Research Note

Grazing and Grazing Exclusion Effects on New Mexico Shortgrass Prairie

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Abstract

Vegetative differences and changes were evaluated over a 6-year period (1999–2004) on adjoining conservatively grazed and grazing-excluded (22 years) shortgrass rangelands in northwestern New Mexico. Autumn total perennial grass and blue grama (*Bouteloua gracilis* [Willd. ex Kunth] Lag. Griffiths) standing crop did not differ on grazed and grazing-excluded areas when data were averaged across years. There were no long-term differences in vegetation basal cover or composition between the grazed and grazing-excluded areas. Plant community similarity values between the grazed and grazing-excluded areas were 80% and 93% during the first 2 years (1999–2000) and last 2 years (2003–2004) of study, respectively. Climatic conditions had more impact on vegetation composition of the 2 areas than livestock grazing. Similarity values between 1999–2000 and 2003–2004 periods were 52% and 64% for the grazed and grazing-excluded plant communities, respectively. At the beginning of our study, blue grama productivity was depressed on the grazed area compared to the exclosure, but after 3 years of conservative winter grazing, it was similar on the 2 areas. Our study indicates there is no benefit to blue grama rangelands from long-term rest from the standpoint of vegetation composition.

Resumen

Las diferencias vegetativas y sus cambios se evaluaron por un periodo de seis años (1999–2004) en dos pastizales de zacates cortos adjuntos y ubicados en el noroeste de New Mexico, uno de ellos apacentado conservativamente y el otro excluido al apacentamiento (22 años). La biomasa total de zacates perennes y de "Blue grama" (*Bouteloua gracilis* [Willd. ex Kunth] Lag. Griffiths) en otoño, promediada a través de los años, no difirió entre las áreas apacentada y excluida. No hubo diferencias a largo plazo en términos de cobertura basal de la vegetación o su composición entre las dos áreas evaluadas. Los valores de similaridad de la comunidad vegetal entre las áreas apacentada y excluida fueron 80% y 93% durante los primeros dos años (1999–2000) y los dos últimos (2003–2004) del estudio respectivamente. Las condiciones climáticas tuvieron más impacto sobre la composición de la vegetación de las dos áreas que el apacentamiento. Los valores de similaridad entre los periodos de 1999–2000 y 2003–2004 fueron 52% y 64% para las comunidades vegetales apacentada y excluida, respectivamente. Al inicio de nuestro estudio la productividad del "Blue grama" disminuyó en el área apacentada en comparación con la excluida, pero después de tres años de apacentamiento conservativo en invierno fue similar en las dos áreas. Nuestro estudio indica que, desde el punto de vista de la composición de la vegetación, no hay beneficio para el "Blue grama" por el descanso de largo plazo.

Key Words: rangelands, cattle, drought, forage, grazing management

INTRODUCTION

Research on the impacts of controlled grazing versus long-term grazing exclusion on rangeland vegetation in the western United States is limited to 20 studies reviewed by Holechek et al. (2006). Sixteen of these studies evaluated trend, 11 evaluated productivity, and 2 evaluated responses to drought. Generally, these studies indicate that well-controlled livestock grazing has a small impact on rangeland vegetation and can be beneficial to some range plant communities. However, more information is needed on the effects of controlled livestock grazing versus grazing exclusion on rangeland vegetation to better understand the benefits of short- and long-term rest, changes in grazing timing, and changes in grazing intensities as rangeland improvement tools.

During the 6-year period from 1999 through 2004, we compared vegetation basal cover, vegetation composition, and current-year growth of perennial grasses on adjacent areas of shortgrass prairie in northwestern New Mexico with similar soils, climate, and terrain that had received either conservative winter grazing or 22 years of livestock grazing exclusion (1982–2004). In the 20-year period prior to our study, the grazed area had received continuous moderate grazing in most years based on observations from Bureau of Land Management (BLM) range conservationists. Our objectives were to evaluate trend in perennial grass current-year growth, basal cover, vegetation composition, and rangeland condition on the 2 areas.

