Grazing System Influences on Cattle Performance on Mountain Range

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Abstract

A 5-year study was conducted to evaluate the influences of rest-rotation, deferred-rotation, and season-long grazing systems on cattle diet botanical composition and quality and weight gains on mountain rangeland in northeastern Oregon. The grazing season in each year lasted from 20 June to 10 October. Esophageally fistulated animals were used to evaluate diet quality and botanical composition. All study pastures included forest, grassland, and meadow vegetation types. Each pasture had a north and south-facing slope divided by a riparian zone and creek. The grazing pressure for each system was similar. Grazing intensity was the same as National Forest Allotments in the area. There were no differences ($P>.05$) in weight gains among the 3 systems when data were pooled across years. Crude protein, in vitro organic matter digestibility, and acid detergent fiber percentages in fistula samples did not differ ($P>.05$) among systems for any year of study or for data pooled across years. Mid-season movements of cattle under the rest-rotation system had little influence on their diet and performance compared with cattle under the season-long system. Key forages in cattle diets were Idaho fescue *(Festuca idahoensis)*, bluebunch wheatgrass *(Agropyron spicatum)*, and common snowberry (*Symphoricarpos albus)*. Cattle diet botanical composition under the 3 grazing systems did not differ ($P>.05$).

Key Words: ruminants, nutrition, cattle diet, nutrient analysis

Although rest-rotation and deferred-rotation grazing systems have proven effective from vegetation, soil, and wildlife standpoints in mountainous areas, their influences on livestock nutrition and production are not completely understood. In Utah Laycock and Conrad (1981) found cattle daily gains on mountain range did not differ between rest-rotation and season-long grazing systems. Skovlin et al. (1976) found no cattle weight gain differences between deferred-rotation and season-long grazing systems at the Starkey Experimental Range and Forest in northeastern Oregon. Comparisons of cattle diet nutritional quality among rest-rotation, deferred-rotation, and season-long grazing systems on mountain ranges have not been reported.

The objectives of our study were to compare cattle diet botanical composition and quality and cattle performance among rest-rotation, season-long, and deferred-rotation grazing systems during 5 years on mountain rangeland in northeastern Oregon.

Study Area and Methods

The study area was located on the Starkey Experimental Range and Forest in the Blue Mountains of northeastern Oregon. A thorough description of the Starkey Range is given by Skovlin et al. (1976). The average annual precipitation is 53 cm and comes primarily as snow and rainfall in the winter and spring (Table 1). A complete description of the vegetation on the study pastures is given by Ganskopp (1978). The percentage relative cover of important forage species on the 4 study pastures is given in Table 3.

Table 1. Summary of precipitation data (cm) at the Starkey Experimental Forest and Range.

Month	24-year $\bar{x}$	1976	1977	1978	1979	1980
January	6.53	6.86	1.02	5.08	5.21	5.11
February	4.45	2.29	2.54	4.06	6.07	2.79
March	4.52	2.54	2.11	3.56	4.27	4.75
April	4.42	5.08	2.79	6.68	5.84	3.48
May	5.31	4.39	4.80	4.01	5.00	6.66
June	4.42	3.71	1.83	3.12	1.55	6.88
July	1.63	0.05	0.13	2.54	0.74	1.27
August	1.98	6.86	7.42	3.43	6.96	0.48
September	2.77	3.71	9.42	4.11	1.02	2.97
October	4.29	2.67	3.76	7.11	7.85	1.25
November	5.52	4.06	7.75	4.06	6.05	3.91
December	6.93	0.00	9.40	3.20	2.08	6.60
Total	52.77	42.22	53.00	50.96	52.64	46.15

Vegetation types included in each of the 4 study pastures were grassland (south facing slopes), forest (north facing slopes), and meadow (riparian zone). All pastures were divided by Meadow Creek and the associated riparian zone. South facing slopes, north facing slopes, and riparian zones occupied about 65%, 31%, and 4%, respectively, of each pasture.

