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Short-Term Effects of Cattle Exclusion on Riparian Vegetation in Southeastern Kansas

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Effects of cattle exclusion on the structure and composition of riparian vegetation were observed in a 2-yr study in southeastern Kansas. The study was conducted within riparian habitats on the 5,263-ha Kansas Army Ammunition Plant in north-central Labette County, Kansas. Three grazed and three ungrazed riparian areas were sampled in 1996 and 1997 to monitor vegetation changes in response to livestock exclusion. Total understory, grass, and litter cover were significantly different between the grazed and ungrazed study sites with mean cover estimates being higher (16.3%, 14%, and 12.1% greater respectively) in the ungrazed sites. A significant difference in the percentage of bare ground was observed between the grazed (24.6%) and ungrazed (12.5%) study sites. No difference in herbaceous vegetation height was detected between study sites in 1996. In 1997, mean herbaceous vegetation height differed significantly from 1996 (study sites combined) and was greater (95.6 cm vs. 65.6 cm) in the ungrazed study sites. Excluding cattle from closed canopy riparian woodlands in southeastern Kansas resulted in a positive short-term response of understory herbaceous vegetation. Our results suggest that riparian fencing may be an effective management tool for restoring understory vegetation in riparian communities grazed by cattle in the eastern Great Plains.

INTRODUCTION

One of the most controversial land management issues facing many natural resource management agencies is cattle grazing in riparian areas. Riparian areas constitute some of the most productive and diverse natural communities (Kauffman and Krueger, 1984; Hunt, 1985). Kauffman, Krueger, and Vavra (1984) identified 60 distinct vegetation communities in a single riparian area in northeastern Oregon. Riparian areas generally are higher in species diversity and plant productivity than adjacent uplands, providing greater opportunity for space utilization by wildlife (Kauffman and Krueger, 1984). These and other unique factors associated with riparian areas make them vitally important to many species of wildlife (Ames, 1977; Kauffman and Krueger, 1984; Schulz and Leininger, 1990; Sedgwick and Knopf, 1991).

The same attributes that attract wildlife to riparian habitats also attract cattle. These attributes include the availability of water, thermal cover, and high-quality forages (Ames, 1977; Behnke and Raleigh, 1977; Schulz and Leininger, 1990). Cattle grazing in riparian habitats can negatively alter the structure, composition, and productivity of vegetation (Knopf and Cannon, 1982; Green and Kauffman, 1995), but riparian communities can recover quickly when cattle are excluded. Two years after cattle exclusion, herbaceous vegetation cover and height were greater in exclosures than in adjacent grazed areas in a Pennsylvanian riparian habitat (Hafner and Brittingham, 1993). Winegar (1977) reported an increase in plant species richness, from 17 to 45 species, nine years after cattle were excluded from a riparian area in Oregon.

Pressure from the public to better manage riparian habitats has prompted many natural resource management agencies to recommend fencing to eliminate or control cattle grazing in riparian habitats (Platts and Wagstaff, 1984). These recommendations generally are justified on the basis that cattle exclusion will reduce soil erosion, improve water quality, and improve overall habitat conditions by restoring the riparian plant community (Platts and Wagstaff, 1984). Research providing the basis for such recommendations has been conducted mainly in riparian habitats in the western U.S. Riparian systems of the eastern Great Plains differ from those in the West with eastern forest vegetation competing primarily for space and light while vegetation of western riparian habitats compete primarily for soil moisture (Krueper, 1993). Research evaluating the use of fencing to improve riparian habitats is lacking in the eastern Great Plains. The objective of this study was to evaluate how short-term cattle exclusion affects the floral structure and composition of closed canopy riparian woodlands in southeastern Kansas.

Methods and Materials

Study area. The study was conducted within riparian habitats on the 5,263-ha Kansas Army Ammunition Plant (KSAAP) in north-central Labette County, Kansas. Historically, the KSAAP was dominated by native bluestem (*Andropogon* spp.) prairies (Eifler, Busby, and Freeman, 1995). Since the 1940s, much of the native prairie vegetation has been converted to winter

Table 1. Mean percent slope and width of riparian study sites on KSAAP, Labette County, Kansas.

	Grazed		Ungrazed		
Habitat variable	$\bar{x}$	SE	$\bar{x}$	SE	P
Slope (%)	1.83	0.47	2.45	0.55	0.389
Riparian width (m)	124.5	8.1	122.0	6.9	0.815

wheat, grain sorghum, soybeans, and cool-season pastures. Pastures are dominated by tall fescue (*Festuca arundinacea* Schreb.) and grazed by cattle April through November with stocking rates averaging 1.6 ha/animal unit. Grazing allotments on the KSAAP average 32.4 ha. Prior to Euro-American settlement, riparian habitats on the KSAAP consisted of extensive deciduous forests along stream valleys (Eifler, Busby, and Freeman 1995). Today, because of land use changes, much of the riparian habitat is restricted to narrow bands of deciduous forest.

