Steer performance on native and modified Northern Great Plains rangeland

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Abstract

Research was conducted to quantify the effects of various range improvement treatments on diet quality and summer weight gain of steers grazing semiarid rangeland from 1983 through 1988. Treatments were: no treatment (i.e., control), contour furrowing, intertilling with a prototype range improvement machine and combinations of the range improvement machine, nitrogen fertilization, legume interseeding, or brush control. Diet quality was measured in 1987 and 1988. Data were analyzed using various repeated measures analysis of variance models. Various relationships between the animal performance data and previously published herbage standing crop data were examined using standard correlation procedures. There were no significant treatment ($P>0.17$) or year by treatment ($P>0.82$) interaction effects relative to average daily gains, total gain steer⁻¹, and gain ha⁻¹. However, all year effects were significant ($P<0.05$) for these variables with years accounting for about 67% of the observed variation in weight gains. Percentage crude protein in diet samples was greater in 1987 compared to the severe drought year of 1988 and was greater at the beginning than at the end of each grazing season ($P<0.05$). However, in vitro dry matter digestibility of diets was greater in 1988 than 1987 primarily because digestibility of diets increased in 1988 from the beginning to the end of the trial. Significant correlations between gain steer⁻¹ and gain ha⁻¹ and early season total and perennial cool-season grass standing crop estimates indicated some rudimentary information is available at the beginning of each grazing season for predicting season-long weight gains. Because average daily gains during late spring and early summer were several fold greater than late season gains in all years except one, it is hypothesized that intensive early stocking strategies may be appropriate for stocker cattle grazing in the Northern Great Plains.

Key Words: brush control, contour furrowing, diet quality, legume interseeding, range improvements, nitrogen fertilization, production animal⁻¹, production ha⁻¹

The concept of range improvement is an ill-defined, often maligned concept in the rangeland management arena. This is largely because the value of any perceived range improvement practice varies depending upon practitioner's goals. Still, the most common range improvement goal associated with the range livestock industry is increased, long-term (i.e., sustainable) profits. Although there are a number of ways that various range improvement practices can enhance profit, the most commonly accepted avenue is through increased livestock sales. Thus, most range improvement research has been focused primarily on increasing

either the quantity and/or quality of forage produced or consumed by livestock. For example, Wight et al. (1978) reported that contour furrowing of southeastern Montana native rangeland more than doubled forage production over an 8-year period. Similarly, Griffith et al. (1985) reported ripping and contour furrowing of southeastern Wyoming rangeland increased forage production about 175% which they calculated would result in a sufficient increase in livestock carrying capacities so as to pay for the costs of treatment within 4 years of establishment.

The objective of this study was to quantify the integrated impacts of soil tilling, legume interseeding, brush removal, and nitrogen fertilization on the diet quality (i.e., quality of forage consumed) and summer weight gain of steers (i.e., integrated product of quantity and quality of forage consumed) grazing Northern Great Plains rangeland. Although previous research in these same treatment pastures showed herbage standing crops in spring were significantly ($P<0.05$) greater in treated than untreated control pastures (Haferkamp et al. 1993), the impact of the treatments on livestock production has not been reported.

Materials and Methods

Study Area

Research was conducted at 2 sites on the Fort Keogh Livestock and Range Research Laboratory (46°22'N 105°5'W) near Miles City, Mont. Regional topography ranges from rolling hills to broken badlands with small intersecting streams flowing intermittently into large permanent rivers located in broad, nearly level valleys. Indigenous vegetation on the 22,500-ha station is a grama-needlegrass-wheatgrass (*Bouteloua-Stipa-Agropyron*) mixed dominant (Küchler 1964). Long-term annual precipitation averages 338 mm with about 60% received during the April through August growing season (Fig. 1). Total annual precipitation during the 6-year study (1983-1988) was well below average during 3 years, near average during 2 years, and above average 1 year. Daily temperatures often exceed 37° C during summer whereas winter temperatures often dip below -40° C. The average frost-free period is 150 days.

