Vegetational Traits of Patch-grazed Rangeland in West-central Kansas

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Abstract

Indices of vegetation abundance, composition, and grazing were monitored for the grazing seasons of 1980–81 at Hays, Kans., in 2 pastures. One pasture was moderately grazed with yearling steers season-long, while the other was triple-stocked for only the first half of the season. Some areas were grazed repeatedly throughout the grazing seasons, resulting in overgrazed patches, which increased in number as seasons progressed. By the end of each grazing period, more than 70% of each pasture was grazed, but only 23–56% of the areas consisted of overgrazed patches depending on the year and treatment. Grazing treatment also influenced whether the locations of patches remained the same from year to year. Species composition of overgrazed patches was different from the surrounding vegetation, but soil properties were not.

Free-ranging herbivores selectively graze rangeland because of differences in soil, vegetation, or topography, resulting in a diet with a floristic and nutritive composition unlike that of the range average (Bedell 1971, Arnold and Dudzinski 1978, Kiley-Worthington 1977, Stoddart et al. 1975. Stobbs 1973, Wallace et al. 1972, Galt et al. 1969, Cook and Harris 1968, Cook 1959, Cook et al. 1956). At the beginning of the grazing season, some areas are grazed lightly to moderately, while others are ignored (Weaver and Tomanek 1951). This results in differentially grazed patches. Because grazing animals prefer fresh growth more than mature forage (Arnold and Dudzinski 1978, Heady 1975, Stobbs 1973, Van Dyne and Heady 1965, Dwyer 1961, Reppert 1960, Cook et al. 1956, Cook et al. 1953), previously grazed patches are repeatedly grazed. As the grazing season progresses, vegetation of such patches is eventually "over utilized" while the remainder of the range becomes "rank" with accumulation of mature growth (Moorefield and Hopkins 1951). Stoddart et al. (1975) referred to this as "spot overgrazing." Launchbaugh and Owensby (1978) stated that properly stocked pastures are grazed in "small to large patches."

Although the phenomenon of patch-grazing is generally recognized, it has not been described quantitatively. The purpose of this study was to characterize patch-grazing by: (1) estimating the areal proportion of the range consisting of patches; (2) monitoring changes in size, number, and location of patches both seasonally and annually; (3) describing possible differences in vegetational and edaphic traits of patches.

Study Area

This research was conducted in native mixed-grass prairie at Hays, Kans. The range, described by Launchbaugh (1957), is dominated by 2 warm-season grasses, blue grama [*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.][1] and buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.]. The remainder of the vegetation consists predominately of 2 cool-season grasses, western wheatgrass (*Agro-*

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Table 1. Percent floristic composition of the season-long stocked (SLS) pasture and intensive-early stocked (IES) pasture.

	SLS							IES					
	1980	1981						1980	1981				
	19 Oct	1 May	6 June	8 July	18 Aug	1 Oct	mean	11 Oct	2 May	19 May	10 June	30 June	mean
blue grama[1]	32.6	30.7	38.2	39.6	42.4	46.4	38.3	45.0	49.9	47.9	44.6	50.2	47.5
buffalograss	35.3	25.7	29.5	31.7	36.3	33.5	32.0	31.5	30.1	31.5	37.4	35.3	33.2
western wheatgrass[1]	14.7	20.3	11.8	12.9	11.8	10.8	13.7	12.6	6.7	8.9	7.0	6.9	8.4
Japanese brome	14.2	19.7	12.1	8.8	5.7	4.1	10.8	6.5	6.5	4.5	3.4	2.7	4.7
sedges	0.7	2.0	3.0	3.9	1.6	2.2	2.2	2.1	2.2	3.3	4.6	3.5	3.1
red three-awn	1.0	0.7	1.2	0.7	1.3	1.3	1.0	0.9	2.5	1.6	1.6	0.8	1.5
other species	1.5	0.9	4.2	2.4	0.9	1.7	2.0	1.4	2.2	2.3	1.4	0.6	1.6

[1]Under H_o: IES-SLS=0, p=0.0285

pyron smithii Rydb.) and Japanese brome (*Bromus japonicus* Thunb.), and several miscellaneous grasses and forbs. Except for occasional shallow, poorly drained depressions, the topography is nearly flat to gently sloping. Soils are deep, well-drained silt-loams (Harney series: fine, montmorillonitic, mesic, Typic Argiustolls) formed from calcareous, medium-textured loess (Glover et al. 1975). The climate, although highly variable, is characterized by generally moist, cool springs; hot, often dry summers; mild autumns; and mild to cold winters. Yearly average precipitation is 57.7 cm (22.7 in.) with most of it received in spring and early summer. Extremes in weather frequently occur, thus greatly altering the growing season. The summer of 1980 was hotter and drier than average, and the beginning of spring 1981 was earlier than average. In general, there was adequate soil water for plant growth each spring and early summer, followed by mid-summer drought.

