Cattle Grazing a Riparian Mountain Meadow: Effects of Low and Moderate Stocking Density on Nutrition, Behavior, Diet Selection, and Plant Growth Response[1]

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ABSTRACT: Twelve ruminally cannulated and six intact crossbred beef steers were used in a randomized complete block design to evaluate the effects of stocking density of a riparian pasture in the Sierra Nevada mountains on grazing behavior, dietary selection, forage intake, digesta kinetics, and growth rates of *Carex nebraskensis* and *Juncus balticus*. Nine .5-ha pastures were assigned to one of three treatments: ungrazed (CON) or grazed to leave either 1,500 kg/ha (LOW) or 1,000 kg/ha (MOD). Two collections were conducted during the summer of 1992 (following winter drought) and 1993 (following above-average winter precipitation). Standing crop biomass was greater ($P < .05$) in grazed pastures than in CON pastures at initiation of grazing in 1992 but not in 1993. After grazing in both 1992 and 1993, a treatment × intrapasture location interaction was noted ($P < .05$). Tiller growth rates in both 1992 and 1993 were affected ($P < .05$) by a treatment × growth period interaction. Stocking density did not alter ($P > .10$) botanical or chemical composition of the diet in 1992, and only minor differences were noted ($P < .05$) in 1993. Forage intake, passage rate measures, and total time spent loafing did not differ ($P > .10$) between LOW and MOD steers. Within the mid-meadow area in 1992, loafing time was greater ($P < .05$) for MOD steers than for LOW steers. In 1993, a treatment × trial interaction was noted for loafing time in all three areas. Total time spent grazing was greater ($P < .05$) for MOD steers than for LOW steers in 1992 and was affected ($P < .05$) by a treatment × trial interaction in 1993. In 1992 grazing time along the streamside was greater ($P < .05$) for LOW steers than for MOD steers, and significant treatment × trial interactions were noted for grazing time spent along the forest edge and mid-meadow areas. In 1993, only streamside grazing time was influenced by treatment being greater ($P < .05$) for MOD steers than for LOW steers. In general, our data suggest that management decisions to reduce stocking densities may force cattle to congregate along streambanks and to concentrate grazing and loafing activities in those areas.

Key Words: Cattle, Stocking Density, Forage Intake

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Introduction

In recent years, there has been increasing concern over the impact of livestock on streamside vegetation. Livestock can affect streamside vegetation and associated meadows by removing vegetation and congregating along the streambanks (Kauffman and Krueger, 1984). Although excessive removal of vegetation is deleterious, moderate grazing of the riparian area may enhance the watershed by preventing decadent or stagnant plant communities (Anderson, 1993) and by increasing forage production (Sedgwick and Knopf, 1991). Nonetheless, cattle can spend a greater amount of time along the riparian area than in upland areas (Marlow and Pogacnik, 1986), which increases the opportunity for trampling damage.

Livestock grazing of riparian zones has been the focus of concern for public and private land managers. This concern has at times led to the reduction of stocking rates for riparian areas to reduce the impacts of grazing. Unfortunately, few replicated studies are available to adequately assess whether reduced stock-

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ing reduces the impact of livestock to the riparian ecosystem.

Therefore, our objective was to evaluate low and moderate stocking effects on cattle behavior, intake, and dietary selection, as well as plant growth in a riparian pasture system.

Materials and Methods

Research Site. The study site was established in 1989 on upper Big Grizzly Creek in Plumas County, CA, approximately 80 km northwest of Reno, NV, and is located on a riparian mountain meadow in the Sierra Nevada Mountains at an elevation of 1,933 m. The meadow is surrounded by a mixed coniferous forest composed primarily of lodgepole pine (*Pinus contorta* Dougl.), ponderosa pine (*P. ponderosa* Dougl.), Jeffery pine (*P. jefferyi* Grev. & Balf.), Douglas fir (*Pseudotsuga menziesii* [Mirb.] Franco.), and white fir (*Abies concolor* [Gord. & Glend.] Lindl.) and is divided by the east-flowing Big Grizzly Creek. Dominant plant species within the meadow include Kentucky bluegrass (*Poa pratensis* L.), tufted hair grass (*Deschampsia caespitosa* [L.] Beauv.), California oatgrass (*Danthonia californica* Bol.), sedges (*Carex nebraskensis* Dewey; *C. exserta* Mkze.; *C. aquatilis* Whal.), rush (*Juncus balticus* Willd.), purple camas (*Zigadenus exaltus* Eastw.). Rydbergs penstemon (*Penstemon rydbergii* A. Nels.), yampa (*Polygonum bistortoides* Pursh.), clover (*Trifolium longipes* Nutt.), and buttercup (*Ranunculus alismaefolius* Geyer). Before establishment of the experimental pastures in 1989, the study site was one pasture of a three-pasture rotational grazing system and was grazed for approximately 2 wk in each month of June, July, and August.

Treatment Design. In the summers of 1992 and 1993, the present grazing study was conducted utilizing ruminally cannulated steers. Previously, in 1989, 5 ha of the meadow was fenced into 10 .5-ha pastures (Figure 1). Each pasture contained nearly equal areas of the forest-edge, mid-meadow, and streamside communities. An additional .5 ha pasture adjacent to the experimental pastures was established in 1992 as a holding pasture for experimental cattle. The study pastures were arranged as a randomized complete block design with three treatments. Pastures were arranged in blocks to account for any gradient that might exist from the upstream to downstream area. Block was a significant factor in all data analyses. Within each of the three blocks, pastures were randomly allotted to 1) no grazing (control; **CON**); 2) grazed to leave 1,500 kg/ha (**LOW**); or 3) grazed to leave 1,000 kg/ha (**MOD**). A fourth control pasture was also included in the pasture design but was not used in the data analysis. Each year, turnout of cattle was allowed when bluegrass was in mid-bloom and clover, camas, penstemon, and buttercup were in