The 2 study sites were located about 6 km apart. Topography of both sites ranged from nearly level to gently sloping (<2%). Soils at Site 1 were primarily a composite of the Absher heavy clay and Gerdum claypan series (Borollic Natrargrids). The soils at Site 2 were silty clay loams and loams of the Ethridge and Pinelli series (Borollic Camborthids). Vegetation at both sites was characterized by a mixed dominate of western wheatgrass [*Agropyron smithii* Rydb.; new cytogenetic = *Pascopyrum smithii* Rydb. (Love)] and bluegrama [*Bouteloua gracilis* (H.B.K.) Lag. ex Griffiths], Sandberg bluegrass (*Poa secunda* Presl.), needle-and-thread (*Stipa comata* Trin. & Rupr.), threadleaf sedge (*Carex filifolia* Nutt.), june grass [*Koeleria pyramidata* (Lam.) Beauv.], tumblegrass

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Fig. 1. Monthly precipitation (mm) received from 1983 through 1988 at Miles City, Mont., and longterm (92-year) average.

[*Schedonnardus paniculatus* (Nutt.) Trelease], downy brome (*Bromus tectorum* L.), and Japanese brome (*B. japonicus* Thunb.). Wyoming big sagebrush (*Artemisia tridentata* Pursh. subsp. *wyomingensis* Beetle and Young) was the dominant shrub present. For a detailed description of vegetation growth dynamics, see Haferkamp et al. (1993).

Treatments

Seven treatments were established in eight 12-ha pastures at both sites in 1982. Treatments were: (1) untreated control + SL; (2) ST + SL; (3) ST + DS + SL; (4) BC + ST + DS + SB; (5) BC + ST + DS + SL; (6) ST + NF + SL; and (7) CF + AS + SL, where

SL = season long grazing

SB = 2 pasture, 1 herd switchback SL grazing

ST = soil tilling with Range Improvement Machine (RIM) (Currie et al. 1989)

BC = brush control

CF = contour furrowing (Kartchner et al. 1983)

DS = drill seeding with RIM

AS = aerial seeding, and

NF = nitrogen fertilization.

Interseeded legumes were alfalfa 'Spreador II' (*Medicago falcata* L.) and Cicer milkvetch (*Astragalus cicer* L.). Both legumes were seeded at a rate of either 2.2 kg ha⁻¹ with the range improvement machine or 4.4 kg ha⁻¹ aerially. Brush was controlled by mechanical chopping during winter at Site 1 and spraying 2,4-D [(2,4-dichlorophenoxy) acetic acid] at a rate of 2.8 kg ha⁻¹ before legumes emerged at Site 2. Nitrogen fertilizer was applied as a single application of 56 kg ha⁻¹ of ammonium nitrate in 1982.

Grazing Regimen and Field Sampling

Treatment pastures were stocked annually with Hereford crossbred steers weighed at the beginning, near mid-season, and end of each annual trial. Initial weights averaged 306 kg. From 1983 through 1986, all season-long grazing treatments were stocked with 5 steer season long. The single 2-pasture switch back grazing treatment was stocked with 10 steers with the herds switched between pastures near mid-season with the pasture grazed first alternated among years. In 1987 and 1988, a put-and-take stocking strategy was utilized in all treatments in an attempt to maintain similar levels of grazing pressure among treatments; otherwise differences among years and between sites in annual stocking rates varied depending upon length of grazing season (Table 1).

Table 1. Annual date grazing trials were initiated, duration of grazing season and season-long stocking rates from 1983 to 1988 at the 2 study sites.

Location	Beginning date (mo/d/yr)	Duration (days)	Stocking rate (SD ha ⁻¹) ¹
Site 1	6/16/83	96	48.0
	6/18/84	63	31.5
	6/18/85	41	20.5
	6/9/86	103 ¹	51.5 ²
	6/3/87	92	36.4–59.1 ³
	6/15/88	30	9.0–12.0 ³
Site 2	6/22/83	90	45
	5/31/84	60	30
	6/5/85	40	20
	5/22/86	90	45
	5/18/87	91	36.4–57.3 ³
	6/3/88	41	12.0–16.0 ³

¹Steer days ha⁻¹.

²Control = 72d and 36.0 SD ha⁻¹.

³Range across treatments for put-and-take stocking strategy.

Diet quality was estimated in all treatments at both sites at the beginning and end of the 1987 and 1988 grazing seasons. Diets from 4 esophageally fistulated steers per pasture were collected in early morning on each sample date. Steers were fasted for 14 hours prior to sampling. Samples were oven-dried at 60° C and ground through a 1-mm screen prior to analyses for crude protein concentration (AOAC 1980) and in vitro organic matter digestibility determinations (White et al. 1981).