The 4 study pastures were delineated and fenced so they would be as equal as possible in grazing capacity, vegetation composition, vegetation structure, and terrain. Size of each pasture is given in Table 2. One pasture was used for the season-long grazing system. The deferred-rotation system involved alternating grazing between early (June 10–August 15) and late use (August 16–October 10) in consecutive years on the 1 pasture. A 4 pasture–2 herd rest-rotation grazing system was applied to the remaining 2 pastures. The grazing schedule involved 1 pasture at season-long use; 1 pasture grazed early to mid-season (June 20–August 15), 1 pasture grazed mid-season to grazing season end (August 16–October 10); and 1 pasture rested.

Berry (1982) evaluated grazing pressure under the 3 systems in 1979 and 1980. His data, summarized in Table 2, show grazing pressure was nearly equal among the 3 systems. The stocking rate of the pastures was similar to that on National Forest allotments in the immediate area and many other parts of the western United States.

Hereford/Angus crossbred yearling heifers weighing 320 ± 10 kg and owned by a cooperating rancher were used to evaluate livestock performance. These heifers had been grazed on the Starkey range the previous summer as calves. During each year of study, the rest-rotation, deferred-rotation, and season-long grazing systems were stocked with 20, 20, and 10 head of yearling heifers, respectively. Three of the animals assigned to each system were owned by Oregon State University and equipped with esophageal fistulas. The grazing season lasted 120 days in each year of study. The performance of animals (weight gains) assigned to each system was evaluated in late spring (20 June to 18 July), early summer (19 July to 15 August), late summer (16 August to 12 September), and fall (13 September to 10 October). Fistulated animals were not used for livestock performance evaluation. Heifers were weighed without shrink at the onset of grazing and at the end of each period.

Diet samples from each grazed pasture were collected twice every other week during all 5 years of study. Collections on each

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Table 2. Grazing pressure under rest rotation (RR), season long (SL) and deferred rotation (DR) grazing systems.[1]

System	Total Production of forage (kg/ha)	Utilization (%) (uplands)	Utilization (%) (Riparian zone)[2]	Area (AUM's)	Animal Unit Months (Ha/AUM)	Stocking Rate Forage	Metric Tons of Available Available Forage	Grazing Pressure (AUM)/ Metric Ton of
RR	160	29	52[3] - 73%[4]	67 - 57[5]	48	2.58	19.8	2.4
SL	181	19	50	50	24	2.09	9.1	2.6
DR	128	20	70	74	24	3.09	9.5	2.5

[1] Production and utilization data were collected in 1979 and 1980 and pooled across years.
[2] Larry Bryant, Unpublished data, PNWFRES, Forest Service, LaGrande, Oregon.
[3] Ungrazed and grazed pastures.
[4] Grazed pastures only.
[5] RR1 = 67 ha, RR2 = 57 ha.

Table 3. Percentage relative cover of primary forage species on grazing system pastures and their percentage by weight contribution to cattle diets for data pooled across years and periods.

Species	% Cover[1]					Cattle Diet % Composition[12]					
	RR1	RR2	SL	DR	$\bar{x}$	RR1 $\bar{x}$	RR2 $\bar{x}$	RR[3] $\bar{x}$	SL $\bar{x}$	DR $\bar{x}$	Diet $\bar{x}$
Bluebunch wheatgrass *(Agropyron spicatum)*	16	8	7	8	10	8	14	11	12	13	13
Idaho fescue *(Festuca idahoensis)*	8	15	15	7	11	11	14	13	16	10	12
Elk sedge *(Carex geyeri)*	6	7	6	7	6	8	3	6	6	3	5
Sandberg bluegrass *(Poa sandbergii)*	7	15	16	16	14	3	6	5	5	3	4
Kentucky bluegrass *(Poa pratensis)*	8	7	7	8	8	10	6	8	7	8	7
Miscellaneous grasses	15	4	8	11	9	22	20	21	20	25	21
Total grasses	60	56	59	57	58	62	63	63	66	66	65
Clover (*Trifolium* sp.)	1	1	1	1	1	2	1	2	2	3	2
Western yarrow *(Achillea millefolium)*	3	2	2	2	2	5	5	5	2	3	4
Miscellaneous forbs	17	20	15	18	17	14	16	15	11	15	15
Total forbs	20	23	18	21	20	21	22	21	18	21	21
Common snowberry *(Symphoricarpos albus)*	7	8	9	8	8	11	8	10	9	11	10
Ninebark *(Physocarpus malvaceus)*	8	8	6	7	7	3	3	3	2	1	2
Miscellaneous shrubs	5	5	8	7	7	3	4	4	5	1	2
Total shrubs	20	21	23	22	22	17	16	16	16	13	14