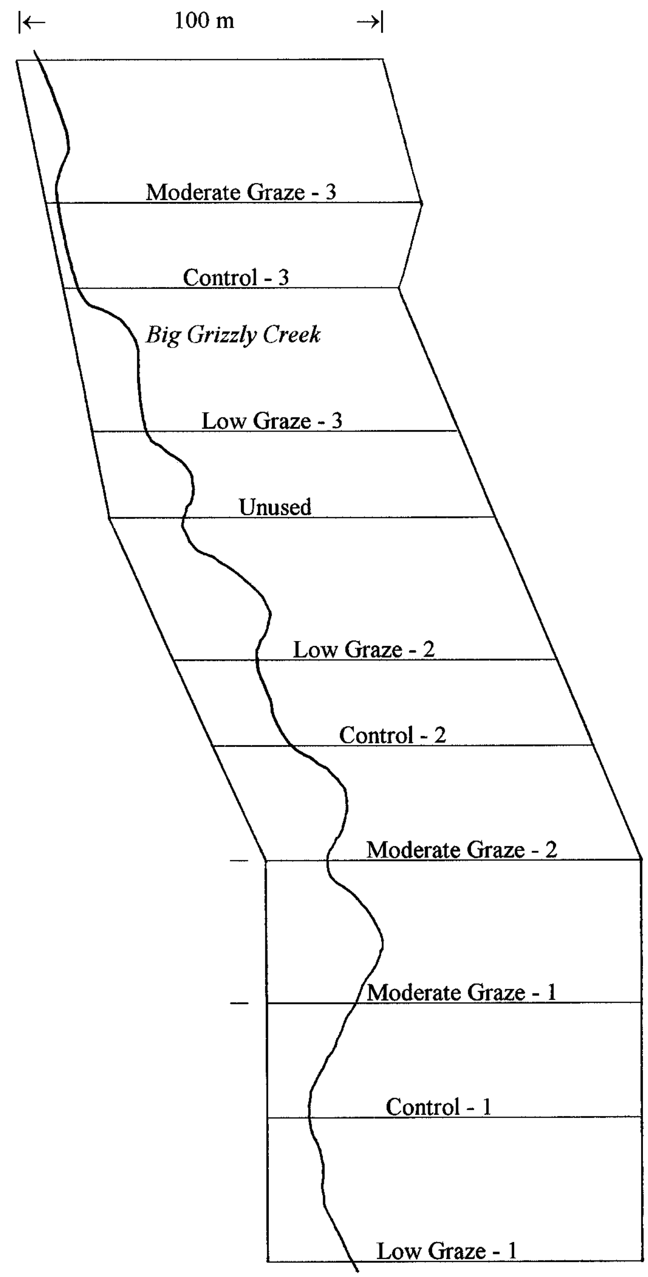

Figure 1. Diagram of pasture layout and randomization of treatments (Control = no grazing; Low graze = grazed to leave 1,500 kg/ha; Moderate graze = grazed to leave 1,000 kg/ha) and blocks (1 to 3).

bloom to seedset. Grazing treatments for the nonstudy years of 1989, 1990, and 1991 were short-term (7 to 14 d) at a high stocking density that achieved the study objectives.

Precipitation in the study area occurs primarily in the winter months as snow. Before initiation of the present study and during the study (1986 to 1992), the entire region had experienced drought conditions. During the first year of this study (1992), precipitation at a nearby site (Quincey, CA) was 60% of normal. Conversely, during the winter preceding the 1993 data collection, precipitation at the same site (Quincey, CA) was 150% of normal. At termination of the animal sampling in both years, nearly all major forage plants had become senescent.

In both years, data were collected from 12 ruminally cannulated crossbred steers (beef × Holstein; 1992 average BW 195 ± 4.0 kg; 1993 average BW 242 ± 3.2 kg). The steers were allotted (two per pasture) to one of the six grazed pastures (three LOW pastures and three MOD pastures). Additionally, in both years, two extra steers (average BW 198 ± 2.0 kg) were allotted to each MOD pasture; data were not collected from these extra steers. A different group of cattle was used to graze the study pastures in each of the collection years because of the need to keep animal size minimal and stocking density similar so that duration of grazing could be extended as long as possible. During 1992, the grazing period was limited to May 22 to June 18 in order to achieve the prescribed forage removal. In 1993, pastures were grazed from July 11 to August 11. The later grazing period in 1993 was a result of the large amount of snow that left standing water on the meadow. Each year before steers were allotted to each pasture, the steers grazed a holding pasture as a group for the first 24 h after introduction to the study site.

Steers were ruminally cannulated at least 8 wk before sampling began, and surgical and animal care procedures followed recommendations of the Consortium (1988) and were approved by the University Animal Care and Use Committee. Cattle had free access to trace mineral salt (Diamond trace mineralized salt; Diamond Crystal Salt, St. Clair, MI; guaranteed analysis [percentage of DM]: NaCl, 97 to 99; Zn, .85; Mn, .22; Fe, .21; Mg, .10; Cu, .30; I, .01; and Co, .006); salt was placed along the forest edge. Stream water was the major source of water; however, in 1992, as a result of drought conditions, stream flow was minimal. Thus, 379-L water troughs were placed along the streambank in each pasture before the first collection; troughs were not used in 1993.

Sampling Procedures. Before cattle turnout, and after removal of cattle, standing crop biomass was estimated by clipping forage to ground level inside .1-m^2 frames (nine per pasture). Within each pasture, three frames were clipped in each of the vegetation communities (forest edge, mid-meadow, and streamside) along paced transects. Herbage samples were sorted for only current year's growth and were dried at 60°C to a constant weight and allowed to air equilibrate before weighing to determine standing crop. Average forage production for the 2 yr studied was approximately 2,700 kg/ha for the 3-mo summer growing season.

Tiller growth rates were measured for *C. nebraskensis* (**CAREX**) and *J. balticus* (**JUBA**) in all nine pastures. These two plants were selected for evaluation because they are found in abundance within the pasture, persist throughout the growing season, and have been reported to contribute up to 50% of the forage base in the Sierra Nevada mountains. Within each pasture, two 10-m transects, one at streamside and the other at mid-meadow, were randomly established. Ten tillers of each of the two plants along each transect were identified and marked at ground level with a permanent marker. In 1992, plants were initially marked on May 31 and growth was measured every 10 d for the next 30 d and then 30 d later. In 1993, growth was initially measured on July 15 and was measured every 15 d for the next 45 d. Sampling in 1993 was delayed because of delayed plant phenology as a result of snow runoff.

During 1992, 7-d collections for diet composition, forage intake, and behavior began on June 5 (**EJUN**) and on June 12 (**MJUN**); in 1993, collections began on July 26 (**JULY**) and August 4 (**AUG**). At 0600 on d 1 of each collection period, the same two ruminal cannulated steers per pasture were ruminally evacuated for diet collections (Lesperance et al., 1960). Steers were gathered within each pasture at 0500 and evacuated of their reticuloruminal contents. Steers were released to freely graze the pasture for approximately 1 h; access to salt and water was denied. Newly grazed masticate was removed (more than 2,000 g/steer), and ruminal contents were replaced. Approximately 1,000 g of masticate per steer was composited within treatment, rinsed with water, and labeled with Yb to serve as a particulate phase marker (Teeter et al., 1984). Each steer's remaining masticate was freeze-dried (Virtis Freeze Drier, Virtis, Gardner, NY) using methods described by Broesder et al. (1992). Freeze-dried masticate was used for diet botanical and chemical analysis of the diet and for determination of in vitro OM disappearance.

From 1800 on d 1 to 1800 on d 2, behavioral observation were recorded for each of the two ruminal cannulated steers in each pasture. Each steer's activity (grazing, lying, standing, and watering) as well as its location within the pasture (forest edge, mid-meadow, and streamside) was recorded every 15 min for 24 h. The same two trained observers were used both years. Night observations were conducted using a 300,000 candle-power spotlight. Gary et al. (1970) determined that observations at 15-min intervals provide reliable data for the activities of beef cattle on pasture. For purposes of analysis, behavior was grouped into two categories, grazing and loafing. Loafing was the sum of lying, watering, and standing behavior. Watering was not analyzed separately because of the use of watering troughs in 1992 and because few observations were recorded for this activity.

At 0600 on d 3 of each sampling period, Yb-labeled masticate was stratified from the mid-ventral to mid-dorsal sections of the rumen in each steer. Due to differences in DM and Yb concentrations, doses varied in size (range of 2.3 g of YB to 3.2 g of Yb and range of

32 to 50 g of DM dosed). Fecal samples were taken from the rectum at 0, 10, 14, 20, 24, 28, 32, 36, 42, 48, 54, 72, 84, and 96 h after dosing.

On d 7 of each collection period, approximately 500 mL of whole ruminal contents was withdrawn from each ruminally cannulated steer in each pasture. The sample was strained through four layers of cheesecloth and placed into airtight containers. The samples were placed in an insulated cooler containing warm water (39°C) for transport to the laboratory to be used as inoculum for determination of in vitro OM disappearance (IVOMD; Judkins et al., 1990).

Laboratory Analysis. Freeze-dried ruminal masticate samples were ground in a Wiley mill to pass a 2-mm screen and analyzed for DM, ash, and Kjeldahl N (AOAC, 1984). Neutral detergent fiber, ADF, ADL, and ADIN were analyzed by nonsequential methods of Goering and Van Soest (1970).

