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Grazing strategies, stocking rates, and frequency and intensity of grazing on western wheatgrass and blue grama

R.H. HART, S. CLAPP, AND P.S. TEST

Authors are, respectively, range scientist and agricultural research technician, USDA-ARS, High Plains Grasslands Research Station, 8408 Hildreth Road, Cheyenne, Wyo. 82009; and former graduate assistant, Range Management Dept., University of Wyoming, now agricultural extension agent, Oregon State University Extension Service, Box 97, John Day, Ore. 97845.

Abstract

Stocking rates and grazing strategies may alter botanical composition of rangeland vegetation by altering frequency and intensity of defoliation of individual plant species. We used long-interval time-lapse photography to study frequency and intensity of defoliation of western wheatgrass (*Pascopyrum smithii* [Rydb.] A. Love) and blue grama (*Bouteloua gracilis* [H.B.K.] Lag. ex Steud.) tillers under continuous season-long and time-controlled short-duration rotation grazing by steers at 2 stocking rates. Frequency, intensity, and variability of defoliation of both grasses were similar under both grazing systems. Western wheatgrass tillers were grazed more frequently under heavy than under moderate stocking, and in 1990 more herbage was removed the second time a tiller was grazed under heavy stocking. Blue grama tillers were grazed more frequently under heavy than under moderate stocking in both years under rotation grazing, but only in 1990 under continuous grazing; more herbage was removed under heavy stocking the second time a tiller was grazed. Under heavy and moderate stocking, respectively, 19% and 36% of western wheatgrass tillers and 42% and 54% of blue grama tillers were ungrazed throughout the grazing season. Few western wheatgrass tillers were grazed more than twice, and few blue grama tillers were grazed more than once. Stocking rates have much greater potential than grazing systems for altering frequency and intensity of defoliation and subsequent changes in botanical composition of range plant communities. Results of grazing studies support this conclusion.

Key Words: *Pascopyrum smithii, Bouteloua gracilis,* time-lapse photography, rotation grazing, season-long grazing, grazing systems

Savory (1988) claimed that intensive time-controlled short-duration planned rotation grazing will shift botanical composition of rangeland vegetation toward more palatable, more nutritious, more successionally advanced, and more all-around desirable plant species. This improvement is to be achieved by "hoof action", which improves water and nutrient cycling and favors establishment of desirable plant species, and by control of frequency, severity, and timing of defoliation of key plant species. Inasmuch as considerable doubts have been cast on the benefits of "hoof action" (St. Clair et al. 1984; Balph and Malechek 1985; Graetz and Tongway 1986; Thurow et al. 1986; Weltz and Wood 1986; Warren et al. 1986a, 1986b, 1986c; Abdel-Magid et al. 1987; Pluhar et al. 1987; Weigel et al. 1990; Hart et al. 1993), more attention should be paid to the effects of grazing strategies on frequency and intensity of defoliation.

Increasing stocking rate increased frequency and severity of defoliation (Hart and Balla 1982, Briske and Stuth 1982, Curll and Wilkins 1982, Pierson and Scarnecchia 1987, Ruyle et al. 1988). Grazing strategies have much less effect. Gammon and Roberts (1978a, 1978b, 1978c) found no significant differences in defoliation frequency and intensity between continuous and 6-paddock rotational grazing. Gillen et al. (1990) reported little effect of grazing schedule on percent of tillers defoliated or height to which tillers were defoliated.

In all these studies except Hart and Balla (1982), the techniques used required frequent and intensive measurements of individual plants, with considerable disturbance of the stand. Hart (1970) pioneered the use of long-interval time-lapse photography for nondestructive estimates of grazing effects on individual plants. Hart and Balla (1982) used the technique to estimate frequency and intensity of grazing of western and crested wheatgrass (*Pascopyrum smithii* [Rydb.] A. Love and *Agropyron desertorum* [Fisch.] Schult.), and Springfield (1974) used it to estimate forage production and utilization of shrubs. Stuth et al. (1987) used time-lapse photography at 5-minute intervals to monitor grazing of 0.1 ha areas of grassland.

Western wheatgrass and blue grama (*Bouteloua gracilis* [H.B.K.] Lag. ex Steud.) are major constituents of range vegetation and cattle diets on mixed-grass prairie rangelands in the Central High Plains (Samuel and Howard 1982). Black et al. (1937) found that blue grama was much less affected by clipping than was western wheatgrass. Clarke et al. (1947) found that forage production of needleandthread (*Stipa comata* Trin. & Rupr.) was affected more by frequency of use than was that of blue grama. Buwai and Trlica (1977a, 1977b) found that multiple defoliations of western wheatgrass produced proportionately greater reductions in subsequent herbage production and total nonstructural carbohydrate concentration than did similar defoliations of blue grama. Therefore, one might expect that increasing frequency and intensity of defoliation would reduce the proportion of western wheatgrass in the stand and increase that of blue grama.