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MATERIALS AND METHODS

Study Area Description

Our 2 study areas in northwestern New Mexico were within a shortgrass prairie pasture with a long history of moderate cattle grazing and an adjoining area with grazing exclusion since 1982. Both areas are controlled by the BLM (lat 34°630′N, long 107°797′W). They occur near Highway 117 about 57 km south and 4 km east of Grants, New Mexico. The grazed pasture is approximately 7 365 ha in size, while the grazing-excluded area contains about 200 ha. These units are in a basin on the western edge of the New Mexico North Plains. Scattered mountains occur to the east and west of our study areas. Elevation of the study areas is 2 214 m. Terrain of the study areas is flat. A well providing yearlong water for livestock and wildlife occurs 1.3 km from the grazing exclosure. Soils of both study areas are cobbly, clay loams (Aridisols) of the Vivda association (USDA–NRCS 1993). They are classified as mixed mesolithic ustollic haplargids. A basaltic restrictive layer occurs at 25–50 cm from the soil surface. Both permeability and water-holding capacity are low for this soil.

Long-term (1952–2004) average annual precipitation is near 309 mm based on NOAA (2004) data collected at Grants, New Mexico. Seasonal patterns of precipitation are characterized by small amounts in spring and a peak in late summer (August) with gradually reduced amounts during autumn. A smaller peak occurs in early winter (January). About 57% of the precipitation occurs during the growing season in June, July, August, and September.

Because of the high elevation, the frost-free period is restricted to about 140 days from late May through early October. Summer day temperatures are usually between 21° and 27°C and occasionally reach 32°C. Winter temperatures are usually between 1° and 10°C during the day and between −9° and −4°C during the night.

Vegetation is classified as shortgrass prairie and characterized by Pieper et al. (1971). The perennial shortgrass blue grama (*Bouteloua gracilis* [Willd. ex Kunth] Lag. Ex Griffiths) dominates the vegetation composition, while threeawns (*Aristida* spp.), ring muhly (*Muhlenbergia torreyi* [Kunth] Hitch.), spike muhly (*Muhlenbergia wrightii* Vasey), bottlebrush squirreltail (*Elymus elymoides* nutt.), and wolftail (*Lycurus phleoides* H.B.K.) are subordinate grasses found on both study areas. Scarlet globemallow (*Sphaeralcea coccinea* [Pursh] Rydb) and Wrights buckwheat (*Erigonum wrightii* Torr.) are dominant forbs. Rubber rabbitbrush (*Chrysothamnus nauseosus* [Pall.] Brittan) is scattered through both study sites. Important half shrubs are broom snakeweed (*Gutierrezia sarothrae* Pursh) and fringed sagewort (*Artemisia frigidia* Willd.).

Pronghorn antelope (*Antilocapra americana*) are the primary large game animal found on the study area. Although the exclosure was built to restrict cattle, it does allow access by pronghorn. A watering facility for pronghorn occurs at the west end of the exclosure. Mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) use the study pasture but were seldom seen.

A detailed grazing history of the study areas cannot be provided. We did learn from BLM range conservationists that the study pasture in most years from 1979 to 1999 received moderate continuous cattle grazing. However, a few years of drought and heavy grazing occurred in the mid-1990s. The grazing allotment came under new custodianship in 1997. A detailed forage production/grazing capacity survey was conducted on the allotment in the 1999–2001 period by Western Range Consultants owned and operated by Dee Galt and Jerry Holechek. A stocking rate of 20 ha/animal unit was applied beginning in autumn 1999. After summer rest in 1999, the study pasture received conservative grazing (35%–40% grazing use) in the mid-winter/spring period (February–April) and summer/autumn deferment from 2000 through 2004. The goal was to improve vigor of the primary forage grass, blue grama.

Vegetation Surveys

Twelve permanent transects inside and 12 transects outside the exclosure (each 50 m in length) were established in May 1999 to evaluate vegetation basal cover, vegetation composition, and perennial grass current-year growth. Four transects inside and 4 transects outside the exclosure spaced about 40 m apart were located on the north, east, and south sides of the exclosure using fence posts. The west side of the exclosure was not sampled because the area outside the exclosure was a separate pasture and part of another BLM grazing allotment. We started each transect 30 m from the fence post to avoid bias from livestock concentrating at or near the fence.