The research area consisted of two 12.65-ha (31.25-acre) pastures with contrasting treatments of grazing by yearling steers (stocked 1 May 1980 and 15 April 1981). One treatment was season-long stocked (SLS) at the normal, moderate rate of 1.42 ha (3.50 acres) per head for approximately 150 days. The other treatment was intensive-early stocking (IES) similar to treatments described by Owensby and Smith (1975). Grazing was the first 75 days only, at 3 times the normal rate [0.47 ha (1.17 acres) per head].

Materials and Methods

Data were collected during the grazing seasons of 1980 and 1981 using several methods to quantify patch-grazing characteristics. The step-point technique developed by Evans and Love (1957) was modified to record, at each pin placement, plant species, plant height, grazed or ungrazed condition of the plant, and overgrazed or undergrazed condition of the vegetation. Areas that contained virtually no residue from the previous year and with nearly all available forage consumed defined overgrazed patches, whereas areas that were ungrazed to moderately grazed were called undergrazed patches. Points were placed systematically and were examined on 6 occasions in the SLS pasture and on 5 occasions in the IES pasture. The Kruskal-Wallis test (Sokal and Rohlf 1981) was used to estimate statistical significance of differences. A two-sample t-test, independent for each species, was used to estimate the statistical significance of plant height differences between overgrazed and undergrazed patches.

To estimate the size, variability and proportion of patches under season-long grazing, intercept lengths of overgrazed and undergrazed patches were recorded at the end of both grazing seasons, on 35 temporary, systematically located 15-m line transects. To allow for yearly comparison between treatments, intercept lengths of patches also were recorded on permanent line transects (12, 15-m transects in the IES pastures; 15, 15-m transects in the SLS pasture). These were located in selected patch-grazed areas, then after livestock were removed each year, locations of overgrazed patches were recorded. Chi-square contingency analysis was used to assess association between location of patches in both years. Cole's index (Cole 1949) was calculated to indicate whether the association was positive or negative. To characterize seasonal changes, intercept lengths of overgrazed patches were recorded periodically throughout the grazing season on an additional 15, 15-m transects placed systematically in each pasture. Analysis of variance was used to estimate statistical differences in the size, number, and location of patches among sampling dates and transects during the grazing periods. An area that appeared typical of patch grazing (15 × 15m) in the SLS pasture was mapped at the end of the 1981 grazing season to depict configuration of overgrazed and undergrazed patches.

Residual standing crop on overgrazed and undergrazed patches in the SLS pasture at the end of grazing in 1980 was estimated with 25 paired, 1/8-m^2 clipped plots. A paired *t*-test was used to assess statistical differences.

Soils of selected adjacent overgrazed and undergrazed patches were sampled with a hydraulic probe to a depth of 1.2 m (4.0 ft.). Cores from contrasting patches were composited by horizon (A, B_2, B_3, C) for standard textural (sand, silt, clay) and chemical (P, K, OM, NH_4, NO_3, pH) analyses. Chemical tests were performed by the Soils Testing Laboratory, Kansas State University, Manhattan. Bulk density of the first 7.6 cm (3.0 in.) of topsoil was mea-

Table 2. Percent floristic composition of overgrazed patches (OP) and undergrazed patches (UP) in the season-long stocked (SLS) and intensive-early stocked (IES) pastures.

	SLS				IES	
	19 Oct. 1980		1 Oct 1981		8 Aug 1980	
Species	OP	UP	OP	UP	OP	UP
blue grama	29.4	34.7	39.0	48.6	48.4	40.7
buffalograss[1]	54.7	22.5	44.7	30.2	39.2	21.7
western wheatgrass[1]	8.6	18.7	5.7	12.3	8.5	18.0
Japanese brome	2.0	22.2	5.7	3.6	1.6	12.9
other species	5.3	1.9	4.9	5.3	2.4	6.7

[1]H_o: UP-OP=0, p=0.0495

sured in both overgrazed and undergrazed patches. Multivariate analysis of variance was used to assess statistical differences.