Floodplain soils on the KSAAP are classified as Verdigris silt loam and are moderately well drained (USDA, 1990). Mean daily temperatures for April, May, June, July, and August are 15.1, 19.9, 24.5, 27.2, and 26.7°C, with a mean precipitation of 9.9, 13.2, 11.9, 9.7, and 8.0 cm for the respective months (USDA, 1990).

No attempt was made to manage the riparian habitats on the KSAAP separate from the surrounding uplands prior to the late 1970's. Since that time, several riparian exclosures have been constructed to eliminate cattle grazing from the riparian habitats, but most of the exclosures deteriorated or gates were left open, resulting in continued grazing at unregulated intensities (A. E. Hynek, Dept. of Army, pers. obser.). In March 1996, fences around three exclosures (ungrazed), 5.7 ha, 9.2 ha, and 11.2 ha in size, were repaired and gates locked, permanently excluding cattle. Three grazed study sites, 8.1 ha, 6.5 ha, and 11.8 ha in size, were paired with the three ungrazed study sites. Overstory canopy cover, mean dbh of overstory trees, mean tree density, and mean stream length were similar among all the riparian study sites. A detailed description of overstory canopy cover and composition was presented by Hoover (1997). The three grazed sites were located adjacent and directly downstream from the ungrazed study sites. Mean riparian habitat width and percent slopes were similar between the paired grazed and ungrazed study sites (Table 1).

Vegetation surveys. Vegetation surveys were conducted twice annually, 3–12 June and 12–16 August 1996 and 1997. Eight 30-m permanent line-transects were located randomly in each of the grazed and ungrazed study sites in June of 1996. Transects started at the streambank edge and extended perpendicular to it. In instances where the fence was less than 30 m from the streambank edge, transects were terminated at the fence. Percent slope at each transect was determined using a clinometer. Riparian habitat width and stream length were estimated from 1 in = 400 ft scale county ownership maps.

Circular sampling plots, 2 m^2 in size, were used to estimate herbaceous and shrub canopy cover along the transects. Sampling plots were centered 1 m to the right of the transects and placed at 5, 10, 15, 20, and 25 m from the streambank. Canopy cover values were estimated visually and assigned to 1 of 6 coverage categories described by Daubenmire (1959). Canopy cover was determined in an overlapping manner, thus some estimates of total canopy cover exceeded 100%. Eight transects were sampled in each of the grazed and ungrazed study sites for a total of 24 in the grazed areas (118 plots) and 24 in the ungrazed areas (115 plots) in both 1996 and 1997. Canopy cover estimates were recorded for all plant species present and for the following cover classes: forbs, grasses, shrubs, litter, and bare ground. Sedges were included with the grasses for cover class estimates and were grouped and recorded as *Carex* spp. for the species cover estimates. Maximum height of herbaceous and shrub vegetation at the center of each sampling plot was measured to the nearest centimeter using a visual obstruction pole (Robel and others, 1970) modified to record heights in centimeter. Readings were taken from a distance of 4 m and a height of 1 m. Species cover estimates were summed for each sampling plot and used as a measurement of total vegetation cover. The June cover class data and height estimates were used for statistical comparisons to test cumulative effects of grazing between years. Because the June cover measurements were taken during a time of peak vegetative production, we believe they provided a better and more meaningful measurement of cover than data collected in August. In order to obtain a comprehensive species list, the species cover data collected in June and August were combined and used in the analysis. Voucher specimens for all herbaceous species recorded were collected and identified by key and compared with herbarium specimens. Scientific names of plant species follow the Great Plains Flora Association (1986).

Statistical analysis. The placement of grazed and ungrazed study sites constituted a randomized complete block experimental design and differences in means for overstory canopy cover, dbh, tree density, riparian width, and slope between grazed and ungrazed study sites were tested using a 1-way analysis of variance (ANOVA) mixed effects model (SAS Inst. Inc., 1996). Differences in means for total cover, all vegetation cover classes, maximum herbaceous and shrub height, and species cover estimates were tested between grazed and ungrazed study sites and for year by treatment interactions using a 2-way mixed effects repeated measures ANOVA (SAS Inst. Inc., 1996) with year as the repeated measure. A compound symmetric covariance structure was used to model the error covariances with respect

Table 2. Mean percent cover of microhabitat variables in grazed and ungrazed riparian study sites on KSAAP, Labette County, Kans.