The 24 permanent transects (12 inside and 12 outside the exclosure) were used for basal cover measurements. Cover readings (50) on each transect were taken and recorded at 1-m intervals using a loop 1.91 cm in diameter. Data recorded along the 50-m transects included presence of all herbaceous plants and shrubs rooted within the loop. There were no recordings of more than 1 plant species within the loop. This resulted in recording a total of 600 observations both inside and outside the exclosure.

Aboveground current-year growth of perennial grasses was sampled every year at the end of the growing season (late October) from 1999 through 2004. Perennial grass biomass sampling was oriented along the 24 permanent transects. However, each year the transect was offset by 5 m to avoid repeat clipping of the same location. Vegetation within each of the round 0.25-m^2 quadrats was clipped at ground level at 10-m intervals along each 50-m transect. This resulted in clipping 120 quadrats (60 inside and 60 outside the exclosure). Vegetation was hand separated by species in the field, oven dried at 60°C for 72 hours, and weighed. Only current-year growth was measured.

Grazing intensity was evaluated in late May after cattle grazing in the February–April period. New growth of perennial grasses usually occurs in late June or early July. Grazing intensity was evaluated using procedures of Anderson and Currier (1973) as modified by Holechek and Galt (2000). Residual perennial grass biomass and blue grama stubble heights were measured in late May along the same 12 transects outside the exclosure with the same procedures used to determine autumn perennial grass biomass. However, only 2 quadrats were clipped per transect at 15 and 35 m from the transect beginning. Each year, the transect was offset by 5 m to avoid repeat clipping. Annual percent forage use was calculated by dividing the May standing crop by October standing crop from the previous autumn. This number was then subtracted from 1 and multiplied by 100 to obtain percent use. Stubble heights of the nearest blue grama plant were collected along each transect at 10-m intervals on the opposite of each transect used for autumn biomass evaluation. A total of 60 blue grama plants were measured for stubble height each year.

In October 2000, the percentages of live and dead perennial grasses were evaluated on all transects. The procedure involved recording the nearest perennial grass plant to the sampling point at 5-m intervals along transects as live or dead based on the presence or absence of live aboveground biomass. Dead plants were characterized by all blackish aboveground biomass, while presence of green or yellow aboveground biomass characterized living plants.

Rangeland ecological condition scores were calculated from current USDA Natural Resource Conservation Service (NRCS) site guides for New Mexico using the Dyksterhuis (1949) procedure. Relative percent composition was used to calculate rangeland ecological condition scores for the 1999–2000 and the 2003–2004 periods both inside and outside the exclosure.

Statistical Analyses

A randomized factorial analysis of variance was used to compare autumn current-year perennial grass and blue grama standing crop across grazing treatments (2) with years as replications (6) (Steel and Torrie 1980). Individual transects inside (12) and outside (12) the exclosure were considered to be subsamples and were not used as replications or pseudoreplications. A randomized factorial analysis of variance was also used to compare average autumn basal cover, relative plant composition based on cover, and rangeland ecological condition scores between grazing treatments (2) and periods (2) with years (2) as replications.

Similarity of the plant communities on conservatively grazed and grazing-excluded areas was evaluated using Kulcyznski's formula discussed by Oosting (1956). The practical application of this formula in comparing plant composition data is demonstrated in detail by Holechek et al. (1984). This same approach was used to evaluate vegetation composition change on each area between the 1999–2000 and 2003–2004 periods. Kulcyznski's formula has been widely used for quantitative evaluation of similarity and overlap of plant communities. This formula provides a direct measure of common proportionality. The general formula is S = (2) (W) (100) divided by (A + B). The similarity in plant communities is S, W represents the sum of the quantity of each plant species that 2 communities have in common, A represents the total quantity of all species in plant community a, and B represents the total quantity of all species in plant community b.

RESULTS

Total standing crop of current-year perennial grass growth did not differ ($P > 0.05$) between grazing treatments (Table 1). Across years, blue grama accounted for 69% and 74% of perennial grass standing crop on conservatively grazed and grazing-excluded areas, respectively (Table 1). Blue grama standing crop did not differ ($P > 0.05$) between conservatively grazed and grazing-excluded areas (Table 1).

