

Cattle Responses to Continuous and Seasonal Grazing of California Annual Grassland

RAYMOND D. RATLIFF

Abstract

An 8-year (1961-1968) study at the San Joaquin Experimental Range, in the Sierra Nevada foothills in central California, compared continuous, repeated seasonal, and rotated seasonal grazing on native range, and continuous grazing on sulfur-fertilized range. Cow and calf weight responses showed continuous grazing of annual grassland range to be most productive for cow-calf production. At birth, no advantage of one grazing treatment over another was found among calf weights. At the start of the adequate green forage season, calves under both continuous grazing treatments (native and fertilized) averaged 15 kg heavier than calves under rotated seasonal grazing; calves on continuously grazed fertilized range averaged 12 kg heavier than calves under repeated seasonal grazing. At weaning, calves under continuous grazing treatments averaged 25 kg heavier than calves under seasonal grazing treatments. No advantage of one grazing treatment over another was found among mature cow weights.

Overstocking their rangeland was the reason Abram and Lot parted ways (Genesis 13:2-11). The concept of periodically resting the land was set forth by Moses (Exodus 23:10-11, Leviticus 25:1-7). Centuries later specialized grazing management or grazing systems (Range Term Glossary Committee 1974) were set forth to maintain and improve rangeland.

Most current grazing systems are designed for managing perennial grasslands. Their purpose is to improve range condition through better livestock distribution, improved plant vigor, greater seed production and seedling establishment, and breaks in habitual use patterns.

Such grazing systems may be of little value in managing annual grasslands. Annual plants grow, produce seed, and die in a single year. They need not accumulate food reserves or maintain vigor. Nevertheless, annual plants do respond to factors of seed germination and seedling establishment. And grazing management can affect annual grassland species composition, herbage yield, and livestock production.

Can better cow and calf production be obtained on annual grassland under continuous yearling grazing or under some form of grazing system? Cows kept all year in a single range unit at the San Joaquin Experimental Range, Madera County, California, had lower pregnancy and weaning percentages than cows moved to ungrazed units in August (Wagnon et al. 1959). Both groups received supplemental feeding. A third group of cows (moved but unsupplemented) had fewer stillbirths and otherwise did as well as the cows not moved. Interpreting responses of the cows not moved was, however, complicated by possible and unusual trace-element deficiencies. Their responses, therefore, were not attributed solely to grazing the same range unit yearlong. The question remained.

This paper reports cow and calf weight responses from an 8-year (1961-1968) study intended to answer that question. Herbage

residue amounts and cow reproductive performance are also discussed.

Methods

Experimental Area

The San Joaquin Experimental Range occupies about 1,862 ha of annual grass-oak woodland in the Sierra Nevada foothills. Elevations range from 213 to 518 m. Winters are relatively cool and wet. Summers are hot and dry.

Average (1934 to 1978) annual precipitation is 48.3 cm. December, January, and February are the wettest months with 8.6, 8.3, and 8.6 cm, respectively. July and August are the driest months with 2.5 mm. January is the coldest month with maximum and minimum temperatures averaging 11.8° C and 0.7° C, respectively. July is the hottest month with maximum and minimum temperatures averaging 36.7° C and 16.2° C, respectively.

Weather produces 3 characteristic forage seasons (Bentley and Talbot 1951). The "inadequate green" season begins after fall rains stimulate seed germination. During that forage season, environmental conditions usually limit plant growth. As a result, green forage is not of sufficient volume for cattle needs. Protein and energy supplements are usually necessary. The "adequate green" season begins in January or February when major grass species are 5 to 8 cm high. During that forage season, growth so accelerates that livestock cannot use all the herbage produced. The "dry" season begins when soil water becomes depleted in May or June. The annual plants produce seed and die. If it has cured well, dry season herbage may supply cattle with adequate protein and energy for several weeks.

Grazing Treatments

Historically, factors such as family tradition, ranch size, and available alternate forage have determined local practices. About half the operators (usually the larger ones) practiced a form of seasonal grazing. Cattle were taken to the higher mountains during the dry forage season. The home ranch was grazed continuously during the inadequate and adequate green forage seasons. Year-long grazing, with some attempts at rotation, was the usual practice of small and part-time operators (Voorhies et al. 1942). Practices have changed little over the years.

This study compared continuous, repeated seasonal, and rotated seasonal grazing of native (unfertilized) range and continuous grazing of fertilized range. Elemental sulfur at 67 kg/ha was applied to fertilized areas every third year.