Date Summarization and Analyses

Average daily gains, total gain per steer and per hectare, and diet quality parameters were statistically analyzed using repeated measure analysis of variance models. Main effects in the animal performance model were replication (i.e., site), treatment, and year. The error mean square (d.f.=6) for detecting treatment effects was replication by treatment. The residual error mean square (d.f.=28) was used to test for year and year by treatment effects. Main effects in the diet quality model were replication, treatment, year, and sample date (beginning vs. end of grazing season). The error mean square (d.f.=6) for treatment was replication by treatment. The error mean square for year and year by treatment was replication

by year (d.f.=1) plus replication by treatment by year (d.f.=6). The residual mean square (d.f.=14) was used to test for differences between sample dates and all associated interactions. Tukey Q values were utilized for mean separation of significant ($P<0.05$) means.

To further assess the potential impact of variable stocking strategies on differences among treatments and years in animal performance values, correlation coefficients (r) between the various animal performance and early season standing crop parameters (Haferkamp et al. 1993) were calculated by treatment within site within year ($n=84$). Variables included in the analyses were average daily gains during the first and last one half of each grazing trial, full season average daily gain, total gain per steer (gain steer⁻¹) and per hectare (gain ha⁻¹), and early season standing crop estimates for total, perennial cool-season grasses, perennial warm-season grasses, annual grasses, sedges, and forbs.

Results

Steer Performance

There were no significant treatment ($P>0.17$) or year by treatment interaction ($P>0.82$) effects relative to average daily gains, total gain steer⁻¹ and gain ha⁻¹ (Table 2). There were significant

Table 2. Steer performance for 7 treatments averaged across 6 years. Differences among treatments were not statistically significant ($P>0.17$).

Treatment ¹	ADG _F ²	ADG _L ³	ADG _T ⁴	Gain steer ⁻¹	Gain ha ⁻¹
	(kg)				
Control + SL	1.0	0.1	0.5	36	14
ST + SL	1.0	0.1	0.6	41	17
ST + DS + SL	1.0	0.3	0.6	45	20
BC + ST + DS + SB	0.9	0.3	0.6	42	18
BC + ST + DS + SL	1.0	0.4	0.7	51	22
ST + NF + SL	1.0	0.3	0.6	45	19
CF + AS + SL	0.9	0.5	0.7	48	21

¹See text Materials and Methods for treatment definitions.

²ADG_F = average daily gains during first one-half of grazing season.

³ADG_L = average daily gains during last one-half of grazing season.

⁴ADG_T = average daily gains during entire grazing season.

year effects for early and season-long average daily gains, gain steer⁻¹, and gain ha⁻¹ (Table 3). Differences among years in average daily gains were related primarily to differences among years in amount and seasonal distribution of rainfall (Fig. 1) whereas differences among years in gain steer⁻¹ and gain ha⁻¹ were related to differences in both average daily gains (Table 3) and seasonal stocking rates (Table 1). Late spring and early summer average daily gains were several fold greater than late season gains in all years except the severe drought year of 1988.

Diet Quality

There were no significant treatment ($P>0.38$), year by treatment ($P>0.86$), sample date by treatment ($P>0.23$), or 3-way interaction ($P>0.66$) effects on diet crude protein concentrations or in vitro

Table 3. Steer performance (kg) for 1983 through 1988 averaged across 7 treatments.

Parameter ²	Year ¹						Tukey Q values
	1983	1984	1985	1986	1987	1988	
	(kg)						
ADG _F ²	1.0 _b	1.2 _b	1.0 _b	1.1 _b	1.2 _b	0.4 _a	0.3
ADG _L ³	0.1 _a	0.4 _a	0.4 _a	0.2 _a	0.2 _a	0.4 _a	NS
ADG _T ⁴	0.5 _b	0.8 _c	0.7 _{bc}	0.7 _{bc}	0.7 _{bc}	0.3 _a	0.2
Gain steer ⁻¹	49 _c	49 _c	28 _b	65 _c	62 _c	10 _a	15.7
Gain ha ⁻¹	21 _c	21 _c	12 _b	27 _{cd}	29 _d	3 _a	6.6

¹Means in a row followed by same letter are not significantly different at $P<0.05$.

²ADG_F = average daily gains during first one-half of grazing season.

³ADG_L = average daily gains during last one-half of grazing season.

⁴ADG_T = average daily gains during entire grazing season.

