinauer Assoc. Inc. Sunderland, Mass.

Freeman, C.C., and L.C. Hulbert. 1985. An annotated list of the vascular flora of Konza Prairie Research Natural Area, Kansas. Trans. Kans. Acad. Sci. 88:84-115.

Forwood, J.R., and M.M. Magai. 1992. Clipping frequency and intensity effects on big bluestem yield, quality, and persistence. J. Range Manage. 456:544-559.

Ganskopp, D., R. Angell, and J. Rose. 1992. Response of cattle to cured reproductive stems in a caespitose grass. J. Range Manage. 45: 401-404.

Ganskopp, D., and J. Rose. 1992. Bunchgrass basal area affects selection of plants by cattle. J. Range Manage. 45:538-541.

Hartnett, D.C. 1989. Density- and growth stage-dependent responses to defoliation in two rhizomatous grasses. Oecologia 80:414-420.

Hartnett, D.C. 1990. Size-dependent allocation to seed and vegetative reproduction in four clonal composites. Oecologia 84:254-259.

Hulbert, L.C. 1986. Fire effects on tallgrass prairie. *In:* G.K. Clambey and R.H. Pemble (ed.), Proc. Ninth North Amer. Prairie Conf. Tri-College Press. Fargo, N.D.

Knapp, A.K., and L.C. Hulbert. 1986. Production, density, and height of flower stalks of three grasses in annually burned and unburned eastern Kansas tallgrass prairie: a four year record. Southwest. Natur. 31:235-241.

Kuchler, A.W. 1967. Some geographic features of the Kansas prairie. Trans. Kans. Acad. Sci. 70:388-401.

Mack, R.N., and J.N. Thompson. 1982. Evolution in steppe with few large, hoofed mammals. Amer. Natur. 119:757-773.

Mueggler, W.F. 1972. Influence of competition on the response of bluebunch wheatgrass to clipping. J. Range Manage. 25:88-92.

Mullahey, J.J.,S.S. Waller, and L.E. Moser. 1990. Defoliation effects on production and morphological development of little bluestem. J. Range Manage. 43:497-500.

Mullahey, J.J., S.S. Waller, and L.E. Moser. 1991. Defoliation effects on yield and bud and tiller numbers of two Sandhills grasses. J. Range

Manage. 44: 241-245.
Peet, M., R.C. Anderson, and M.S. Adams. 1975. Effect of fire on big bluestem production. Amer. Midland Natural. 94:15-24.
Ruyle, G.B., and R.W. Rice. 1991. Influence of residual bunchgrass stems on cattle grazing intensity. Abstr. Anu. Mtg. Soc. Range Manage. 44:41.
Svejcar, T., and S. Christiansen. 1986. Influence of burning on tillering and aboveground biomass partitioning in little bluestem (*Schizachyrium scoparium*). Southwest. Natural. 31: 116-118.
Towne, G., and C. Owensby. 1984. Long-term effects of annual burning at different dates in ungrazed Kansas tallgrass prairie. J. Range Manage. 37:392-397.
Vinton, M.A., and D.C. Hartnett. 1992. Effects of bison grazing on *Andropogon gerardii* and *Panicum virgatum* in burned and unburned tallgrass prairie. Oecologia 90:374-382.
Vinton, M.A., D.C. Hartnett, E.J. Finck, and J.M. Briggs. 1993. Interactive effects of fire, bison (*Bison bison*) grazing and plant community composition in tallgrass prairie. Amer. Midland Natural. 129:10-18.
Williams, D.G., and D.D. Briske. 1991. Size and ecological significance of the physiological individual in the bunchgrass *Schizachyrium scoparium*. Oikos 62:41-47.

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