Under continuous grazing, cattle have access to all of their range all year. In this paper, the continuous grazing treatments are abbreviated to "cont-N" and "cont-F" for continuous grazing of native and fertilized range, respectively.

Under repeated seasonal grazing, cattle are on annual grassland range yearlong, but graze specifically restricted portions of their range during given forage seasons each year. Repeated seasonal grazing was studied by Wagnon et al. (1959) and Heady and Pitt (1979). Heady (1961) rotated the time (early, mid, late) of grazing during the growing season, but opened all areas to grazing during the dry and inadequate green forage seasons.

Under rotated seasonal grazing, cattle are on annual grassland range yearlong but graze specifically restricted portions of their range rotationally. The forage season of grazing is rotated among

Author is range scientist, Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, 2081 E. Sierra Ave., Fresno, Calif. 93710.

Many people were involved in this research. Specific recognition and thanks are due to: Stanley L. Anderson (range technician/herdsman), James L. Burns (maintenance foreman), C. Eugene Conrad (range scientist), Don A. Duncan (range scientist/project leader), Robert Flournoy (rancher/cooperator, Likely, California), Charles A. Graham (range scientist/superintendent), C. Dick Hansen (rancher/cooperator, Biola, California), Merton J. Reed (range scientist/project leader), Jack N. Reppert (range scientist), Stanley E. Westfall (range technician), and E. Joseph Woolfolk (division chief/assistant director).

Manuscript accepted 10 April 1986.

different portions of the range each year.

More efficient cattle production and better herbage production occur with moderate grazing than with close grazing on annual grassland (Bentley and Talbot 1951). Moderate grazing was therefore planned under all treatments.

Range Units

Swale, open-rolling, and rocky-brushy range site classes at the San Joaquin Experimental Range are described by Bentley and Talbot (1951) and Gaylord (1972). Productivity varies with site. Herbage production was therefore monitored for 2 years to determine and equalize grazing capacities.

The 4 treatments were then randomly assigned to 2 replications (blocks) of range units. One block of range units had about 26% open-rolling sites and 74% rocky-brushy sites. The other block of range units had about 89% rocky-brushy sites and 11% open-rolling sites. The 8 range units average 91 ha in size. Range units assigned seasonal treatments were partitioned into 3 subunits for grazing in the 3 forage seasons.

Supplemental Feeding

To properly maintain their animals, ranchers in the area supplement dry and/or inadequate green herbage (Voorhies et al. 1942). Therefore, when quality herbage was in short supply, 4.5 kg/head/day of high quality alfalfa (*Medicago sativa*) hay was fed in all treatments. Iodized salt was provided in the last half of the gestation to prevent goiter in new-born calves. Block salt was provided as needed.

The Cattle

A select herd of 99 yearling Hereford heifers was brought to the San Joaquin Experimental Range in April 1959. All were of good-to-choice feeder grades, weighed 204 to 227 kg, and were raised together. In November and December 1960, they had their first calves (Duncan and Reed 1973). In January 1961, balanced weight groups of 8 cows with calves were formed from the herd. The groups were randomly and permanently assigned to treatments and range units. The cows in the groups were called "testers." Their responses and those of their calves provided the measure of treatment effects. Other cows were put into and taken out of range units as needed to assure moderate use.

The breeding program was designed so that cows under all treatments would calve from late October to early December. Testers were culled if they twice failed to conceive and/or wean a calf, were sick for a protracted period, or, of course, died. To maintain a basic herd of 8 cows, culled testers were replaced.

At the change of forage seasons, cows were individually weighed following an overnight shrink. Calves were weighed within 24 hours of birth, when their dams were weighed, and at weaning.

Herbage Production and Residue

Herbage production by treatment was 3,100 kg/ha under cont-F, 2,390 kg/ha under cont-N, 2,240 kg/ha under repeated seasonal, and 2,460 kg/ha under rotated seasonal grazing (Caldwell et al. 1985; Caldwell, Menke and Duncan, unpublished manuscript).

At the start of the inadequate green forage season, 897 to 1,121 kg/ha of herbage residue was to remain in continuously grazed range units and subunits grazed in the adequate green and dry forage seasons. Estimates of herbage residues were made along random, permanent transects, and sampling was proportional to the amount of a site class in a range unit. The overall average therefore estimated amounts left in the range unit or subunit. Residual herbage on subunits grazed in the inadequate green forage season was assumed to equal the herbage production.