Diet botanical composition was determined through microhistological techniques described by Sparks and Malechek (1968); however, samples of masticate were soaked in 5.5% (wt/vol) sodium hypochlorite (domestic bleach) for 30 min before being placed on slide mounts (Holechek et al., 1982a). Five slides were prepared for each steer's masticate in each collection period and 20 random fields/slide were located. Because of similarities in plant cell structure, individual identification of some plant species was impossible. Specifically, the following plants were grouped: *Poa pratensis*, *P. glaucifoila*, and *P. bulbosa* (**POA**); *Danthonia californica* and *Deschampsia caespitosa* (**DACA**); *Sitanion hystirx* and *Deschampsia elongata* (**SIDE**). In addition to expression by individual species, dietary composition was grouped by total grasses, total grass-like (*Carex* spp. and *Juncus balticus*), total forbs, and total browse.

Fecal grab samples collected for particulate passage rate estimates were dried in a forced-air oven at 60°C and ground in a Wiley mill to pass a 2-mm screen. Ytterbium was extracted using .1 *M* diethylenetriaminepentaacetic acid (Karimi et al., 1987) that contained 1 g of KCl/L as an ionization buffer. To correct for background interference, standards were made using fecal material collected before Yb was dosed. Ytterbium concentration were measured by atomic absorption spectrometry with a nitrous oxide-acetylene flame. One composite fecal sample from the 24-, 48-, 72-, and 96-h samples for each steer was analyzed for DM and ash so that fecal output estimates could be corrected for ash content.

Calculations and Statistical Analyses. Standing forage production was estimated for each area within each pasture using the average of the three clip-plots. Quantity of forage remaining was computed and expressed as kilograms per hectare. Tiller growth of *Carex nebraskensis* and *Juncus balticus* was expressed as daily growth by dividing the length of each tiller by the number of days since the previous measurement. Fecal Yb concentration curves were fitted to a one-compartment model (Pond et al., 1988) using the nonlinear regression option (Marquardt method) of SAS (1988). Particulate passage rate, retention times, gastrointestinal fill, and fecal output were estimated using the one-compartment model (Krysl et al., 1988). Intake was estimated from fecal OM output and IVOMD.

Using the GLM procedure of SAS (1988), within each year, standing crop biomass by clip date, diet botanical and chemical composition, grazing behavior and area of use, forage intake, and digesta kinetics were analyzed as a split-plot in a randomized complete block design (Gill, 1986). Treatment (forage removal) was tested against treatment × block (error a), and the effect of sampling period and treatment × sampling period were tested against residual error (error b). A split-split-plot within a randomized complete block design was used to analyze tiller daily growth response by *C. nebraskensis* and *J. balticus*, and the respective two- and three-way interactions were added to the model. When a significant *F*-test was detected ($P < .05$) with tiller growth data, the least significant difference procedure was used for mean separations (Steel and Torrie, 1980). All data were analyzed within year because of the use of different collection steers and plants. Although differing environmental conditions (i.e., precipitation) would make examination of interactions with treatment of interest, these interactions are confounded with the use of different cattle.

Results and Discussion

Standing Crop Biomass. In 1992, standing crop biomass (Table 1) at initiation of grazing was greater ($P < .05$) in grazed pastures (LOW and MOD) than in CON pastures; LOW and MOD pastures did not differ ($P > .10$). Before grazing began in 1993, no difference was noted ($P > .10$) in standing crop biomass among treatments. Reasons for the greater standing crop of forage in the grazed pastures in 1992 are not readily apparent. By visual observation, the CON pastures had considerably more litter build-up than grazed pastures, which may have insulated the soil and prevented soil temperatures from rising as quickly as in the grazed pastures. The litter build-up, however, seemed to be removed by overland movement of water (flooding) following the above-average snowfall of 1993. Popolizio et al. (1994) noted that removal of grazing on a riparian area in north central Colorado resulted in increased litter accumulation, and this litter cover seemed to decrease foliar cover. Furthermore, Sharrow and Wright (1977) and Kauffman et al. (1983) noted a delay in plant phenology as a result of removing grazing. Our results would support the concept that litter slows initiation of plant growth. In 1992, the accumulation of litter delayed spring growth on ungrazed compared with grazed pastures; however,

Table 1. Standing crop biomass (kilograms/hectare) at initiation of grazing and at cessation of grazing a Sierra Nevada mountain meadow pasture during 1992 and 1993

	Pre-grazing				Post-grazing			
	Grazing treatment[a]				Grazing treatment[a]			
Item	CON	LOW	MOD	SEM[b]	CON	LOW	MOD	SEM[b]
1992 total	1,164[d]	1,402[e]	1,374[e]	62.8	1,432	1,369	1,020	86.0
Forestedge	728	759	787	50.9	845[g]	1,005[g]	1,049	49.2
Mid-meadow	1,087	1,183	1,219	85.5	1,539[eh]	1,386[deh]	1,049[d]	66.1
Streamside	1,677	2,264	1,916	184.9	1,912[eh]	1,715[eh]	960[d]	186.0
SEM[c]	182.9	131.0	38.5		168.3	132.3	40.5	
1993 total	3,241	3,616	3,813	162.7	2,685	1,594	1,134	96.3
Forestedge	2,448	3,060	2,147	185.7	1,566[g]	1,358[g]	1,178	104.0
Mid-meadow	3,614	3,897	4,455	180.9	2,940[eh]	1,568[dh]	1,121[d]	282.7
Streamside	3,662	3,891	4,836	282.0	3,549[fh]	1,857[eh]	1,104[d]	384.3
SEM	220.7	185.5	482.8		310.0	146.8	58.1	

[a]CON = ungrazed; LOW = grazed to leave 1,500 kg/ha; MOD = grazed to leave 1,000 kg/ha.
[b]n = 9 for locations and n = 27 for total.
[c]n = 9 for treatment means within location.
[d,e,f]Within a row, treatment means lacking a common superscript letter differ ($P < .05$).
[g,h]Within a treatment, location means lacking a common superscript letter differ ($P < .05$).

in 1993, removal of litter by flooding resulted in no difference among pastures in standing crop biomass. Standing crop biomass before grazing during 1992 and 1993 differed ($P < .05$) among locations. Specifically, forest edge locations produced less ($P < .05$) standing crop (1992, 758 kg/ha; 1993, 2,552 kg/ha) than mid-meadow areas (1992, 1,163 kg/ha; 1993, 3,998 kg/ha) or streamside locations (1992, 1,952 kg/ha; 1993, 4,129 kg/ha). Differences were noted between the mid-meadow and streamside locations in 1992 ($P < .05$) but not in 1993 ($P > .10$). Standing crop biomass differences between the forest edge and streamside locations may be reflective of both the soil moisture gradient and light availability.

After grazing in both 1992 and 1993, a treatment × location interaction was noted ($P < .05$) for standing crop biomass. In both 1992 and 1993, at the forest edge location (Table 1), no difference in standing crop biomass was noted ($P > .10$) among treatments, whereas at the mid-meadow location and streamside location, standing crop was less ($P < .05$) for the MOD pastures after grazing than for the CON pastures. In 1992, standing crop biomass at the streamside locations was similar ($P > .10$) between the CON and LOW pastures, and in the mid-meadow area, LOW pastures were similar ($P > .10$) to both the CON and MOD pastures. The LOW grazing treatment did not seem to significantly reduce the amount of forage produced in the pastures compared with the CON pastures. Similar results were noted by Clary and Booth (1993) with light stocking rates, but these researchers found heavier use of the mid-meadow than streamside with moderate stocking. Conversely, standing crop biomass after grazing in 1993 was less ($P < .05$) in the LOW pastures at both the mid-meadow location and the streamside location than in the CON pastures. Although streamside locations for the LOW pastures had greater ($P < .05$) standing crop than MOD pastures, in the mid-meadow locations LOW pastures did not differ ($P > .10$) from the MOD pastures. Following grazing in 1992 and 1993, standing crop in the CON and LOW pastures was less ($P < .05$) for the forest edge locations than for the mid-meadow and streamside locations, which did not differ ($P > .10$); standing crop biomass remaining in the MOD pastures did not differ ($P > .10$) by location. These results indicate that in an above-average precipitation year, MOD grazing resulted in less variation among locations within the pasture than did LOW grazing.