[1] RR1 = Rest rotation pasture 1, RR2 = Rest rotation pasture 2, SL = Season long pasture, DR = Deferred rotation pasture.
[2] There were no statistical differences ($P<.05$) between grazing systems for any diet species or category.
[3] $\bar{x}$ of RR1 and RR2.

pasture were always made during the same week. This resulted in the collection of 12 samples from each grazed pasture for each period. Fistulated animals were moved to preselected areas and allowed to feed uninhibited until at least 1 kg of grazed forage was acquired. Fistula samples were dried in a forced-air oven at 40° C for 7 days and then ground through a 20-mesh screen. Data by Acosta and Kothmann (1978) indicate that oven drying for an extended period as in our study can elevate fiber values compared to freeze drying methods. Although our drying methods may have elevated fiber and reduced digestibility values, we doubt that it had much influence on treatment differences. Crude protein (Kjeldahl procedure) was determined by AOAC (1980) methods. The in vitro digestion technique of Tilley and Terry (1963) was modified by Vavra et al. (1973) and used to determine organic matter digestibility. Acid detergent fiber was determined using methods of Goering and Van Soest (1970). Both crude protein and acid detergent fiber were converted to an organic matter basis. Diet botanical composition of fistula samples was determined by the technique of Sparks and Malechek (1968).

Differences in diet botanical composition, diet quality and daily gains among systems were evaluated using a completely randomized one-way analysis of variance model (Steel and Torrie 1980). Animals in each pasture were used as replicates for this analysis because pastures for each grazing system were not replicated. We recognize this as an important limitation to our study. Statistical comparisons were made between grazing systems within each period and year. LSD mean separation was used to compare grazing system means. Covariance analysis was used to adjust average daily gains for initial weights at the beginning of each period.

Results and Discussion

Diet Botanical Composition

Idaho fescue *(Festuca idahoensis)*, bluebunch wheatgrass *(Agropyron spicatum)*, Kentucky bluegrass *(Poa pratensis)*, elk sedge *(Carex geyeri)*, and common snowberry *(Symphoricarpos albus)* were the most important forage species found in cattle diets (Table 3). Other researchers on similar but different pastures at the Starkey Range from those in the present study have shown these to be the primary forages for cattle (Pickford and Reid 1948; Holechek et al. 1982b,c; Holechek and Vavra 1983a). Seasonal trends in forage selection were consistent with the other studies and therefore will not be discussed.

No differences ($P>.05$) occurred between grazing systems for any forage species or category when diet botanical composition data were pooled across seasons and years (Table 3). However, there were some yearly and seasonal differences ($P<.05$) in grass, forb, and shrub consumption between the rest-rotation and season-long grazing systems.

Our research indicates rest-rotation grazing does not increase ($P>.05$) use of secondary forages, such as Sandberg bluegrass *(Poa sandbergii)* compared to season-long or deferred-rotation grazing (Table 3).

Diet Quality

Grazing systems had a small influence on overall cattle diet quality during the 5 years of study (Tables 4, 5 and 6). With seasonal advance, cattle diets showed a general decline in quality (lower crude protein and digestibility; higher acid detergent fiber) until the fall period when quality improved. Diet quality was lowest in the late summer period due to forage maturation. In years with late summer and fall rains (all years except 1980), forage regrowth occurred in the grassland openings. This explains why diet quality improved during the fall period in all years except 1980.

Table 4. Percent crude protein (organic matter basis) in diet samples by year, period, and grazing system.