Variable	Year	Grazed		Ungrazed		P
		$\bar{x}$	SE	$\bar{x}$	SE	
Total cover	1996	64.0	3.1	80.3	3.5	
	1997	60.1	2.2	76.4	3.0	
	Combined	62.1	1.9	78.4	2.3	0.0001
Forb	1996	14.9	2.2	26.3	3.6	
	1997[1]	33.9	2.8	35.1	3.3	
	Combined	24.4	2.2	30.7	2.5	0.120
Grass	1996	26.1	2.8	34.1	3.8	
	1997[1]	42.5	3.3	62.5	3.8	
	Combined	34.3	2.4	48.3	3.4	0.056
Shrub	1996	18.8	3.9	19.1	2.8	
	1997	22.2	3.0	15.6	2.2	
	Combined	20.5	2.4	17.3	1.8	0.618
Litter	1996	76.3	3.5	85.4	2.6	
	1997	74.4	2.6	89.5	1.5	
	Combined	75.3	2.1	87.4	1.5	0.005
Bare ground	1996	23.6	2.5	14.5	2.6	
	1997	25.5	2.6	10.5	1.5	
	Combined	24.6	2.1	12.5	1.5	0.005

[1] Significantly different ($P < 0.10$) from 1996.

to years before testing. Selection of the covariance structure was done using Akaike's information criterion (SAS Inst. Inc., 1996). Plant species comparisons between the grazed and ungrazed study sites were made only for those species recorded during both years and with a canopy cover greater than 1.0%. An alpha level of 0.10, established *a priori*, was used to determine statistical significance.

Results

Precipitation varied greatly during the two years of the study. The fall of 1995 and spring of 1996 were characterized by dry conditions. October through May 1995 to 1996 precipitation was 50% below the 30-yr average. However, rainfall increased markedly during the summer of 1996. July through September 1996 precipitation was 48% above the 30-yr average. Precipitation during the fall and spring of 1996 and 1997 returned to near normal, 9% below the 30-yr average, a 40% increase from the previous year. Rainfall continued through the summer of 1997 with May through August precipitation increasing to 34% above the 30-year average.

Total understory vegetation cover differed between the grazed (62.1%) and ungrazed (78.4%) study sites (Table 2). Grass canopy cover differed

Table 3. Mean herbaceous and shrub vegetation height (cm) in grazed and ungrazed study sites on KSAAP, Labette County, Kans.

Variable	Year	Grazed $\bar{x}$	Grazed SE	Ungrazed $\bar{x}$	Ungrazed SE	P
Herbaceous height	1996	45.3[a2]	2.6	54.0[a]	2.4	
	1997[1]	65.6[b]	2.3	95.6[c]	3.0	
	Combined	55.5	2.3	74.8	3.6	0.001
Shrub height	1996	77.9	4.4	77.8	5.2	
	1997	76.0	3.9	75.7	3.9	
	Combined	77.0	2.9	76.8	3.2	0.962

[1] Significantly different ($P < 0.10$) from 1996.
[2] Means with the same lower case letters are not significantly different at $P < 0.10$.

between years (study sites combined) and between sites (years combined) with grass canopy cover values being greater in the ungrazed study sites in 1997. Litter cover also differed between study sites with the ungrazed study sites having greater mean values whereas percent bare ground was higher in the grazed study sites (Table 2). Although forb cover did not differ statistically between study sites, an increase (study sites combined) was noted from 1996 to 1997 (Table 2). Shrub cover did not differ between the grazed and ungrazed study sites (Table 2). The understory shrub canopy of both the grazed and ungrazed study sites was composed primarily of buckbrush (*Symphocarpus orbiculatus* Moench.) and rough-leaf dogwood (*Cornus drummondii* C.A. Mey.) (Hoover, 1997).

Shrub height was similar between the grazed and ungrazed study sites (Table 3). Herbaceous vegetation height increased (study sites combined) from 1996 to 1997 and was higher (years combined) in the ungrazed study sites, however, there was a significant year by treatment interaction. Increased rainfall in 1997 combined with the exclusion of cattle was the likely cause for the disproportional increase in herbaceous vegetation height in the ungrazed compared to the grazed study sites.