Table 4. Average crude protein (CP) and in vitro organic matter digestibility (IVOMD) of diets near beginning (early) and end (late) of 1987 and 1988 grazing seasons averaged across 7 treatments. Differences among treatments were not statistically significant ($P>0.38$).

Year	Diet quality parameters ¹			
	CP		IVOMD	
	Early	Late	Early	Late
	----- % -----			
1987	11.9 _a	6.1 _b	67 _a	55 _b
1988	7.4 _c	4.2 _d	63 _c	66 _d

¹Means in a row or column within a diet quality parameter followed by same letter are not significantly different at $P<0.05$.

organic matter digestibility in 1987 and 1988. Average crude protein did vary significantly between 1987 (9.0%) and 1988 (5.8%) and between the beginning (9.6%) and end (5.2%) of each trial. In addition, magnitude of differences varied between years (Table 4) which resulted in a significant year by sample date interaction. The results were quite different for the in vitro organic matter digestibility than crude protein estimates in that digestibility of diets increased significantly in 1988 from the beginning to the end of the trial. Although the reasons for this unexpected increase were unclear, the resulting effect was that average in vitro organic matter digestibility was less in 1987 than 1988.

Correlation Analyses

Early season average daily gains were significantly correlated with season-long average daily gains, total gain steer⁻¹, and gain ha⁻¹ (Tables 5 and 6). Early season gains were not correlated with any standing crop estimates from 1983 through 1988 (Table 5). However, early season average daily gains were weakly correlated with total standing crop estimates in 1987 and 1988 and strongly correlated with diet quality values (Table 6).

Late season average daily gains, total gain steer⁻¹, and gain ha⁻¹ were strongly related from 1983 through 1988 (Table 5) and during 1987 and 1988 (Table 6). This was as expected because of the interdependence of the 3 variables. Surprisingly, season-long average daily gains from 1983 through 1988 were not correlated with any herbage standing crop estimates but gains steer⁻¹ and gains ha⁻¹ were correlated with total and perennial cool-season grass standing crop estimates (Table 5). In 1987 and 1988, season-long average daily gains, gain steer⁻¹, and gain ha⁻¹ were all highly correlated with total early season standing crop estimates and both diet quality values (Table 6).

Discussion and Conclusions

The results from this study show steer performance did not vary significantly among treatments even though Haferkamp et al. (1993) showed herbage standing crops near the beginning of each annual trial were significantly greater in the 6 treatments than the control. There are at least 3 potential explanations for this discrepancy. Firstly, it might be hypothesized that the quality of available forage was significantly greater in the control than the treatment pastures, thereby offsetting the potential benefits derived from the greater standing crop. However, the diet quality data from 1987 and 1988 (Table 4) certainly do not support this hypothesis. Likewise, it might be hypothesized that stocking rates in all treatments were below that required [i.e., the "critical stocking rate" (Hart 1980)] to limit nutrient intake and thereby reduce steer performance. Although it can be reasoned that this might have been the case during the first 4 years of the study when stocking rates were equal across all treatments, the absence of any significant treatment by year interaction effects implies the relative production values did not change appreciably among treatments between the years (1983–1986) when rates of stocking were set and the years (1987–1988) when rates of stocking were varied among treatments. It should be noted, also, that the positive and highly

Table 5. Correlation coefficients between various animal performance and herbage standing crop estimates from 1983 through 1988 (7 treatments * 6 years * replications = n = 84).

Parameter	Animal performance					Herbage standing crop estimates ¹					
	ADG _F ²	ADG _L ³	ADG _T ⁴	Gain steer ⁻¹	Gain ha ⁻¹	CSGR ⁵	WSGR ⁶	ANGR ⁷	Sedges	Forbs	Total
ADG _F ²	—	-0.22	0.56**	0.57***	0.57***	0.05	-0.14	0.18	-0.13	0.01	0.07
ADG _L ³		—	0.67***	0.19	0.19	-0.26*	-0.20	-0.02*	-0.64	-0.22	-0.47***
ADG _T ⁴			—	0.74***	0.71***	0.15	-0.10	0.14	-0.12	0.02	0.12
Gain steer ⁻¹				—	0.98***	0.41***	0.08	0.22*	-0.03	0.17	0.43***
Gain ha ⁻¹					—	0.41***	0.06	0.21*	-0.03	0.12	0.41***

¹From Haferkamp et al. (1993)

²ADG_F = average daily gains during first one-half of grazing season.