Year Period[1,2]	Rest-rotation	Season-long	Deferred-rotation
1976			
Late spring	14.5	14.7	12.5
Early summer	11.1	11.3	9.3
Late summer	13.3	13.7	
Fall	11.1	11.0	
$\bar{x}$	12.5	12.7	10.9
1977			
Late spring	16.7^{a}	13.8^{b}	
Early summer	9.1^{a}	10.9^{b}	
Late summer	8.2	8.3	8.4
Fall	9.6	8.4	8.8
$\bar{x}$	10.9	10.4	8.6
1978			
Late spring	12.6	12.4	13.0
Early summer	12.1	11.0	11.6
Late summer	8.7	8.5	
Fall	10.8	9.1	
$\bar{x}$	11.0	10.2	12.3
1979			
Late spring	13.4	12.3	
Early summer	14.4	13.0	
Late summer	10.6^{a}	13.0^{b}	9.8
Fall	11.9	10.2	10.6
$\bar{x}$	12.6	12.1	10.2
1980			
Late spring	13.0	12.7	13.2
Early summer	12.4	12.1	12.1
Late summer	9.5	9.8	
Fall	8.2^{a}	9.7^{b}	
$\bar{x}$	10.8	11.1	10.6
Grazing System Overall $\bar{x}$	11.6	11.3	10.9

[1] Means with different letters are significantly different ($P<.05$).
[2] Statistical tests apply only across columns: overall means of all 3 grazing systems were compared statistically but yearly means were compared only for season-long and rest-rotation system.

Table 5. Percent in vitro organic matter digestibility in diet samples by year, period, and grazing system.

Year Period[1,2]	Rest-rotation	Season-long	Deferred-rotation
1976			
Late spring	69.3	69.4	68.0
Early summer	59.2^{a}	54.7^{b}	57.8^{ab}
Late summer	56.6	56.8	
Fall	52.1	55.2	
$\bar{x}$	59.3	59.0	62.9
1977			
Late spring	68.0	69.9	
Early summer	46.3	48.9	
Late summer	52.3	51.9	53.6
Fall	53.8	53.6	52.5
$\bar{x}$	55.1	56.1	53.0
1978			
Late spring	62.7	62.8	62.3
Early summer	62.6	62.0	62.9
Late summer	52.2	54.4	
Fall	48.1	52.2	
$\bar{x}$	56.4	57.8	62.6
1979			
Late spring	62.3	61.5	
Early summer	54.9	52.7	
Late summer	55.2	57.8	50.6
Fall	52.2^{a}	47.7^{b}	49.8
$\bar{x}$	56.2	54.9	50.2
1980			
Late spring	64.3	64.8	64.3
Early summer	58.4	59.2	54.6
Late summer	55.0	57.4	
Fall	45.2^{a}	57.7^{b}	
$\bar{x}$	57.7	59.8	59.4
Grazing System Overall $\bar{x}$	56.5	57.5	57.6

[1] Means with different letter are significantly different ($P<.05$).
[2] Statistical tests apply only across columns; overall means of all 3 grazing systems were compared statistically but yearly means were compared only for season-long and rest-rotation systems.

The years in which cattle grazing pressure under the rest-rotation system was double the season-long system (1976, 1978, 1980) are of particular interest. In these years, period differences between grazing systems were generally nonsignificant ($P>.05$). One exception was the fall period in 1980 when cattle diets in the season-long pasture had lower ($P<.05$) acid detergent fiber and higher crude protein and digestibility values than the rest-rotation pasture. The relatively dry summer in 1980 compared to other years greatly reduced fall regrowth in the grassland openings. The heavier grazing pressure associated with the rest-rotation system appears to have forced cattle to select lower quality diet than those on the season-long pasture in the fall of 1980.

The movement of cattle to a fresh pasture at the end of the early summer period in 1977 and 1979 under the rest-rotation system had little effect on diet quality characteristics compared to the season-long system. This indicates in most years forage maturation is far more important than forage availability as a determinant of cattle nutritional status under the stocking rates (30–35% utilization of forage) used in this study.

Inadequate diet crude protein concentration may be an important nutritional constraint on cattle production on the Starkey Range. Protein requirements for growing yearling heifers, as outlined by the NRC (1984), indicate 320 kg heifers require 9.7 crude

Table 6. Percent acid detergent fiber (organic matter basis) in diet samples by year, period, and grazing system.