Intensive rotation grazing might decrease the patchiness of grazing often observed under season-long grazing. Under season-long grazing, up to 22% of western wheatgrass tillers and 16% of crested wheatgrass tillers were not grazed at all, while up to 51% and 59%, respectively, were grazed 3 or more times (Hart and Balla 1982). Hormay and Evanko (1958) found 40% of Idaho fescue (*Festuca idahoensis* Elmer) plants were overgrazed (stubble 2.5 cm or shorter) while 15% were not grazed at all. Rotation grazing also

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removes animals from each paddock before they have a chance to graze new regrowth of previously grazed plants. This may benefit the more palatable plant species.

Changing the frequency and intensity of defoliation of plant species might alter botanical composition and condition of rangelands. We tested the hypotheses that increasing stocking rate would increase frequency and intensity of defoliation of western wheatgrass and blue grama, but that grazing strategy would not. However, intensive rotation grazing might reduce variability in the amount of forage removed per tiller and thus increase uniformity of grazing.

Materials and Methods

This experiment was conducted as part of the grazing study reported by Hart et al. (1988). Pastures were grazed 16 June–27 October 1983 at 1 steer/3.0 ha (moderate stocking, M) or 2.25 ha (heavy stocking, H). They were grazed 4 June–10 October 1990 at 1 steer/2.4 ha (M) or 1.8 ha (H). Forage production (peak standing crop) and utilization [(peak standing crop — end-of-season residue)/peak standing crop] were estimated as described in Hart et al. (1988).

In 1983, a pair of 25-m transects were laid out in each continuously grazed pasture under heavy and moderate stocking and in one paddock of each short-duration rotationally grazed pasture under heavy and moderate stocking in 1 of the 2 replications. Along 1 transect of each pair, the western wheatgrass tiller nearest each 1-m mark was encircled by a poultry leg band wired to a spike, and the spike was driven into the ground. Along the other transect, the blue grama tiller nearest each 1-m mark was similarly marked. Five colors of leg bands were used in a regular rotation to aid in identifying the number of each tiller along a transect.

In 1990, 2 pairs of 10-m transects were laid out in each continuously grazed pasture under heavy and moderate stocking and in 1 paddock of each short-duration rotationally grazed pasture under heavy and moderate stocking in both replications. Western wheatgrass tillers were marked along 1 transect of each pair and blue grama tillers along the other transect as in 1983.

Thus in 1983, 25 tillers of each grass species were identified in each grazing system × stocking rate combination, all in replication 1. In 1990, 40 tillers of each species were identified in each combination, 20 in each replication.

At intervals marked tillers were photographed against a gridded background. Date and pasture identification were on cards attached to the background; tiller numbers were on dials built into the background. Tillers in short-duration rotationally grazed pastures were photographed at the beginning and end of each grazing period, 3 per year, in the paddock where they were located. Tillers in continuously grazed pastures were photographed at 14- to 25-day intervals in 1983 and 21- to 34-day intervals in 1990, with 3 dates each year within 1 to 3 days of the beginning of a grazing period on the short-duration rotationally grazed pastures. There were 2 exceptions. The last interval in 1983, from near the beginning of the last grazing period under rotation grazing to the end of grazing, was 36 days. In 1990, tillers under continuous grazing were photographed 31 August near the beginning of the last grazing period under rotation grazing, but the photographs were ruined during developing and tillers were re-photographed 12 September. Dates on which tillers were photographed are listed in Table 1. When a leg band marking a tiller disappeared, a similar replacement tiller was marked. Only 6 tillers were replaced during the 2 years, and no tillers were lost to senescence.

At the end of each year, photographs of each tiller were put in chronological order and examined. If a tiller had been grazed between 2 consecutive photographs, the percent removed was estimated from reductions in tiller height and leaf size and number. If a tiller had grown, the percent growth was estimated.

Table 1. Dates on which marked tillers were photographed under season-long continuous or short duration rotation grazing strategies, 1983 and 1990.

1983		1990	
Continuous	Rotation	Continuous	Rotation
Date photographed			
24 Jun	23 Jun	22 May	18 Jun
8 Jul	28 Jun	18 Jun	21 Jun
28 Jul	27 Jul	19 Jul	18 Jul
11 Aug	4 Aug	22 Aug	24 Jul
1 Sep	29 Sep	12 Sep	30 Aug
26 Sep	6 Oct	12 Oct	7 Sep
1 Nov			

In 1983, because transects were not replicated, chi-square was first computed for each grass from the data on number of times grazed during grazing season, with 4 classes (grazed 0, 1, 2, or 3 times) within 4 populations (CM, CH, SM, and SH). When significant ($P \leq 0.05$) differences were detected among populations, chi-square values were computed for the appropriate subsets of data. Data on percent removed at each grazing was analysed as 4 populations with unequal sample numbers.