³ADG_L = average daily gains during last one-half of grazing season.

⁴ADG_T = average daily gains during entire grazing season.

⁵CSGR = perennial cool-season grasses

⁶WSGR = perennial warm-season grasses

⁷ANGR = annual grasses.

* $P < 0.05$ ** $P < 0.01$ *** $P < 0.001$

Table 6. Correlation coefficients between various animal performance parameters (kg), estimated early season herbage standing crop (kg ha⁻¹) and estimated early season diet percentage crude protein (CP) and in vitro organic matter digestibility (IVOMD) during 1987 and 1988 trials (7 treatments * 2 years * 2 replications = n = 28).

Parameter	Animal performance					Diet Quality		Total Standing crop ¹
	ADG _F ²	ADG _L ³	ADG _T ⁴	Gain steer ⁻¹	Gain ha ⁻¹	CP	IVOMD	
ADG _F ²	—	-0.38	0.82**	0.94***	0.89***	0.63**	0.66**	0.44*
ADG _L ³		—	0.20	-0.19	-0.14	-0.18	-0.10	-0.23
ADG _T ⁴			—	0.91***	0.88***	0.71***	0.61***	0.80***
Gain steer ⁻¹				—	0.97***	0.72***	0.67***	0.71***
Gain ha ⁻¹					—	0.74***	0.70***	0.65***

¹From Haferkamp et al. (1992)

²ADG_F = average daily gains during first one-half of grazing season.

³ADG_L = average daily gains during last one-half of grazing season.

⁴ADG_T = average daily gains during entire grazing season.

* $P < 0.05$, ** $P < 0.01$ *** $P < 0.001$.

significant ($P < 0.001$) correlations between gain steer⁻¹ and gain ha⁻¹ and early season standing crops (Table 4 and 5), coupled with the findings of Haferkamp (1993), imply that steer performance in the control pastures should have been less than that in the modified pastures. Since this in fact was the case (Table 2), we forthrightly conclude that this study simply lacked the appropriate level of robustness required to detect statistically significant differences in steer production among treatments. In light of this conclusion, it is important we recognize that the absence of any statistically significant differences among treatments does not preclude the existence of biologically significant differences. Rather, the absence of statistical differences in the presence of true biological differences only reflects our failure to detect such differences with a given level of confidence. We suspect that this was the case in this study because the results clearly show that the magnitude of the impact of the various treatments imposed on steer gains was much less than annual variations. The magnitude of this variation is reflected in the fact that 67% of the variation in the production animal⁻¹ data was attributed to the main effects of year alone, whereas 69% of the variation in the production ha⁻¹ data was attributed to the year effect alone. Such findings are not surprising in this highly variable, semiarid rangeland setting.

The differences in this study between early- and late-season average daily gains (Table 3) and the differences reported by Currie et al. (1989) suggest an intensive early stocking (IES) strategy may be an appropriate stocker cattle grazing tactic for the Northern Great Plains. Launchbaugh et al. (1983) has shown that stocker cattle gains ha⁻¹ can be increased in Kansas about 25% over gains derived from season-long grazing by stocking at a 2X rate for about one half (1 May–15 July) of the normal season-long grazing season (1 May–1 October). Presumably, the enhanced performance during the early portion of the season stemmed from the higher quality of available forage. Certainly, the average daily gains (Table 3) and diet quality (Table 4) data from our study support such a hypothesis and the potential advocacy for employ-

ment of intensive early stocking strategies in the Northern Great Plains.

A basic problem in grazing management is identifying optimal rates of stocking *a priori*. The fundamental correlations between seasonal gain steer⁻¹ and gain ha⁻¹ revealed in this study (Tables 5 and 6), imply that at least some rudimentary information is available in late May and early June whereby rational seasonal stocking rate decisions can be made. Previous research in this region (Dodd et al. 1982, Lauenroth et al. 1984) has shown generally that about 50–60% of annual herbage production occurs prior to 1 June with most of the remaining production occurring during June. Moreover, Haferkamp et al. (1993) showed a series of strong predictive relationships existed in the 16 study pastures between early June herbage standing crops and fall/spring precipitation patterns. For example, 44% of the variation in total standing crop could be explained by either the previous October plus November rainfall or the previous September and October plus November and December rainfall. Thus, it seems appropriate that future research should focus on developing early season decision aids to assist managers in selecting optimal rates of stocking to meet desired enterprise goals *a priori*.

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