Analysis of Data

Differences in cattle responses among grazing treatments were of primary interest. Owing to variation in the quantity and quality of forage, variation in cattle responses from year to year was expected. Therefore, mature cow weights (at weaning in 1964) and average calf weights (over the 8 years) expressed long-term

responses to treatment. The analysis of variance model to estimate differences between treatments was a randomized complete-block design, with 1 observation per cell. Calf weights analyzed were those at birth, at the start of the adequate green forage season, and at the start of the dry forage season (the usual weaning time). Mature cow weights were analyzed using their initial weights at the start of the study as a covariate. Determining 95% confidence intervals for pairwise differences among treatment means was by Tukey's "w-procedure" (Steel and Torrie 1960). In this paper, differences between treatments are expressed as $(\bar{X}_1 - \bar{X}_2) \pm w$, where $w = Q (SE)$. Q comes from tables for the number of means compared and error degrees of freedom.

Results

Variation in the Green Forage Season

Starting dates for the adequate green forage season (Table 1) varied from 12 January to 20 February. On the average, they were similar to those reported for the experimental range by Bentley and Talbot (1951).

Table 1. Adequate green forage season at the San Joaquin Experimental Range, Madera County, California (1961-1968).

Year	Dates		Length (days)
	Start	End	
1961	Feb. 9	May 31	111
1962	Feb. 20	June 19	119
1963	Feb. 8	July 11	153
1964	Jan. 15	June 18	155
1965	Jan. 12	July 13	182
1966	Feb. 15	May 24	98
1967	Jan. 12	Aug. 4	204
1968	Feb. 7	May 24	107
Average	Feb. 1	June 22	141

Based on past ending dates (Bentley and Talbot 1951), the adequate green forage seasons in 1963, 1965, and 1967 ended later than usual. Those were 3 of 6 years from 1935 to 1978 in which April and May precipitation exceeded 10 cm and April, May, and June average maximum temperatures were below average. Late spring rains and low temperatures delayed the dry forage season.

Grazing Use and Herbage Residue

Based on the production estimates given earlier and leaving 1,121 kg/ha of residue, grazing potentials were 1.1, 1.8, 1.2, and 1.0 AUM/ha under cont-N, cont-F, rotated seasonal, and repeated seasonal grazing, respectively. Actual use by treatment was 1.1, 1.5, 0.8, and 0.7 AUM/ha, respectively.

Differences among years in residual herbage amounts relate to

Table 2. Estimated plant residue prior to fall germination by grazing treatment at the San Joaquin Experimental Range, Madera County, California (1961-1967).

Year	Grazing treatments				Average
	Continuous		Seasonal ¹		
	Native	Fertilized ²	Rotated	Repeated	
-----Kilograms per hectare-----					
1961	701	805	495	441	610
1962	432	459	414	440	436
1963	984	1132	833	887	959
1964	1542	1478	1301	1245	1392
1965	1340	2282	1490	1201	1578
1966	1124	1226	1391	1169	1228
1967	1997	2786	2072	1900	2189
Average	1160	1452	1142	1040	1199

¹Residue in the inadequate green forage season subunits was not included.

²Fertilized with mineral sulfur every third year.

production and stocking. Average residue amounts range from 7% less to 30% more than planned (Table 2). Over all 7 years and all grazing treatments (excluding inadequate green forage season subunits), 7% more remained than planned. The lowest amount (-63%) occurred under rotated seasonal grazing in 1962. The highest amount (+148%) occurred under cont-F in 1967.

Residual herbage has little nutritional value after being leached by rain, and leaving an excess amount wastes resources. Under cont-N residual herbage averaged 39 kg/ha more than planned. Under cont-F an excess of 331 kg/ha remained. With additional cattle, another 0.3 AUM/ha/yr could have been obtained under the treatment. Including the inadequate green forage season subunits, residual amounts were 1,440 kg/ha (319 kg/ha extra) under repeated seasonal grazing and 1,581 kg/ha (460 kg/ha extra) under rotated seasonal grazing. Until the inadequate green forage season, a third of the production (one subunit) could not be used. It represents a loss of 0.3 AUM/ha/yr under repeated seasonal grazing and 0.4 AUM/ha/yr under rotated seasonal grazing.

Grazing use could probably have been heavier under all treatments during 1964, 1965, 1966, and 1967. Clawson et al. (1982) reported that 448 to 785 kg/ha of residual herbage (moderate use) produces the best cattle production on land like the San Joaquin Experimental Range. They also suggested minimum residual amounts of 448 kg/ha for lower or flat slopes, 672 kg/ha for average-gentle slopes, and 897 kg/ha for upper or steep slopes. Over the years studied, therefore, any difference among grazing treatments in residual herbage levels should have had minimal influence on cow and calf weight responses.