In 1990, data on times grazed and percent removed was subjected to analysis of variance, first with grazing strategies and stocking rates as treatments and sub-treatments, respectively, blocks as replications, and transects within blocks as sub-samples. As block effects never approached significance ($P \leq 0.05$), data were re-analysed with blocks, blocks × treatments and sub-treatments, and transects within blocks pooled as the error term. When analysis of variance indicated significant differences ($P \leq 0.05$), Tukey's Highest Significant Difference was used to separate means.

Results and Discussion

Grazing strategies had no effect on peak standing crop or utilization. Peak standing crop was 1,670 kg/ha in 1983 and 1,560 kg/ha in 1990. Utilization was estimated at 44% and 48% under moderate and heavy grazing, respectively, in 1983 and 39% and 48% in 1990.

Grazing strategy had no effect on the percent of western wheatgrass tillers grazed once, twice, 3 times, or not at all; data from continuous and rotation grazing are pooled in Table 2. Stocking rates had marked effects. In both years, fewer tillers were ungrazed under heavy than under moderate stocking. In 1983, more wheatgrass tillers were grazed once under heavy than under moderate stocking, but not in 1990, when more tillers were grazed twice under heavy stocking. In 1983 only 4% of the western wheatgrass tillers observed were grazed 3 times; in 1990 none were.

In 1983, an average of 73% of aboveground biomass was removed from wheatgrass tillers grazed the first time; from tillers grazed a second time, 74% of the remaining biomass was removed. Neither strategy nor stocking rate had any effect on percent biomass removed. At the first grazing in 1990, more was removed from western wheatgrass under rotation than under continuous grazing at the moderate, but not at the heavy, stocking rate (Table 3). Within strategies, stocking rate had no effect. At the second grazing, 39% was removed under moderate vs. 74% under heavy stocking.

Hart and Balla (1982) reported that increasing stocking rate markedly increased frequency of grazing of western wheatgrass but only occasionally increased the amount removed. They also reported higher frequencies of grazing than were observed in this study, with some tillers grazed 4 times. Forage production in the 2

Table 2. Frequency of grazing of western wheatgrass and blue grama tillers under season-long continuous or short-duration rotation grazing strategies and moderate or heavy stocking rates, 1983 and 1990.

Grass	Year	Strategy	rate	Times grazed 0	1	2	3
				% of tillers grazed			
Western wheatgrass	1983	Continuous & rotation	Moderate	31a	43b	22a	4a
			Heavy	17b	67a	12b	4a
	1990	Continuous & rotation	Moderate	39a	51b	10b	0a
			Heavy	20b	55ab	25a	0a
Blue grama	1983	Continuous	Moderate	60a	32b	8a	0a
			Heavy	56ab	40ab	4a	0a
		Rotation	Moderate	64a	32b	4a	0a
			Heavy	48b	48a	4a	0a
	1990	Continuous	Moderate	32b	63a	5bc	0a
			Heavy	28b	60a	12a	0a
		Rotation	Moderate	58a	40b	2c	0a
			Heavy	38b	54a	8b	0a

[a,b]Percentages for the same grass, year, and column, followed by the same letter, are not significantly different ($P\leq0.05$).

years of their study was much lower, 970 and 1,020 kg/ha, than the 1,670 and 1,560 kg/ha recorded in the 2 years of this study. Grazing pressure of Hart and Balla (1982) was 15.9–32.4 cow-calf days/Mg of forage produced, vs. 26.5–45.6 steer-days/Mg in this study. Hart and Balla's (1982) grazing seasons were 110, 143, 147, and 185 days vs. 133 and 128 days in 1983 and 1990, respectively.

Table 3. Herbage removed from western wheatgrass and blue grama tillers at the first grazing under season-long continuous or short-duration rotation grazing strategies and moderate or heavy stocking rates, 1983 and 1990.

Grass	System	Stocking rate	1983 Mean	1983 Std error	1990 Mean	1990 Std error
			% removed			
Western wheatgrass	Continuous	Moderate	71a	5.7	70b	5.4
		Heavy	75a	5.4	60bc	5.3
	Rotation	Moderate	69a	6.5	90a	1.5
		Heavy	76a	6.1	79ab	4.2
Blue grama	Continuous	Moderate	34a	7.0	57a	4.8
		Heavy	40a	4.7	49a	3.5
	Rotation	Moderate	46a	7.1	50a	7.3
		Heavy	40a	6.9	54a	5.2

[a,b]Means for the same grass and year, followed by the same letter, are not significantly different ($P\leq0.05$).