Year Period[1][2]	Rest-rotation	Season-long	Deferred-rotation
1976			
Late spring	49.9	51.1	52.1
Early summer	48.5	51.4	53.1
Late summer	61.4	59.6	
Fall	61.3	60.6	
$\bar{x}$	55.3	55.7	52.7
1977			
Late spring	57.0^{a}	65.1^{b}	
Early summer	59.6	56.4	
Late summer	67.0^{a}	64.6^{ab}	62.1^{b}
Fall	64.9	67.3	62.9
$\bar{x}$	62.1	63.3	62.5
1978			
Late spring	54.4	53.5	54.4
Early summer	56.2	59.0	57.1
Late summer	60.3	61.1	
Fall	57.9	62.4	
$\bar{x}$	57.2	59.0	55.8
1979			
Late spring	54.9	54.2	
Early summer	62.7	61.1	
Late summer	58.2	61.1	60.2
Fall	61.4^{a}	65.4^{b}	66.1
$\bar{x}$	59.3	60.4	63.2
1980			
Late spring	58.3	57.0	56.9
Early summer	60.1	58.3	60.5
Late summer	61.9	59.1	
Fall	68.0^{a}	62.8^{b}	
$\bar{x}$	62.1	59.3	58.7
Grazing System Overall $\bar{x}$	59.2	59.6	58.5

[1] Means with different letters are significantly different ($P<.05$).
[2] Statistical tests apply only across columns; overall means of all 3 grazing systems were compared statistically but yearly means were compared only for season-long and rest-rotation systems.

protein on an organic matter basis for a .8-kg gain. Diet crude protein levels were inadequate for this level of gain during the latter half of the grazing season in 1977, 1978, and 1980. Crude protein deficiencies were most severe in the late summer period. This is consistent with other research involving cattle nutritional status on the Starkey Range (Holechek et al. 1981, Holechek and Vavra 1983a).

Common snowberry plays a critical role in permitting cattle to meet their protein requirements during the latter half of the grazing season because of its high palatability and crude protein content (11+%). This species had nearly all leaf material removed by late summer in the drought year of 1977.

The increase in diet acid detergent fiber content with seasonal advance reflected the increased consumption of grass and indicated a decline in forage intake. Holechek and Vavra (1982) found a significant ($P<.05$) negative correlation between forage intake and cattle diet acid detergent fiber concentration on other pastures at the Starkey Range.

Cattle diet in vitro digestibility differences between systems are difficult to interpret with the exception of the fall in 1980 when late summer drought occurred. Both diet digestibility and acid detergent fiber values suggest grazing system had little influence on cattle diet energy status.

Cattle Weight Gains

Grazing systems did not ($P>.05$) affect cattle weight gains in any year of study or when data were pooled across years (Table 7). Cattle weight gains did differ ($P<.05$) for some seasons within years.

After movement of cattle at mid-season in 1977, under rest-rotation, weight gains increased compared to a decrease for the season-long pasture in 1977. This difference is difficult to explain because diet quality characteristics did not differ ($P>.05$) between the 2 systems. In 1979 weight gains declined after mid-season movement under the rest-rotation system. However, weight gains also declined under the season-long pasture. Because there were no differences ($P>.05$) between the rest-rotation and season-long systems in the late summer of 1977, we doubt movement influenced cattle performance. Smoliak (1960) and Hormay (1970) have reported forced movements of cattle to another pasture can result in weight losses. Cattle in all our pastures were trailed to a scale at the end of each period. Therefore our data reflect only animal response to the new pasture and not extra handling and movement responses associated with rest-rotation grazing.

Table 7. Average daily gain (kg) for cattle by year, period and grazing system.

Year Period[1][2]	Rest-rotation	Season-long	Deferred-rotation
1976			
Late spring	0.73	0.78	0.58
Early summer	0.68^{a}	0.53^{b}	0.39^{c}
Late summer	0.70	0.63	—
Fall	0.56	0.66	—
$\bar{x}$ Daily gain	0.68	0.64	0.48
1977			
Late spring	0.95	0.76	—
Early summer	0.08^{b}	0.70^{a}	—
Late summer	0.71^{a}	0.05^{b}	0.74^{a}
Fall	0.31	0.31	0.12
$\bar{x}$ Daily gain	0.51	0.55	0.43
1978			
Late spring	0.86	0.92	0.71
Early summer	0.65	0.60	0.80
Late summer	0.15^{b}	0.30^{a}	—
Fall	0.36^{b}	0.55^{a}	—
$\bar{x}$ Daily Gain	0.51	0.57	0.76
1979			
Late spring	0.11	0.08	—
Early summer	1.05	1.31	—
Late summer	0.49	0.61	0.38
Fall	0.40	0.38	0.50
$\bar{x}$ Daily gain	0.51	0.60	0.44
1980			
Late spring	1.49	1.62	1.57
Early summer	0.10	0.38	0.15
Late summer	0.49	0.51	
Fall	-0.04	0.02	
$\bar{x}$ Daily gain	0.51	0.63	0.86
Overall $\bar{x}$	0.54	0.58	0.59