Species richness estimates were not tested statistically, but were similar between the grazed and ungrazed study sites with 85 species recorded in the grazed and 80 species in the ungrazed sites. A total of 93 plant species were recorded in the understory. Annual herbs comprised 25.8% and 28.7% of the species recorded in the grazed and ungrazed study sites, respectively (Hoover, 1997). During both years of the study, only 16 species had canopy cover estimates ≥1% (Table 4). Sedges (*Carex* spp.), marsh muhly (*Muhlenbergia racemosa* Michx.), tall fescue and Virginia wild rye (*Elymus virginicus* L.) were the most abundant graminoid species. Wingstem (*Verbesina alternifolia* L.), smooth yellow violet (*Viola pubescens* Ait.), ragweed (*Ambrosia* spp.), white avens (*Geum canadense* Jacq.), and white snakeroot (*Eu-*

Table 4. Mean cover for species with >1.0 percent canopy coverage in grazed and ungrazed riparian study sites on KSAAP, Labette, County, Kans.

Species	Year	Grazed		Ungrazed		P
		$\bar{x}$	SE	$\bar{x}$	SE	
White snakeroot	1996	0.80	0.29	1.91	0.58	
Eupatorium rugosum Hout.	1997	0.62	0.18	1.54	0.38	
	Combined	0.72	0.12	1.72	0.27	0.158
Sedges	1996	14.1	2.16	12.0	1.55	
Carex spp.	1997	10.4	1.44	14.7	2.18	
	Combined	12.2	0.88	13.7	0.89	0.726
Rough-leaved dogwood	1996	0.95	0.30	1.40	0.53	
Cornus drummondii C. A. Mey	1997	1.13	0.35	0.47	0.23	
	Combined	1.04	0.22	0.98	0.25	0.772
Catchweed bedstraw	1996	0.43	0.14	0.33	0.11	
Galium aparine L.	1997[1]	0.46	0.12	1.76	0.44	
	Combined	0.45	0.06	1.08	0.16	0.163
White avens	1996	1.13	0.18	2.33	0.54	
Geum canadense Jacq.	1997	0.64	0.14	1.21	0.70	
	Combined	0.89	0.09	1.84	0.43	0.261
Heartleaf avens	1996	0.81	0.14	1.35	0.35	
Geum vernum (Raf) T&G.	1997	0.86	0.16	1.09	0.29	
	Combined	0.84	0.07	1.27	0.17	0.321
Marsh muhly	1996	6.18	1.18	13.0	3.51	
Muhlenbergia racemosa	1979	6.44	1.39	2.86	0.89	
(Michx.) B. S. P.	**Combined**	6.29	0.64	7.53	1.06	0.604
Yellow wood sorrel	1996	1.68	0.38	1.15	0.43	
Oxalis stricta L	1997[1]	0.74	0.13	0.33	0.09	
	Combined	1.18	0.15	0.74	0.15	0.285
Virginia creeper	1996	1.20	0.35	0.97	0.49	
Parthenocissus quinquefolia	1997	1.40	0.41	1.27	0.15	
(L.) Pall.	**Combined**	1.33	0.17	1.16	0.19	0.572
Common ragweed	1996	3.36	1.39	3.09	0.74	
Ambrosia artemisiifolia L.	1997[1]	—	—	0.02	0.02	
	Combined	1.72	0.50	1.50	0.30	0.863
Buckbrush	1996	17.2	4.03	16.9	2.96	
Symphoricarpos	1997	13.3	2.95	8.80	2.07	
orbiculatus Moench	**Combined**	15.3	1.48	13.3	1.22	0.695
Wingstem	1996	3.70	0.97	11.3	3.15	
Verbesina alternifolia (L)	1997	1.85	0.78	7.25	2.04	
Britt.	**Combined**	2.84	0.47	9.70	1.19	0.099
Smooth yellow violet	1996	1.16	0.19	2.28	0.46	
Viola pubescens Ait.	1997	1.73	0.30	1.36	0.29	
	Combined	1.68	0.14	1.89	0.21	0.758
Virginia wild rye	1996	1.52[a2]	0.77	1.55[a]	0.64	
Elymus virginicus L	1997	0.44[a]	0.10	6.27[b]	1.60	
	Combined	1.00	0.33	4.00	0.57	0.081
Tall fescue	1996	1.47	1.05	2.65	1.75	
Festuca arundinacea	1997[1]	5.89	2.90	16.0	4.95	
Schreb.	**Combined**	3.52	0.87	8.25	1.42	0.145

Table 4. Continued.

Species	Year	Grazed $\bar{x}$	Grazed SE	Ungrazed $\bar{x}$	Ungrazed SE	P
Poison ivy	1996	0.51	0.16	1.10	0.41	
Toxicodendron radicans	1997	0.42	0.10	0.90	0.28	
(L) O. Ktze.	**Combined**	0.47	0.08	1.04	0.18	0.118

[1] Significantly different (P < 0.10) from 1996.
[2] Means with the same lower case letters are not significantly different at P < 0.10.

patorium rugosum Houtt.) dominated the forb canopy in both the grazed and ungrazed study sites (Table 4).