Extreme drought in summer 2000 caused mortality of blue grama, threeawn, and bottlebrush squirreltail. In October 2000, we observed only 57% of the blue grama, 33% of the threeawn, and 24% of the bottlebrush squirreltail plants had growth. There was no difference ($P > 0.05$) between areas outside and inside the exclosure in percentage of plants showing growth (51% vs. 49% of plants inside the exclosure showed growth).

Table 1. Autumn blue grama and total perennial grass standing crop of current-year growth (kg$\cdot$ha^{-1}) on conservatively grazed and grazing-excluded shortgrass rangeland in north-central New Mexico in 1999–2004.

	Blue grama standing crop of current-year growth		Total perennial grass standing crop of current-year growth	
Year	Conservatively grazed	Grazing excluded	Conservatively grazed	Grazing excluded
1999	51	121	176	246
2000	29	49	60	82
2001	101	193	183	280
2002	168	143	193	148
2003	155	121	181	143
2004	157	186	170	192
Mean	110	136	160	182
SEM	24	21	20	30

Basal cover of total vegetation, perennial grasses, forbs, and shrubs was similar ($P > 0.05$) between conservatively grazed and grazing-excluded treatments in both sampling periods (Table 2). However, blue grama increased ($P < 0.05$), while bottlebrush squirreltail and threeawns declined ($P < 0.05$) in the vegetation cover and composition during the last 2 years compared to the first 2 years of study (Table 2). Rubber rabbitbrush and total shrubs increased ($P < 0.05$) in basal cover and composition during the period of study (Table 2).

Vegetation composition similarity (Table 2) between grazed and grazing-excluded areas was 80% and 93% in the 1999–2000 and 2003–2004 periods, respectively. These values reflect little vegetation composition difference between the 2 areas either at the beginning or at the end of our study period. In contrast, similarity values between the 1999–2000 and 2003–2004 periods were 52% for the grazed plant community and 64% for the grazing-excluded plant community (Table 2).

Rangeland ecological condition scores, based on the USDA–NRCS method and current New Mexico range site guides, were similar ($P > 0.05$) on conservatively grazed and grazing-excluded areas in both periods of study (Table 2). However, ecological condition on both areas declined ($P < 0.05$) when the last and first 2 years of study were compared. This reduction was caused by a shift toward more blue grama and rubber rabbitbrush and away from other perennial grasses and forbs.

Forage utilization on the grazed transects during our 6-year study period averaged 38% (SEM = 4) or conservative. Stubble heights on blue grama in all years were between 5.0 and 6.5 cm, which generally correspond to conservative grazing (Holechek and Galt 2000).

DISCUSSION

Our data are consistent with a well-replicated 55-year study from blue grama shortgrass prairie rangeland in Colorado that showed small differences between areas with light to moderate cattle grazing and grazing exclusion (Hart and Ashby 1998). In this study, prickly pear cactus (*Opuntia polyacantha* Haw.), slender buckwheat (*Eriogonum microthecum* Nutt.), and broom snakeweed were higher under grazing exclusion than

Table 2. Means and standard errors of autumn vegetation basal cover (%), relative composition (%), and rangeland ecological condition scores on conservatively grazed and grazing-excluded shortgrass prairie rangeland in north-central New Mexico for the 1999–2000 and 2003–2004 periods.

	Relative basal vegetation composition[1]			
	Conservatively grazed[2]		Grazing exclosure[2]	
Species or group	1999–2000	2003–2004	1999–2000	2003–2004
Blue grama	38 ± 4c[3]	77 ± 6a	52 ± 4b	80 ± 5a
Threeawns	15 ± 3a	6 ± 2b	7 ± 2b	1c
Bottlebrush squirreltail	26 ± 6a	1b	22 ± 3a	tb
Ring muhly	4 ± 2a	3 ± 1a	6 ± 1a	3 ± 2a
Spike muhly	3 ± 2	t	t	t
Wolftail	t	2	t	0
Total grasses	86 ± 2a	88 ± 2a	87 ± 3a	84 ± 4a
Wrights buckwheat	2 ± 1	1	t	2 ± 1
Scarlet globemallow	1	t	t	t
Pingue	4 ± 1a	tb	4 ± 1a	tb
Total forbs	7 ± 2a	1b	4 ± 1ab	2 ± 1b
Broom snakeweed	1	2 ± 1	1	3 ± 1
Fringed sagewort	6 ± 1a	2 ± 1b	6 ± 2a	2 ± 1b
Rubber rabbitbrush	tb	7 ± 1a	2 ± 1b	9 ± 2a
Total shrubs	7 ± 1b	11 ± 2ab	9 ± 3b	14 ± 3a
Rangeland ecological condition score	51 ± 3a	38 ± 3b	47 ± 4a	33 ± 3b
	Vegetation basal cover[1]			
Total vegetation cover	56 ± 3a	54 ± 2a	56 ± 3a	52 ± 3a