Results

Floristic composition of the 2 treatments differed significantly, with the IES pasture having more blue grama and less western wheatgrass than the SLS pasture (Table 1). Floristic composition of the patches also differed significantly (Table 2), with overgrazed patches having more buffalograss and less western wheatgrass than undergrazed patches. The amount of Japanese brome was less in the overgrazed patches, but not statistically significant.

Area grazed increased throughout the 1981 grazing season until 75% of the IES pasture had been grazed at least once by the time livestock were removed (Fig. 1). Surface configuration of an area in the SLS pasture was typical of patch grazing at the end of the 1982 season (Fig. 2). Transect data (Fig. 3) showed that the proportion of the range consisting of overgrazed patches increased gradually throughout the growing season. Number of intercepts differed significantly among both transects (P=0.0001) and sampling dates (p=0.0001). Intercept length (size) differed significantly among transects (p=0.0001) but not among sampling dates. Mean intercept lengths of overgrazed patches derived from 35 temporary line transects in the SLS pasture were 137 and 185 cm at the end of the 1980 and 1981 grazing seasons, respectively. Mean intercept lengths derived from permanent transects in the IES pasture were 55 and 88 cm. Thus, mean intercept lengths in SLS were 82 and 97 cm greater than IES in 1980 and 1981, respectively.

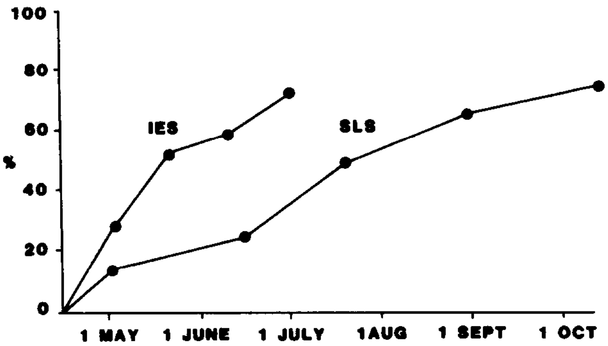

Fig. 1. *Proportion of the range being grazed to some extent in the season-long stocked (SLS) and intensive-early stocked (IES) pastures during the 1981 grazing season.*

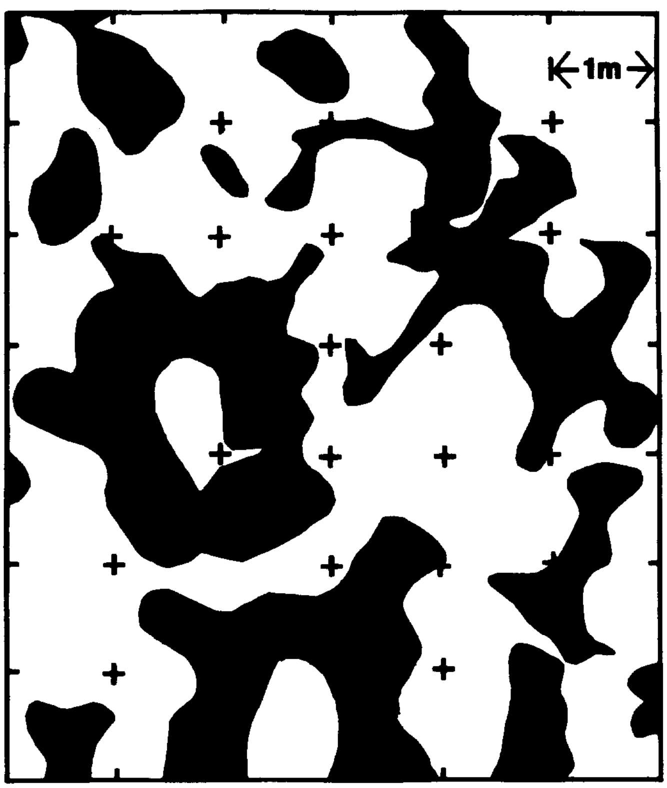

Fig. 2. *A typical patch-grazed area at the end of the 1981 grazing season in the season-long stocked pasture (Black = overgrazed patches).*