Ungrazed pastures' post-grazing standing crop biomass in 1992 numerically increased over pre-grazing standing crop estimates, whereas in 1993 post-grazing standing crop biomass declined compared with pre-grazing estimates. Total standing crop biomass in grazed pastures declined in both years. The reason for the lack of a decline in biomass within CON pastures during 1992 may be their delayed phenology as a result of litter accumulation. Conversely, the decline in standing crop in CON pastures between pre- and post-grazing may reflect the lack of litter and the abundance of forbs in the spring that become senescent and wither.

1992 Tiller Growth Rates. Tiller growth rate of CAREX was affected ($P < .05$) by a treatment × growth period interaction. No influence of any main effects or other interactions was noted ($P > .10$). Only on June 10 and 20 did growth rate of CAREX differ ($P < .05$; Figure 2a) among treatments. Growth of CAREX measured on June 10 was similar ($P > .10$) for CON and MOD, which were greater ($P < .05$) than LOW. Conversely, at the June 20 measurement CON and LOW were similar ($P > .10$) but greater ($P < .05$) than MOD. Herbage growth rates have been reported

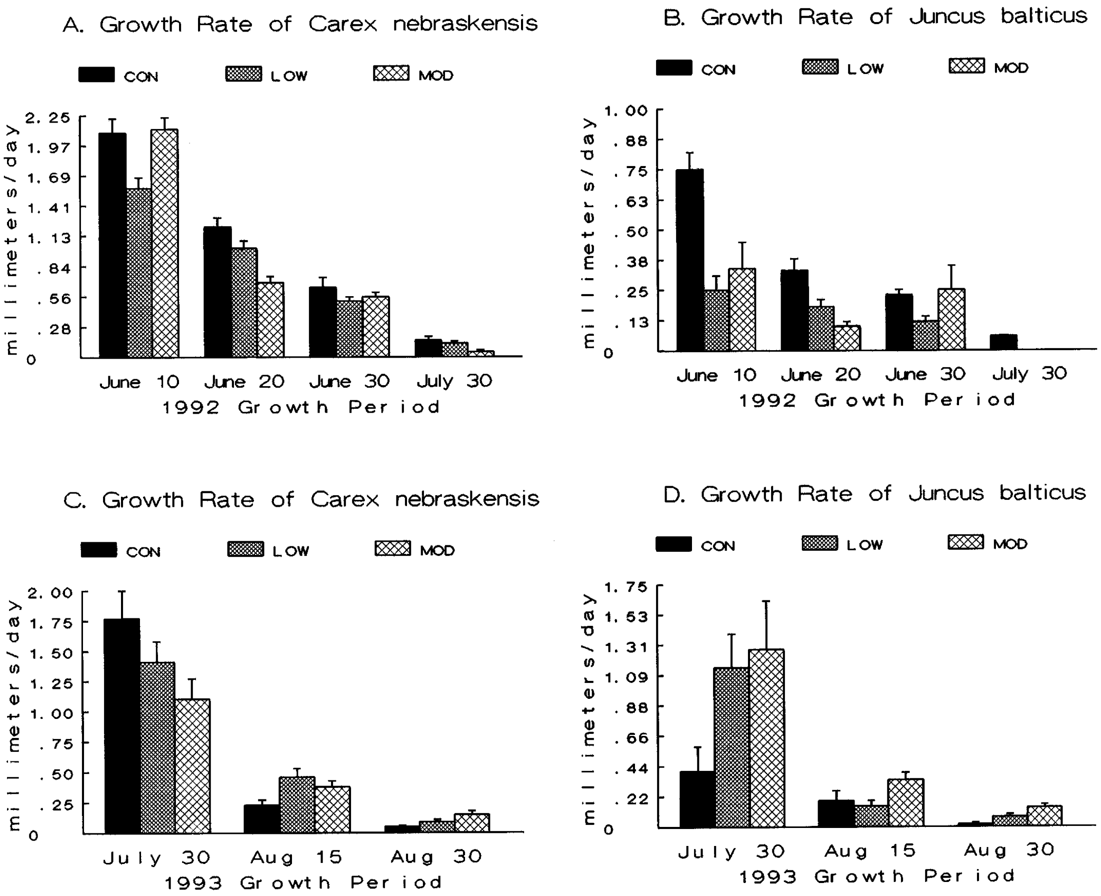

Figure 2. Growth rates of *Carex nebraskensis* and *Juncus balticus* by treatment (CON = ungrazed; LOW = grazed to leave 1,500 kg/ha; MOD = grazed to leave 1,000 kg/ha) and growth period for 1992 and 1993.

to decrease (Curll and Wilkins, 1983) or remain unchanged (Heitschmidt et al., 1989) as a result of an alteration of stocking density. In all treatments, advancing season (growth period) caused a continual reduction in growth rate of CAREX, although MOD grazing caused the largest drop in growth rate between May 31 and June 20. Ratliff (1982) determined that CAREX in the Sierra Nevada mountains generally begins full bloom by mid-July, and thereafter growth rates decline as senescence begins. Conversely, in our study, during the drought of 1992, plant growth seemed to have halted by early July.

Growth rate of JUBA was also significantly influenced by a treatment × growth period interaction and a treatment × location interaction; no main effects or other interactions were noted ($P > .10$). Comparison of growth rates for JUBA tillers by location within a treatment revealed no differences ($P > .10$; Figure 3a) between locations in either the CON or the LOW pastures; however, in MOD pastures JUBA tiller growth rate was less ($P < .05$) in the mid-meadow area than along the streamside zone. Evaluation of tiller growth rates of JUBA within location and among treatments shows that in the mid-meadow CON pastures had greater ($P < .05$) growth rates than either of the grazed treatments, which did not differ ($P > .10$). Within the streamside area, tiller growth rates of JUBA were similar ($P > .10$) in the MOD and CON pastures, which were both greater ($P < .05$) than for the LOW pastures.

Tiller growth rate of JUBA declined ($P < .05$; Figure 2b) across sampling dates but for all treatments was similar ($P > .10$) between the June 20 and 30 sampling. Similar to growth rates of CAREX, JUBA growth rates among treatments differed ($P < .05$) only at the June 10 and June 20 measurements; statistical differences were identical to those for CAREX. Although tiller growth rates for CAREX and JUBA were greater in CON pastures at turnout of the steers (June 10 measurement), standing crop biomass was greater in the grazed pastures than in CON pastures. Again, observed differences in litter cover (greater in the CON pastures than grazed pastures) may be responsible for the increased growth rate as a result of greater soil moisture retention in the CON pastures.