[1]Data were pooled across the first 2 years and last 2 years of study for trend comparisons; t = trace.
[2]Number of observations for each period = 2; years were used as observations.
[3]Means within rows with different letters differ ($P < 0.05$).

grazing. This was not considered advantageous because these plants have low forage value to livestock and some wildlife species. Light and moderate grazing reduced cool-season graminoids but increased warm-season graminoids compared to exclusion.

Pingue (*Hymenoxys richardsoni* Hook), broom snakeweed, and rubber rabbitbrush, the primary poisonous/unpalatable plants found on the study area, had similar cover and composition on conservatively grazed and grazing-excluded areas in both the 1999–2000 and the 2003–2004 period (Table 2). These data are consistent with various studies reviewed by Holechek (2002) that show unpalatable and poisonous plants are not increased by livestock grazing at light to moderate intensities.

Rubber rabbitbrush cover increased on both conservatively grazed and grazing-excluded areas during the period of study (Table 2). Under drought conditions, deeper-rooted shrubs can better compete with shallow-rooted grasses because their long roots give better access to moisture stored deep in the soil profile (Molinar et al. 2002).

Climatic conditions had much more influence on our 2 study areas than whether controlled livestock grazing occurred. During our 6-year study, total yearlong and growing-season precipitation at Grants averaged 73% and 67% of the long-term mean, respectively, indicating conditions of drought on our study areas. All years except 1999 had below-average total and growing-season precipitation. Extreme drought occurred in 2000, when growing-season precipitation was only 22% of normal. Drought conditions during our study favored blue grama and rubber rabbitbrush but depressed other perennial grasses, forbs, and fringed sagewort.

During the first 3 years of our study, blue grama standing crop under grazing exclusion (121 $kg \cdot ha^{-1}$) was nearly double that under grazing (61 $kg \cdot ha^{-1}$), but during the last 3 years of the study, little difference occurred between grazing-excluded (150 $kg \cdot ha^{-1}$) and grazed areas (160 $kg \cdot ha^{-1}$). Based on observations of BLM range conservationists, heavy grazing in the 2 years prior to our study reduced blue grama productivity outside the exclosure. However, summer rest and conservative grazing in the 1999–2004 period restored blue grama productivity. Only 3 years were needed for blue grama production on the grazed area to equal that inside the exclosure. Klipple and Bement (1961) found that 2–4 years of light grazing could be an effective tool to increase productivity of heavily grazed blue grama rangelands.

MANAGEMENT IMPLICATIONS

Our 6-year study (1999–2004) showed little difference in perennial grass standing crop, total vegetation cover, vegetation composition, or rangeland ecological condition between adjacent areas receiving conservative winter grazing and long-term (22-year) grazing exclusion. Vegetation composition based on basal cover was similar between the grazed and grazing-excluded area at both the beginning and the end of our study period. At the beginning of our study, perennial grass productivity (primarily blue grama) was depressed on the grazed area compared to the exclosure. However, after 3 consecutive years of conservative winter grazing, perennial grass production equaled that on the grazing-excluded area. On the other hand, our study indicates no benefit to blue grama rangelands from long-term rest in terms of either vegetation composition or productivity. Our findings are most applicable to shortgrass prairie rangelands and may not apply well to other range types such as the Chihuahuan Desert, cold desert, coniferous forest, or tall grass prairie with different climatic patterns and perennial grasses that have lower grazing resistance than blue grama.

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