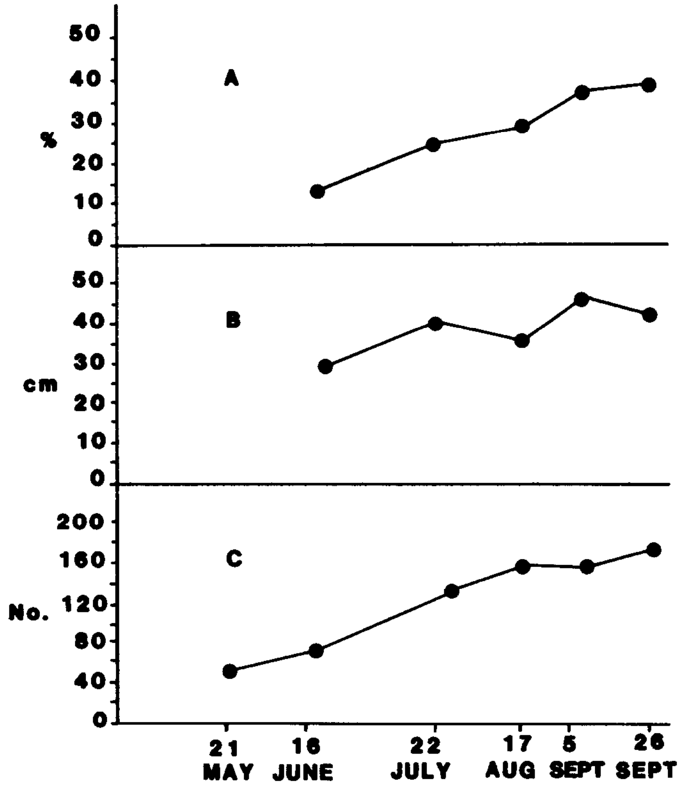

Fig. 3. *Changes in proportion (A), size (B), and number (C) of overgrazed patches in a selected area of the season-long stocked pasture during the 1981 grazing season.*

By the end of the 1980 growing season, essentially all available forage was utilized (overgrazed) on 56% of the IES pasture, 7% was selectively grazed to a lesser extent (lightly to moderately), and the remainder not at all. Data from permanent transects suggested that the same proportion was overgrazed in 1981. In the SLS pasture, the manner in which the livestock utilized the forage varied considerably between 1980 and 1981, as shown by estimates from step-point sampling. Livestock overgrazed 40% of the area and lightly to moderately grazed an additional 8% in 1980; however, they overgrazed only 23% and lightly to moderately grazed an additional 53% in 1981. Transects also showed that more of the pasture consisted of overgrazed patches in 1980 (34%) than in 1981 (27%), but the difference was less than estimates from step-points.

Contingency analysis (Table 3), revealed the influence of grazing treatments on patch-grazing. Of the 10,623 intercept intervals that were in the overgrazed category at the end of the 1980 grazing season in the SLS treatment, 6,039 (57%) were overgrazed at the end of the 1981 season. Of the total intercepts that were undergrazed in 1980, 86% remained undergrazed in 1981. Less than 28% [(4,584+1,609)/22,500] of the intercepts changed category from 1980 to 1981. Locations of patches in 1980 and in 1981 were significantly associated as shown by a very large Chi-square value;

Table 3. Chi-square (X^2) contingency analysis and Coles index (C) of locations of overgrazed patches (OP) and undergrazed patches (UP) on transects in the season-long stocked (SLS) and intensive-early stocked (IES) pastures at the end of the 1980 and 1981 grazing season.

		1980					
		SLS			IES		
		OP	UP	total	OP	UP	total
1981	OP	6039	1609	7648	3677	4442	8119
	UP	4584	10268	14852	4425	5456	9881
	total	10623	11877	22500	8102	9898	18000
		$X^2 = 4686.0$ $p < 0.005$	C = 0.60		$X^2 = 0.4609$ $p = 0.5029$		C = 0.005

Table 4. Average height (cm) of plant species in patches in the season-long stocked (SLS) pasture at the end of the 1981 grazing season.

patches	blue grama	buffalograss	western wheatgrass	Japanese brome	other species
overgrazed	4.5	4.4	4.1	6.1	4.8
undergrazed	13.3	9.4	21.1	13.8	13.0
p (H_o:UP-OP=O)	0.001	0.001	0.001	0.020	0.020

Table 5. Selected soil properties for overgrazed and undergrazed patches in the season-long stocked pasture. No differences (p>0.05) for all properties between patches.