Under continuous grazing, the only effect of stocking rate on frequency of grazing on blue grama occurred in 1990. Although few tillers were grazed twice under any treatment, in 1990 more were grazed twice under heavy stocking under both grazing strategies. But under rotation grazing, fewer tillers were ungrazed and more were grazed once under heavy than under moderate stocking in both years. The probability that a blue grama tiller will be grazed increases with increasing stocking rate, and the increase is greater under rotation grazing. No blue grama tillers were grazed 3 times.

Percent of biomass removed from blue grama tillers at the first grazing was unaffected by strategy or stocking rate in either year; 40% was removed in 1983 and 52% in 1990 (Table 3), again reflecting higher stocking rate in 1990. At the second grazing, more was removed under heavy stocking than under moderate, 100% vs. 45% in 1983 and 72% vs. 45% in 1990, although the difference was significant ($P\leq0.05$) only in 1983 and few tillers were grazed twice under any treatment. Strategy had no effect on intensity of defoliation.

Western wheatgrass tillers that were regrazed after the first grazing were those from which less herbage ($P\leq0.05$) was removed at the first grazing. In 1983, tillers grazed twice had 55% of their biomass removed at the first grazing, vs. 79% removed from tillers not grazed again. In 1990 60% and 75%, respectively, were removed at the first grazing from tillers regrazed later and those not grazed again. No significant differences were observed in blue grama; tillers regrazed later lost 39% at the first grazing vs. 46% from tillers not regrazed.

Variation in the amount of herbage removed at the first grazing was not much influenced by stocking rate or grazing system. The standard error of the amount removed at the first grazing was not significantly higher under rotational than under continuous grazing, except on western wheatgrass tillers in the moderately stocked pastures in 1990 (Table 3). Variation in defoliation among tillers on the same plant may be advantageous. Forage production may be greater after defoliation to different heights or defoliation of only some of the available plants or tillers than after uniform defoliation (Matches 1966, Smith 1968, Smith et al. 1975, Stroud et al. 1985).

One of the objectives of rotation or planned grazing is to prevent early grazing or regrowth (Savory 1988). But in the case of western wheatgrass this objective may be irrelevant because western wheatgrass produces little re-growth after mid-July, regardless of treatment. Under continuous grazing in 1983, biomass of ungrazed wheatgrass tillers increased 16% from 24 June to 8 July but only 3% for the rest of the season. Biomass of ungrazed western wheatgrass tillers increased 15% from 28 June to 27 July under rotation grazing, but only 2% from then until the end of the grazing season. Most of this growth probably occurred early in the period. In 1990, biomass increased 35% from 21 June to 18 July under rotation grazing and 39% from 18 June to 19 July under continuous grazing, but only 5% and 1% thereafter under rotation and continuous grazing, respectively. Both 1983 and 1990 were very favorable years, with forage production of 1,670 and 1,560 kg/ha respectively, well above the average of approximately 1,100 kg/ha (Hart 1991). Blue grama tillers continue to grow through August, but again regrowth is not a management consideration because so few tillers are grazed more than once.

Frequency and occasionally intensity of grazing of western wheatgrass and blue grama tillers increased with stocking rate. Similar responses have been previously reported in crested and western wheatgrasses (Hart and Balla 1982), brownseed paspalum (*Paspalum plicatulum* Michx.; Briske and Stuth 1982), perennial ryegrass (*Lolium perenne* L.; Curll and Wilkins 1982), intermediate wheatgrass (*Elytrigia intermedia* [Host] Nevski; Pierson and Scarnecchia 1987), and Lehmann lovegrass (*Eragrostis lehmanniana* Nees; Ruyle et al. 1988). Because severe defoliation is usually less damaging to blue grama than to western wheatgrass, blue grama often increases as stocking rate increases, while western wheatgrass decreases (Sarvis 1941, Klipple and Costello 1960, Houston and Woodward 1966, Launchbaugh 1967, Sims et al. 1976).

In conclusion, grazing strategies had little effect on frequency, severity or variation of grazing of western wheatgrass or blue grama. Therefore it is not surprising that grazing strategies have had little effect on botanical composition of rangelands (Sarvis 1941; Denny and Barnes 1977; Denny and Steyn 1977; Denny et al. 1977; Gammon and Roberts 1978a; Heitschmidt et al. 1985, 1987; Pitts and Bryant 1987; Hart et al. 1988; Bryant et al. 1989; Taylor 1989).

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