1993 Tiller Growth Rates. Carex nebraskensis growth rates in 1993 were influenced ($P < .05$) by the location main effect and a treatment × growth period interaction; no other main effects or interactions were

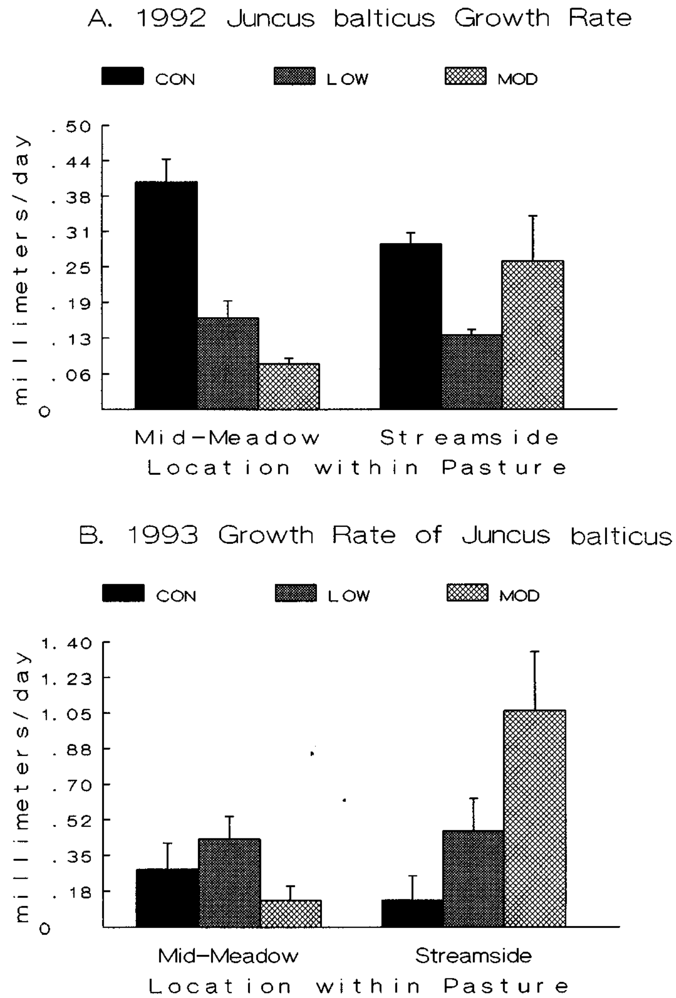

Figure 3. Growth rates of *Juncus balticus* within treatment (CON = ungrazed; LOW = grazed to leave 1,500 kg/ha; MOD = grazed to leave 1,000 kg/ha) across the growing season for the mid-meadow and streamside locations during 1992 (*A*) and 1993 (*B*).

significant. Growth rates of CAREX within the streamside area (.81 mm/d) were greater ($P < .05$) than growth rates in the mid-meadow area (.44 mm/d). The treatment × growth period interaction indicates that as season progressed, growth of CAREX declined ($P < .05$) in all three treatments. Although growth rates did not differ ($P > .10$; Figure 2c) among treatments at the August 15 and August 30 measurements, during the first measurement period (July 30 measurement), tiller growth rates were greatest ($P < .05$) in the CON pastures, least ($P < .05$) in the MOD pastures, and intermediate ($P < .05$) in the LOW pastures.

During 1993, tiller growth rate of JUBA was influenced by a treatment × growth period interaction and a treatment × location interaction; no main effects or other interactions were significant. Evaluation of tiller growth rates of JUBA among treatments within a pasture location shows that JUBA tiller growth within the mid-meadow area did not differ ($P > .10$; Figure 3b) among treatments, but in the streamside area, tiller growth rates were greater ($P < .05$) for MOD than for CON or LOW, which did not differ ($P > .10$). Consideration of pasture location differences within a treatment indicates that only in the MOD pastures was a difference noted ($P < .05$) between the mid-meadow and streamside area for tiller growth of JUBA. Elongation for JUBA numerically declined (Figure 2d) as the season progressed in all three treatments, but only for the grazed pastures was this difference significant. Grazed pastures also had increased ($P < .05$) rates of growth for JUBA at the July 30 measurement, but this difference did not persist.

Diet Composition. No treatment × collection period interactions were noted ($P > .10$) in either 1992 or 1993 for any botanical or chemical component of the diet. In 1992, no treatment differences occurred ($P > .10$) for any botanical component of the diet (Table 2). Conversely, in 1993, steers in LOW pastures consumed less of the POA group (LOW, 12.8%; MOD, 13.9%) and less total grass-like plants (LOW, 34.7%; MOD, 37.9%) than steers grazing the MOD pastures. These differences were relatively small (1.1% and 3.2%, respectively) and may not be biologically significant. No other research is available examining stocking density effects in a riparian pasture system on the diet selected. Nonetheless, other researchers have evaluated the effects of stocking density on diet selection. These other results suggest that increased stocking density results in a reduction of selectivity, perhaps due to the effects of competition. In this regard, Walker et al. (1989) concluded that as cattle density increased, cattle became less selective for plant communities.

Differences in dietary botanical composition did occur between collection periods in both years. During 1992, steers decreased ($P < .05$) their consumption of grass and browse and increased ($P < .05$) their consumption of grass-like plants between EJUN and MJUN. Specifically, the decline in grass in the diet was reflected by a decline ($P < .05$) in the consumption of POA, SIDE, and *B. inermus*, with a concomitant increase ($P < .05$) in *Hordeum brachyantherum* consumption. Of the forbs in the diet, only *Anaphalis magaritacea* and *Taraxicum officinale* declined ($P < .05$); all others remained unchanged between collection periods. Although total browse declined ($P < .05$) in the diet between EJUN and MJUN, no differences were noted ($P > .10$) in *Salix* spp. or *Pinus contortus* contributions to the diet.

During 1993, between JULY and AUG total grasses and grass-likes increased ($P < .05$) in the diet, whereas total forbs declined ($P < .05$) in the diet; total browse remained unchanged ($P > .10$). The increase in grass composition of the diet between JULY and AUG was reflected by an increase ($P < .05$) in POA and *H. brachyantherum*, although a decline was noted ($P < .05$) for SIDE and *B. inermus*. Both *Carex* spp.

Table 2. Botanical composition (%) of diets selected by steers grazing a Sierra Nevada mountain meadow pasture during 1992 and 1993

	1992						1993					
	Forage removal[a]			Collection period[a]			Forage removal[a]			Collection period[a]		
Item	LOW	MOD	SEM[b]	EJUN	MJUN	SEM[b]	LOW	MOD	SEM[b]	JULY	AUG	SEM[b]
Total grass	33.6	29.2	2.20	35.6^{i}	27.3^{h}	1.66	43.2	38.9	1.37	38.3^{h}	43.9^{i}	1.10
Poa spp.[c]	12.8	10.7	.7	14.4^{i}	9.1^{h}	.78	12.8^{f}	13.9^{g}	.16	12.4^{h}	14.3^{i}	.55
DACA[d]	9.6	7.3	1.35	9.1	7.8	.76	12.6	11.2	.71	10.9	12.9	1.03
Hordeum brachyantherum	4.6	5.9	.56	3.3^{h}	7.1^{i}	.59	12.8	8.3	1.37	6.5^{h}	14.6^{i}	.64
SIDE[e]	2.9	2.5	.3	3.4^{i}	1.9^{h}	.40	3.3	2.8	.36	4.6^{i}	1.5^{h}	.27
Bromus inermus	1.9	1.4	.57	3.2^{i}	$.2^{h}$	.2	1.2	1.3	.40	2.0^{i}	$.4^{h}$	.29
Total grass-like	38.0	35.0	1.79	30.3^{h}	42.7^{i}	1.28	34.7^{f}	37.9^{g}	.52	32.4^{h}	40.1^{i}	.79
Carex spp.	22.2	20.5	.82	21.6	21.1	.79	20.9	22.6	1.04	20.5^{h}	23.0^{i}	.41
Juncus balticus	15.8	14.6	1.80	8.7^{h}	21.6^{i}	.92	13.8	15.2	.70	11.8^{h}	17.2^{i}	.51
Total forbs	27.8	35.4	3.26	33.4	29.8	2.39	21.9	23.0	1.85	29.1^{i}	15.8^{h}	.84
Ranunculus alismaefolius	7.1	12.4	2.35	8.2	11.3	1.32	6.8	5.4	1.21	8.3^{i}	3.8^{h}	.41
Trifolium longipes	10.6	11.4	1.0	11.9	10.2	1.05	7.7	8.7	.90	11.9^{i}	4.6^{h}	.43
Anaphalis magaritacea	2.1	2.4	.43	3.3^{i}	1.1^{h}	.46	.1	.4	.05	$.6^{i}$	0^{h}	.20
Taraxicum officinale	.9	.9	.28	1.3^{i}	$.4^{h}$	.29	.5	.5	.08	.4	.6	.13
Total browse	.4	.4	.09	$.7^{i}$	$.2^{h}$	.09	.2	.2	.04	.2	.2	.86
Salix spp.	.1	.1	.03	.1	0	.03	0	0		0	0	
Pinus contorta	.2	.2	.12	.3	.1	.06	.2	.2	.06	.2	.1	.07