Relative contributions of plant species to the herbage produced may change, however, due to treatment. Moreover, differences in cow and calf responses may reflect such changes. Plant species responses to cont-N, cont-F, and the seasonal grazing treatments have been discussed (Caldwell et al. 1985; Caldwell, Menke and Duncan, unpublished manuscript).

Calf Response

Over all years and treatments, calf birth weights at the San Joaquin Experimental Range (Table 3) averaged 31.0 ± 0.8 kg. At

Table 3. Calf birth weights, weights at the start of the adequate green and dry forage seasons, and rates of gain during the adequate green forage season (over all treatments) by crop year at the San Joaquin Experimental Range, Madera County, California.

Year	Calf weights			Green season gain per day
	Birth	Green season	Dry season	
	-----Kilograms-----			
1961	28.1 ¹	82.9 ¹	176.3	0.84
1962	28.3	96.4	201.0	0.87
1963	30.8	99.1	233.4	0.87
1964	31.8	87.3	214.6	0.81
1965	31.5	90.0	244.7	0.85
1966	31.1	106.1	219.3	1.15
1967	31.2	83.2	252.0	0.82
1968	30.4	95.2	189.8	0.88
Average	31.0	94.8	217.8	0.89

¹For reader information; not used in analyses.

the start of adequate green forage, calves averaged 94.8 ± 2.8 kg. At weaning, the average calf weight was 217.8 ± 4.3 kg.

Calf weights at the start of the adequate green forage season reflect their ages more than inadequate green season forage quality. The calves were younger and weighed 90 kg or less when the adequate green forage season started in January. The calves were older and weighed over 90 kg when it started in February.

Variation in its length accounted for 90% ($R = 0.95$) of the variation in calf weight gains (Table 3) during the adequate green forage season. The longer that calves were on the range, the greater their final weights. Calf gains also reflected forage quality. Though

the 1966 season was short (98 days), the adequate green forage was of high quality. Calves gains 1.2 kg per day that season, 0.27 kg per day more than in any other year.

Larger calves are commonly asserted to have greater vitality at birth and to be larger at weaning than smaller calves. For calf birth weights (Table 4), the 95% confidence interval for the difference

Table 4. Calf birth weights and weights at the start of the adequate green and dry forage seasons by grazing treatment at the San Joaquin Experimental Range, Madera County, California.

Grazing treatment	Calf weights ¹		
	Birth	Green season	Dry season
	-----Kilograms-----		
Continuous			
Native	31.9a	100.4ab	229.0a
Fertilized ²	31.9a	101.0a	227.8a
Seasonal			
Repeated	29.5a	88.6bc	205.2b
Rotated	29.7a	86.2c	202.2b
Tukey's "w"	3.3	12.2	18.6

¹Within columns, treatment means followed by the same letter are not statistically different ($P < 0.05$).

²Fertilized with mineral sulfur every third year.

between the continuous grazing treatments and repeated seasonal grazing was 2.4 ± 3.3 kg. The true difference is, therefore, between an advantage of 0.9 kg for repeated seasonal grazing and an advantage of 5.7 kg for continuous grazing. At those extremes, an advantage for repeated seasonal grazing would little affect future calf response, but an advantage for continuous grazing could affect future calf response.

Continued supplementation after parturition should tend to reduce treatment differences in calf weights. Nevertheless, at the start of the adequate green forage season, calves under continuous grazing weighed more than calves under seasonal grazing (Table 4). Calves were 14.2 ± 12.2 kg heavier under cont-N and 14.8 ± 12.2 kg heavier under cont-F than calves under rotated seasonal grazing. Also, calves under cont-F were 12.4 ± 12.2 kg heavier than calves under repeated seasonal grazing.

Treatment differences were amplified during the adequate green forage season. At the start of the dry forage season (the usual weaning time), calves under continuous grazing (Table 4) averaged 25 kg heavier than calves under seasonal grazing. Between cont-N and repeated and rotated seasonal grazing, the differences were 23.8 ± 18.6 kg and 26.8 ± 18.6 kg, respectively. Between cont-F and repeated and rotated seasonal grazing, the differences were 22.6 ± 18.6 kg and 25.6 ± 18.6 kg, respectively.

Similar results were reported by Duncan and Reed (1973). And continuous grazing gave better lamb weights and ewe performance than seasonal grazing of annual grassland (Heady 1961, Heady and Pitt 1979).