	horizons	pH	kg/ha P	kg/ha K	% O.M.	% NH_3	% NO_3	% sand	% silt	% clay
overgrazed patches	A_1	7.17	18.12	1073.3	3.20	5.00	1.77	5.11	54.56	40.33
	B_2	7.30	15.69	1231.2	1.53	4.70	0.97	3.44	47.89	48.67
	B_3	7.35	45.93	1203.2	0.90	4.15	1.00	4.00	52.16	43.84
	C	8.00	31.74	1176.7	0.63	2.90	0.77	4.89	52.27	43.34
undergrazed patches	A_1	7.13	15.69	1112.5	3.60	5.33	2.53	5.44	52.78	41.78
	B_2	7.20	12.69	1185.0	1.37	4.40	1.80	3.22	47.78	49.00
	B_3	7.35	43.13	1177.5	0.95	3.40	1.00	5.00	50.00	45.00
	C	7.93	29.13	1197.3	1.10	2.77	1.07	5.33	52.33	42.34

a positive Cole's index indicated that most patches were found in similar locations. In contrast, most patches in the IES pasture were not maintained in the locations from 1980 to 1981 (Table 3).

Average height of plants in the SLS pasture differed significantly between overgrazed 4.6 cm (1.8 in.) and undergrazed 13.0 cm (5.1 in.) patches at the end of the 1981 grazing season (Table 4). These estimates helped define the contrasting terms of overgrazed and undergrazed. Biomass of overgrazed patches [701.2 kg/ha (625.7 lb/acre)] and undergrazed patches [2459.0 kg/ha (2,194.9 lb/acre)] also differed significantly (p=0.001). Bulk density of soils of overgrazed patches was 1.13 g/cm³, and 1.10 g/cm³ for undergrazed patches. No significant differences in selected soil properties were found between overgrazed and undergrazed patches (Table 5).

Discussion

At the beginning of the grazing season, the steers grazed only certain areas simply because there was more forage available than they could consume. Patches that were grazed at the beginning of the grazing season were regrazed repeatedly whereas the remainder of the range was virtually ignored by the steers. Persistent grazing of patches resulted in overgrazed patches where nearly all available forage was consumed. Because the remainder of the range was growing rapidly, patch-grazed areas became conspicuous as the season progressed. This represents a positive feedback system, where the lack of vegetative residue and presence of succulent regrowth encourages reutilization of the overgrazed patches. Whether areas became overgrazed or not depended mostly on which areas were grazed at the beginning of the grazing season. This in turn, was influenced most by the grazing history of the pasture.

Undergrazed patches discernible at the end of the grazing season in the SLS pasture were reestablished the following year, whereas those in the IES pasture were not. That was because the IES pasture had a more uniform vegetative cover at the beginning of the grazing season that the SLS pasture, due to late-season rest the previous year. Uniformity resulted in grazing behavior of steers being less affected by the distribution of patches of the previous year. Eventually, this results in the utilization of the range being more evenly dispersed under intensive-early stocking.

Seasonal differences in vegetation cause changes in availability of preferred forage, (Hanley and Brady 1977, Uresk and Rickard 1976, Kamstra 1973, Sims et al. 1971), which, in turn, cause livestock to modify their grazing behavior (Holechek et al. 1982, Arnold and Dudzinski 1978, Willms and McLean 1978, Chacon and Stobbs 1976, Galt et al. 1969, Cook and Harris 1968, Arnold et al. 1966). Regrowth on overgrazed patches early in the season was apparently adequate to meet livestock requirements, but as productivity of regrowth on overgrazed patches slowed, the steers were forced to graze elsewhere. They did this in 2 different ways, by grazing only the tops of the plants in previously ungrazed areas and by starting additional overgrazed patches rather than enlarging those already established. Weaver and Tomanek (1951) likewise found that under season-long use, the tops of undergrazed patches were grazed later in the season, but that overgrazed patches were enlarged and eventually merged together leaving "roughs and relict bunches" (undergrazed patches) occurring only occasionally. In our study, it was primarily in the IES pasture that overgrazed patches eventually became so interconnected that only isolated patches of undergrazed forage remained.

Studies of animal performance on season-long grazing show a predictable decline in daily gains in mid-summer (Launchbaugh 1957, Klipple 1964). The incipience of this decline coincides with the shift in grazing preference away from overgrazed patches. The diminished amount of regrowth on overgrazed patches and mature state of plants on undergrazed patches reduces the overall quality of available forage. This implies that it is important to manage rangeland in a manner that accommodates the grazing preference of the animal. Intensive-early stocking does that, while maintaining productive range and improving animal performance (Launchbaugh et al. 1983).

We suspect that floristic differences between overgrazed and undergrazed patches were caused by differential tolerance of species to close grazing. Buffalograss was the most tolerant to close grazing, blue grama was intermediate, while western wheatgrass and Japanese brome were intolerant. Weaver and Tomanek (1951) observed similar floristic differences between preferentially grazed patches.

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