[1] Means with different letters are significantly different ($P<0.05$).
[2] Statistical tests apply only across columns; overall means of all 3 grazing systems were compared statistically but yearly means were compared only for season-long and rest-rotation systems.

Experimental Limitations

Correlation analysis was used to determine how well diet quality characteristics were associated with average daily gains using individual periods for each year as samples ($n = 50$). Coefficients of determination were 0.28, 0.23, and 0.07 for crude protein, in vitro organic matter digestibility, and acid detergent fiber with average daily gain, respectively. Trends in cattle weight gains during late spring and early summer in 1979 were highly inconsistent with other years (Table 7). We have no explanation for the low weight gains of cattle in the late spring of 1979 compared to other years since diet quality was similar to other years. It was definitely not a pasture effect as all cattle responded similarly. We did run the correlations excluding data for late spring in 1979 ($n = 48$). The coefficients of determination showed little improvement ($r^2 = 0.36$, crude protein; $r^2 = 0.29$, IVOMD; $r^2 = 0.22$, ADF). Multiple correlation using all 3 nutritional characteristics slightly improved the association ($R^2 = 0.42$, $n = 48$). These correlations suggest factors other than nutrition probably influenced cattle performance. Holechek (1980) found combining diet quality characteristics with forage intake data greatly improved associations with weight gains compared to only diet quality characteristics. Digestible energy intake and crude protein intake combined explained 83% of the variation ($n = 24$) in weight gains for cattle on forest and grassland pastures on the Starkey Range. Unfortunately, forage intake data were not collected in our study due to monetary and labor limitations.

An important limitation of our study concerns the lack of plant replication in pastures. Rest-rotation pasture 2 and the season-long pasture were very similar in terrain and composition. However, the south slope of rest-rotation pasture 1 was composed primarily of a bluebunch wheatgrass/Sandberg bluegrass plant community (Table 2). On rest-rotation pasture 2 and the season-long pasture, the south slope was dominated by the ponderosa pine/Idaho fescue and Sandberg bluegrass/bluebunch wheatgrass plant communities. The terrain on rest-rotation pasture 1 was much steeper and this appeared to influence use of the different plant communities. Lack of replications coupled with the confounding influences of terrain and vegetation differences between pastures weaken the inferences for our study.

We believe evaluation of animal travel using digital pedometers (Anderson and Kothmann 1977) could have provided useful information. During most periods of study, cattle were observed to better use the inaccessible portions of the rest-rotation and deferred rotation pastures compared to the season-long pasture. This could have increased energy expenditure involved in travel. Our data indicate little difference in diet quality among systems. However, higher utilization levels for the uplands (Table 2) indicate cattle under rest-rotation and deferred-rotation systems may have had to increase their travel to select a diet comparable to those under season-long grazing.

Conclusions

Based on our results, rest-rotation, deferred-rotation, and season-long grazing systems did not differ ($P>.05$) in terms of cattle weight gains or cattle diet quality. The grazing pressure (AUM/metric ton of forage) was nearly identical between systems and typical for many National Forest Allotments in the western United States. Our results indicate the pasture change associated with rest-rotation and deferred-rotation systems have little to no influence on weight gains compared to season-long grazing if cattle movements are under 8 km. It appears rest-rotation and deferred-rotation grazing systems can be applied to rugged mountainous rangelands in the northwestern United States with small to no influence in cattle weight gains compared to season-long grazing if stocking rates are comparable to those in our study. However, improved cattle performance does not appear to be a reason to initiate rest-rotation or deferred-rotation grazing.

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