[a]LOW = grazed to leave 1,500 kg/ha; MOD = grazed to leave 1,000 kg/ha; EJUN = June 5–11; MJUN = June 12–18; JULY = July 26–August 1; AUG = August 4–10.
[b]n = 12.
[c]Represents *Poa pratensis, P. glaucifolia,* and *P. bulbosa*.
[d]Represents *Danthonia californica* and *Deschampsia caespitosa*.
[e]Represents *Sitanion hystrix* and *Deschampsia elongota*.
[f,g]Treatment means for 1993 lacking a common superscript letter differ ($P < .05$).
[h,i]Within a year, collection period means lacking a common superscript letter differ ($P < .05$).

Table 3. Chemical composition and digestibility of diets selected by steers grazing a Sierra Nevada mountain meadow pasture during 1992 and 1993

	1992						1993					
	Forage removal[a]			Collection period[a]			Forage removal[a]			Collection period[a]		
Item	LOW	MOD	SEM[b]	EJUN	MJUN	SEM[b]	LOW	MOD	SEM[b]	JULY	AUG	SEM[b]
Organic matter, %	79.1	79.8	.16	78.9	79.9	.19	91.2	90.5	.03	90.2	91.5	.16
In vitro organic matter disappearance, %	59.4	56.1	1.1	56.8	58.7	1.3	56.7	52.8	1.33	50.7[c]	58.8[d]	.89
	% of OM											
Total N	2.0	1.9	.06	2.0[d]	1.8[c]	.03	1.4	1.4	.02	1.6	1.2	.03
ADIN	.2	.2	.01	.2	.2	.01	.2	.2	.01	.2	.2	.01
NDF	65.8	68.5	.8	64.1[c]	70.1[d]	.67	67.5[f]	63.6[e]	.81	66.7[d]	64.4[c]	.65
ADF	38.3	38.3	.46	37.6[c]	39.1[d]	.48	36.8	35.9	.52	37.0	35.7	.45
ADL	5.3	5.2	.15	5.2	5.3	.26	5.8	5.6	.17	5.7	5.8	.30

[a]LOW = grazed to leave 1,500 kg/ha; MOD = grazed to leave 1,000 kg/ha; EJUN = June 5–11; MJUN = June 12–18; JULY = July 26–August 1; AUG = August 4–10.
[b]n = 12.
[c,d]Within a year, collection period means lacking a common superscript letter differ ($P < .05$).
[e,f]For 1993, treatment means lacking a common superscript letter differ ($P < .05$).

and *J. balticus* increased in the diet between sampling periods. In both 1992 and 1993, these two genera accounted for more than 30% of the diet selected by the steers and individually were the two most predominant plants in the diet. Other researchers have reported that these two genera can contribute as much as 50% of the total forage base in the Sierra Nevada (Sanderson, 1967). The forbs *Ranunculus alismaefolius*, *Trifolium longipes*, and *Anaphalis magaritacea* declined ($P < .05$) in the diet between samplings. Botanical composition of cattle diets has been shown to vary greatly from year to year (Theurer et al., 1976). Similarly, Hurd and Pond (1958) indicated that cattle grazing a mountain range in summer selected grass and grass-like species in preference to both forbs and browse and increased their consumption of forbs only as grass and grass-like species became less available. Furthermore, Holechek et al. (1982b) reported that cattle tend to focus on forbs early in the season and shift their attention to grasses as the phenology changes. Our study may support their results, because in 1993 grasses and grass-like species increased in the diet and forbs declined as the season progressed. Although in 1992 a trend was seen for forbs to decline and grass-like plants to increase in the diet, grasses declined with advancing season. This may be reflective of drought conditions, which may have altered palatability of the grasses.

Chemical composition of masticate from steers in 1992 did not differ ($P > .10$; Table 3) between LOW and MOD treatments, but significant collection date differences were noted. Masticate declined ($P < .05$) in N content and increased ($P < .05$) in NDF and ADF content between EJUN and MJUN. Percentages of ADL, ADIN, and IVOMD did not differ ($P > .10$) between collection periods. The lack of any differences in diet botanical and chemical components between stocking rates indicates that treatment did not influence diet selection by the steers. Advancing season, however, allowed dietary shifts to occur swiftly. These changes seemed to reflect the reduced consumption of grasses and the increased consumption of grass-like plants without a reduction in forb consumption and the effects of advancing plant maturity, because N declined and fiber (NDF and ADF) increased in the diet.

During 1993, masticate from steers grazing LOW pastures was greater ($P < .05$) in NDF than masticate from steers grazing MOD pastures; no other dietary differences were noted ($P > .10$) between treatments. Diet botanical composition was only slightly different between treatments (LOW consumed less POA and less grass-like plants than MOD), and these differences seem to only affect the NDF content of the diet by 3.9 percentage units. Between the two sampling periods, forage N and NDF content declined ($P < .05$) and forage IVOMD increased ($P < .05$). The decline in forage quality occurred even though total grasses in the diet increased between collection periods. This decline in quality seems to be more closely related to the increase of CAREX and JUBA and the reduction of forbs in the diet than to the increase in grass component of the diet.

Forage Organic Matter Intake and Passage Rate. No differences were noted ($P > .10$; Table 4) in forage OM intake, particulate passage rate, gastrointestinal retention time, intestinal transit time, or gastrointestinal fill as a result of grazing treatment in either 1992 or 1993. These results concur with the existing literature (Vavra et al., 1973; Zoby and Holmes, 1983; McKown et al., 1991), which suggests that forage intake is not influenced by stocking density or stocking rate (low vs high rates). Additionally, the

Table 4. Forage intake and digesta kinetics for steers grazing a Sierra Nevada mountain meadow pasture during 1992 and 1993