Cows under continuous grazing had the entire range unit for selecting forage. Those under seasonal grazing had one-third as much area. Consequently, although all cows received equal rations of hay, cows under continuous grazing had greater opportunity, after calving, to select diets conducive to high lactation rates. That may explain the heavier calves under continuous grazing at the start of the adequate green forage season.

Stocking rate differences during the adequate green forage season explain part of the difference in weaning weights between continuous and seasonal grazing treatments. Average stocking rates for cont-N and cont-F units were 2.3 and 1.9 ha/AUM, respectively. Average stocking rates for rotated and repeated seasonal subunits were 0.8 and 0.9 ha/AUM, respectively. Cows and calves under continuous grazing did not have to graze as closely as cows and calves under seasonal grazing. As a result, cows and calves under continuous grazing could be more selective in choos-

Table 5. Starting and mature tester cow weights and 95% confidence intervals for the mean cow weights at the start of the dry forage season (1961-1968) on the San Joaquin Experimental Range, Madera County, California.

Grazing treatment	Starting weight	Mature weight ¹	Confidence Interval ²
Kilograms			
Continuous			
Native	331.6	503.5a ³	471.3 ± 34.2
Fertilized ⁴	339.7	518.7a	492.8 ± 36.0
Seasonal			
Repeated	326.3	464.9a	441.3 ± 24.1
Rotated	336.8	459.4a	437.1 ± 21.1
Average	333.6	486.6	
Tuckey's "w"		146.4	

¹At weaning of calves (18 June 1964) and adjusted for covariate effects of starting weights (10 Jan. 1961).

²For reader information. Cows without calves were not included. Confidence intervals for individual treatment means should not be used to assess treatment effects.

³Within column, values followed by the same letter are not statistically different ($P < 0.05$).

⁴Fertilized with mineral sulfur every third year.

ing their diet (at least toward the end of the adequate green forage season).

Cow Responses

Weights of original tester cows that weaned calves in 1964 were used to estimate grazing treatment effects on the cows. Cow weights (taken on a specific date) summarize all influences from the start of the study. By 1965, many of the original testers in some range units had been replaced. Because their histories and those of the testers differed, replacement cow weights could not be used to reflect long-term treatment effects. Weights of all cows (replacements as well as testers) were used by Duncan and Reed (1973). The weights they reported therefore differ from those given here.

The 95% confidence interval for the difference in weights of mature cows (Table 5) under cont-F and those under rotated seasonal grazing, was 59.3 ± 146.4 kg. The true difference is, therefore, somewhere between an advantage of 87.1 kg for rotated seasonal grazing and an advantage of 205.7 kg for cont-F. Confidence intervals for other continuous and seasonal grazing comparisons may be similarly interpreted.

Ranchers commonly accept the premise that large cows produce large calves. Continuous grazing produced larger calves than seasonal grazing. Any true difference in cow weights is, therefore, likely an advantage for continuous grazing.

Fewer heifers may need be retained annually under rotated seasonal grazing. Over all years and grazing treatments, 34 (7.1% per year) of the original 64 cows were replaced. By treatment, replacements were 63% (cont-N), 56% (cont-F), 63% (repeated seasonal), and 31% (rotated seasonal). For all treatments, except rotated seasonal, 1 or more replacement cows were replaced.

The overall weaning rate was 0.88 calf/cow. Average weaning rates were 0.85 (cont-N), 0.87 (repeated seasonal), 0.90 (cont-F), and 0.90 (rotated seasonal).

The overall conception rate was 0.95 calf/cow. Conception by treatment averaged 0.91 (cont-N), 0.95 (repeated and rotated seasonal), and 0.98 (cont-F). The overall weaning rate per pregnant cows was 0.93 calf/cow. Average weaning rates were 0.91 (repeated seasonal), 0.92 (cont-F), 0.94 (cont-N), and 0.95 (rotated seasonal).

Conclusions

For cow-calf operators dependent yearlong on annual grassland of the Sierra Nevada foothills, continuous grazing should be more productive than seasonal grazing. That conclusion is consistent with previous findings of livestock responses on annual grassland range. To maintain productivity of the resource base, stocking to obtain moderate use is recommended.

At the San Joaquin Experimental Range, calves on range grazed continuously were heavier at weaning than calves on range divided into seasonal units grazed repeatedly or in rotation. At a market price of \$1.36/kg, (based on the 95% confidence interval), the return per calf under continuous grazing on native range would be between \$11.15 and \$61.74 more than per calf under rotated seasonal grazing. Whether differences of those sizes will induce cow-calf operators to change from seasonal to continuous grazing depends on cost-return relationships.

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