Wingstem was more abundant on the ungrazed study sites, although it declined on both the grazed and ungrazed study sites between 1996 and 1997 (Table 4). Virginia wild rye was more abundant on the ungrazed study sites, however, there was a significant year by treatment interaction. Cover of Virginia wild rye decreased from 1996 to 1997 on the grazed study sites and increased on the ungrazed sites during this same time. Canopy cover of tall fescue increased between years (study sites combined) and was more abundant in the ungrazed study sites overall (years combined); however, this difference was not statistically significant (Table 4).

Sedges, heartleaf avens (*Geum vernum* Raf.), Virginia creeper (*Parthenocissus quinquefolia* L.), poison ivy (*Toxicodendron radicans* L.), smooth yellow violet, and white snakeroot all appeared to be unaffected by the elimination of cattle grazing (Table 4). No difference in the cover of marsh muhly was detected between study sites, although cover declined markedly between years on the ungrazed sites (Table 4).

Discussion and Conclusions

Within two years, riparian vegetation changed markedly on sites protected from cattle grazing. Measurements of grass cover, total herbaceous cover, litter cover, and vegetation height were greater in the ungrazed study sites whereas percent bare ground was greater in the grazed study sites. Other researchers have reported similar findings. Schulz and Leininger (1990) reported an increase in total vegetation, grass, and litter cover in ungrazed areas and higher levels of bare ground in grazed areas along a riparian zone in north-central Colorado. Boldt, Uresk, and Severson (1978), Szaro and Pase (1983), and Hafner and Brittingham (1993) reported greater amounts of herbaceous cover in ungrazed riparian areas when compared to grazed areas. Popolizio, Goetz, and Chapman (1994) also reported a significant increase in grass and litter cover in recently protected (1-2 years) riparian zones in Colorado.

We detected no significant difference in shrub cover between grazed and ungrazed study sites. Marcuson (1977) and Schulz and Leininger (1990) reported a significant increase in shrub cover in riparian areas protected from cattle grazing. However, these studies were conducted in riparian areas in arid regions of the United States and had been protected from grazing for longer than two years.

Hayes (1978) and Medin and Clary (1990) reported higher species richness values in grazed riparian areas. Although not tested, species richness was slightly higher in the grazed study areas. The increase in habitat disturbance caused by the presence of cattle may be the cause for the higher species richness values in the grazed areas. Nilsson and others (1989) determined that species richness increased with substrate heterogeneity in a riparian habitat in northern Sweden. Clary (1999) also documented an increase in species richness in moderately grazed riparian areas compared to lightly grazed and ungrazed treatments in a central Idaho riparian system.

Species cover estimates were highly variable between years and study sites. Virginia wild rye seemed to benefit from cattle exclusion. Virginia wild rye canopy cover was virtually the same in both the grazed and ungrazed study sites in 1996, however, it increased markedly in the ungrazed sites and declined by 60% in the grazed sites in 1997. Tall fescue also seemed to benefit from cattle exclusion. From 1996 to 1997, tall fescue increased in cover on both the grazed and ungrazed study sites, but the increase was higher on the ungrazed sites. Marsh muhly, a warm season grass, declined in cover from 1996 to 1997 on both grazed and ungrazed study sites. Competition with taller grasses, such as Virginia wild rye and tall fescue for space and sunlight, intensified by the elimination of cattle grazing, was a likely factor contributing to the changes in canopy cover of marsh muhly.

It is important to note that the substantial variation in precipitation that occurred on the study sites during the two years of this study may have contributed significantly to the high degree of variability recorded in herbaceous canopy cover estimates. Rotenberry and Wiens (1980), working in shrubsteppe habitat, noted that structural changes in habitat accompanied yearly variations in precipitation, with forb cover, total vegetation cover, and maximum vegetation height increasing in a year with above average precipitation.

Healthy riparian habitats provide multiple benefits to wildlife and people. Riparian corridors have the potential to buffer deleterious effects of adjacent land management practices by filtering and slowing overland runoff and reducing streambank erosion, thus helping to improve water quality. Riparian fencing has been shown to be an effective management tool for improving or reestablishing riparian vegetation in studies conducted primarily in arid shrub dominated riparian communities. Our results suggest that riparian fencing may be an effective management tool for restoring understory vegetation in riparian communities grazed by cattle in the eastern Great Plains. Longer term research is needed, however, to determine the full impact of cattle exclusion on closed canopy riparian woodlands, especially on the shrub and overstory canopy layers.

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