	1992						1993					
	Forage removal[a]			Collection period[a]			Forage removal[a]			Collection period[a]		
Item	LOW	MOD	SEM[b]	EJUN	MJUN	SEM[b]	LOW	MOD	SEM[b]	JULY	AUG	SEM[b]
Body weight, kg	192	195	4.3	193	191	4.7	237	246	14.0	242	248	5.3
Organic matter intake, g/kg of BW	25.6	21.0	1.47	21.2[c]	25.4[d]	.75	27.8	24.7	1.2	22.9[c]	29.6[d]	.95
Total tract particulate passage rate, %/h	3.5	3.7	.08	3.8	3.5	.14	2.9	2.9	.15	3.0	2.8	.11
Gastrointestinal mean retention time, h	44.9	44.1	.51	42.8	46.2	1.40	52.8	53.8	2.60	51.6	55.0	1.73
Intestinal transit time, h	10.7	10.9	.70	10.7	10.9	.44	11.4	12.6	.56	11.7	12.3	.55
Gastrointestinal fill, g/kg of BW	15.6	13.3	.43	12.8	16.1	.71	16.4	17.0	.51	15.4[c]	17.9[d]	.21

[a]LOW = grazed to leave 1,500 kg/ha; MOD = grazed to leave 1,000 kg/ha; EJUN = June 5–11; MJUN = June 12–18; JULY = July 26–August 1; AUG = August 4–10.
[b]n = 12.
[c,d]Within a year, collection period means lacking a common superscript letter differ ($P < .05$).

changes that occurred in diet botanical composition did not seem to alter forage intake. Nonetheless, some significant differences did occur between sampling periods. During 1992 and 1993, forage OM intake increased ($P < .05$) as season progressed. This increase in intake during 1992 occurred without ($P > .10$) changes in particulate passage rate, retention times, or gastrointestinal fill. Conversely, during 1993, the greater intake between samplings resulted in greater ($P < .05$) gastrointestinal fill without ($P > .10$) alterations to particulate kinetics. Most studies have reported a decline in forage intake as plants mature (Vavra et al., 1973; Ellis, 1978; Pinchak et al., 1990). In our study, the cause of increased intake with plant maturity is not clear; however, several factors may be at least partially responsible. First, the present study did not evaluate the pastures to complete plant senescence. Rather, this study evaluates an early- to mid-season grazing strategy. Although numerous plant species reached senescence during the evaluation period, many others did not. This point may be more clearly illustrated by the lack of a significant decline in IVOMD with advancing season. Second, as a result of the continual changing forage base, cattle may have limited their intake as a result of selection for plant parts. Such selectivity has been shown to restrict intake in some situations (Minson, 1981).

Loafing Behavior. During 1992 and 1993, total loafing time did not differ ($P > .10$; Table 5) between treatment groups, but loafing time was greater ($P < .05$) in EJUN than in MJUN. In 1992, within a specific pasture location, no treatment × collection date differences were noted ($P > .10$; Table 5) for loafing time, but collection date and treatment effects were noted. Mid-meadow loafing time was greater ($P < .05$) for MOD steers than LOW steers, whereas loafing time along the forest edge and streamside areas did not differ ($P > .10$) between treatments. The only collection date difference for loafing time was at the forest edge, where loafing time was greater ($P < .05$) in EJUN than MJUN.

In 1993, a treatment × collection period interaction was noted ($P < .05$) for loafing time within each specific pasture location. Loafing along the forest edge and streamside areas in JULY was greater ($P < .05$; Table 6) for LOW steers than for MOD steers; no differences were noted ($P > .10$) in AUG. Conversely, mid-meadow loafing in JULY was greater ($P < .05$) for MOD steers than LOW steers, whereas the opposite occurred in AUG. Steers in the MOD pastures during the period from JULY to AUG did not change ($P > .10$) their loafing time along the stream but increased ($P < .05$) their loafing time along the forest edge and decreased ($P < .05$) loafing time in the mid-meadow area. Concomitantly, steers in the LOW stocked pastures increased ($P < .05$) loafing time in the mid-meadow area and decreased ($P < .05$) loafing along the streamside area without changing ($P > .10$) loafing time along the forest edge. Several researchers have indicated that cattle have preferred resting areas, based on habitat type. Smith et al. (1992) reported that floodplain habitats had greater resting use than stream channel or upland. Other researchers (Marlow and Pogacnik, 1986; Smith et al., 1992) reported that cattle often spend more time resting within the streamside areas than the upland areas of the pasture. In the present study, by numerical comparison, only cattle in the LOW stocked pasture during drought conditions loafed in the streamside area more than in the mid-meadow or forest edge areas. During 1993, loafing use was lowest for the streamside area compared with the forest edge and mid-meadow areas. One reason for this difference may

Table 5. Grazing behavior of steers in a Sierra Nevada mountain meadow pasture during 1992 and 1993

	1992						1993					
	Forage removal[a]			Collection period[a]			Forage removal[a]			Collection period[a]		
Item	LOW	MOD	SEM[b]	EJUN	MJUN	SEM[b]	LOW	MOD	SEM[b]	JULY	AUG	SEM[b]
Total loafing time, min	945	887	12.4	964[h]	867[g]	8.2	891	871	35.2	917	846	10.9
Forest edge, min[c]	194	31	103.2	136[h]	89[g]	5.2	439	356	54.4	354	441	45.7
Mid-meadow, min[c]	320[e]	631[f]	46.4	498	452	54.7	309	396	75.8	369	336	41.1
Streamside, min[c]	431	225	76.2	330	326	48.4	144	119	61.4	194	69	19.9
Total grazing time, min[c]	480[e]	514[f]	8.4	447	545	13.0	532	548	28.6	516	565	10.2
Forest edge, min[d]	24	68	9.2	61	30	8.2	151	195	38.9	170	176	12.3
Mid-meadow, min[d]	234	286	26.7	200	320	9.9	275	194	46.9	223	246	10.8
Streamside, min	220[f]	160[e]	15.7	186	195	10.5	106	159	8.0	123[g]	143[h]	14.7
Total time by area												
Forest edge, min[c]	258	114	114.9	243[h]	129[g]	25.0	596	574	88.8	526	638	56.9
Mid-meadow, min[c]	523[e]	943[f]	26.9	676[g]	789[h]	61.9	575	587	92.4	586	588	46.4
Streamside, min[c]	659[f]	393[e]	62.3	521	522	53.0	269	279	52.1	328	214	19.9

[a]LOW = grazed to leave 1,500 kg/ha; MOD = grazed to leave 1,000 kg/ha; EJUN = June 5–11; MJUN = June 12–18; JULY = July 26–August 1; AUG = August 4–10.
[b]n = 12.
[c]Significant treatment × collection period interaction for 1993.
[d]Significant treatment × collection period interaction for 1992.
[e,f]For 1992, treatment means lacking a common superscript letter differ ($P < .05$).
[g,h]Within a year, collection period means lacking a common superscript letter differ ($P < .05$).

be the abundance of biting insects following the abundant precipitation during the winter of 1993. In this regard, Marlow and Pogacnik (1986) suggested that resting use was not a function of temperature or food sources but may be related to factors such as biting insects.

Grazing Behavior. In 1992, no treatment × collection period interaction was noted ($P > .10$) for total time spent grazing. Nonetheless, total time spent grazing was greater ($P < .05$; Table 5) for MOD steers than for LOW steers. Total grazing time in 1993 was affected ($P < .05$) by a treatment × collection period interaction. Total grazing time in 1993 did not differ ($P > .10$; Table 6) between treatments in JULY, but at the AUG observation MOD steers grazed more ($P < .05$) than LOW steers. Grazing activity of the cattle in this study was primarily associated with the daylight hours: less than 1% of the grazing time (data not shown) occurred during the nighttime. Allden and Whittaker (1970) indicated an upper time limit in sheep for grazing of 600 to 700 min/d. Krysl and Hess (1993), in their summary of grazing behavior literature, indicate that daily grazing time for cattle ranges from 359 to 771 min/d; data in the present study are within that range. Reasons for the MOD steers to spend more time grazing in 1992 and in AUG of 1993 without increasing forage intake may be related to the interaction between forage availability and searching behavior by the steers. Krysl and Hess (1993) referred to the relationship between forage intake and grazing time as harvesting efficiency (**HE**; grams of OM intake·kilogram of body weight^{-1}·minute spent grazing^{-1}). These researchers suggested this measure as an indication of energy cost of grazing, but it may also reflect preferred forage availability. In our study, HE did not differ ($P > .10$) between LOW (.053) and MOD (.041) steers in 1992 or 1993 (.052 and .045, LOW and MOD, respectively).

Grazing time for each specific location within the pastures was evaluated, and significant treatment and treatment × collection period interactions were noted. Specifically, in 1992, streamside grazing was not affected ($P > .10$) by a treatment × collection period interaction but was greater ($P < .05$) with LOW stocking than with MOD stocking. In 1992, a significant treatment × collection period interaction was noted for both forest edge and mid-meadow grazing time. Mid-meadow grazing time in 1992 increased ($P < .05$; Table 7) between observation dates for both the steers in the LOW and MOD pastures. Nevertheless, only during the MJUN observation was a treatment difference noted, with the MOD steers spending ($P < .05$) more time grazing the mid-meadow area than LOW steers. Forest edge grazing time was greater ($P < .05$) in EJUN for MOD steers compared with LOW steers. This difference did not persist in MJUN; MOD steers' forest edge grazing time declined to an amount similar ($P > .10$) to that for LOW steers. In this study, during drought conditions, stocking the pastures at a MOD density resulted in a reduction of grazing time along the streamside area and a general increase in grazing use of the forest edge during EJUN and greater use of the mid-meadow in MJUN. Our data suggest that MOD stocking during drought conditions increased grazing time in other areas within the pasture. This difference was also noted for the LOW steers, but was numerically smaller for the LOW than for the MOD steers. Although our data show a time

Table 6. Grazing behavior and location of use by forage removal and collection period for steers grazing a Sierra Nevada mountain meadow during 1993

	Forage removal[a]		
	LOW	MOD	SEM[b]
Loafing time, min			
Forest edge			
JULY[c]	527[e]	180[df]	72.4
AUG[c]	350[d]	532[eg]	60.1
SEM	60.8	72.1	
Mid-meadow			
JULY	163[df]	575[eg]	77.2
AUG	455[g]	218[f]	62.9
SEM	70.5	68.3	
Streamside			
JULY[d]	237[eg]	150[d]	41.2
AUG	50[f]	88	20.4
SEM	42.8	31.0	
Total grazing time, min			
JULY	525	505[f]	15.5
AUG	540[d]	590[eg]	27.9
SEM	25.9	21.3	
Total time by area, min			
Forest edge			
JULY	670[e]	395[df]	66.8
AUG	523	753[g]	73.9
SEM	66.0	77.8	
Mid-meadow			
JULY	395[d]	778[e]	70.3
AUG	755[e]	443[d]	79.5
SEM[b]	78.3	71.5	
Streamside			
JULY	375[eg]	293[d]	33.6
AUG	163[df]	265[e]	24.0
SEM	43.5	21.6	

[a]LOW = grazed to leave 1,500 kg/ha; MOD = grazed to leave 1,000 kg/ha.
[b]n = 6.
[c]JULY = July 26–August 1; AUG = August 4–10.
[d,e]Within a collection period, treatment means lacking a common superscript letter differ ($P < .05$).
[f,g]Within a treatment, collection period means lacking a common superscript letter differ ($P < .05$).

reduction for grazing and loafing time along the streamside area, standing crop biomass data suggest that differences in stocking density resulted in greater forage removal along the streamside areas. Thus, although grazing time was reduced, total use by steers due to increased stocking was not reduced but perhaps was increased (MOD: 4 steers × 160 min = 640 min of use; LOW: 2 steers × 220 min = 440 min of use).

During 1993, forest edge grazing time and mid-meadow grazing time were not influenced ($P > .10$) by treatment or observation date. The lack of treatment differences for grazing time of these two areas suggests that with abundant winter precipitation, preference for vegetation growing in these drier areas of the pasture (forest edge and mid-meadow) may not be reduced such that grazing time in these areas was not reduced. Streamside grazing time was greater ($P < .05$) for MOD steers than for LOW steers; no differences were noted ($P > .10$) for observation date. Numerical comparison to data for 1992 suggests that the greater soil moisture conditions in 1993 increased the time spent grazing along the forest edge and reduced the time grazing the streamside vegetation. Concern over grazing of riparian zones has centered around the problems of concentration of livestock along streambanks, resulting in overuse of the vegetation and degradation of the stream course (Kauffman and Krueger, 1984). This has led to a general recommendation to reduce the stocking rates of riparian pastures. Our research suggests that during drought conditions, the use of LOW stocking rates would cause increased use of the streamside zone for loafing and grazing use. Conversely, during 1993, an above normal precipitation year, MOD stocking resulted in greater use of the streamside area compared with LOW stocking but did not lead to increased loafing in that area. Although grazing time along the streamside was increased by MOD grazing in 1993, this amount was numerically less than the amount of time spent by steers grazing the streamside area in 1992.

Time Budgets for Specific Areas of Each Pasture. Total time spent within each area of the pasture responded differently in each of the two collection years (Table 5). In 1992, no treatment × collection period interactions were noted ($P > .10$); however, total time spent along the forest edge did not differ ($P > .10$) between treatment groups, but did decline ($P < .05$) between observation dates. Time spent in the mid-meadow area was greater ($P < .05$) and time spent in the streamside area was less ($P < .05$) for MOD steers than for LOW steers. The decline in time

Table 7. Grazing behavior and location of use by forage removal and collection period for steers grazing a Sierra Nevada mountain meadow during 1992

	Forage removal[a]		
Item	LOW	MOD	SEM[b]
Mid-meadow grazing, min			
EJUN[c]	197[f]	203[f]	17.3
MJUN[c]	270[dg]	370[g]	23.2
SEM[b]	21.5	30.0	
Forest-edge grazing, min			
EJUN	23[d]	100[eg]	15.5
MJUN	25	35[f]	6.4
SEM	6.5	14.0	

[a]LOW = grazed to leave 1,500 kg/ha; MOD = grazed to leave 1,000 kg/ha.
[b]n = 6.
[c]EJUN = June 5–11; MJUN = June 12–18.
[d,e]Within a collection period, treatment means lacking a common superscript letter differ ($P < .05$).
[f,g]Within a treatment, collection period means lacking a common superscript letter differ ($P < .05$).

spent along the forest edge as season progressed seems reflective of the reduced grazing use of this area and the similar reduction of loafing use. The increased use of the mid-meadow by MOD steers and increased use as the season progressed may reflect the shift away from the forest edge as a result of drying conditions. Given the lack of significant treatment differences in diet botanical composition, dietary selection shifts towards different vegetation seem unlikely.

During 1993, total time spent in the streamside, mid-meadow, and forest edge areas were affected ($P < .05$; Table 6) by a treatment × collection period interaction. Use of the mid-meadow area was less ($P < .05$) for the LOW than for the MOD steers in JULY, but this was reversed ($P < .05$) at the AUG observation. Streamside use showed the opposite effect, with greater ($P < .05$) time in JULY for the LOW cattle than for the MOD cattle; the opposite effect was noted ($P < .05$) in AUG. Although use of the streamside area declined ($P < .05$) between observation dates for the LOW cattle, no difference was noted ($P > .10$) between observation dates for the MOD cattle. Forest edge use in JULY was greater ($P < .05$) for LOW cattle than for MOD cattle; no differences were noted ($P < .05$) between treatments in AUG. Between observation dates only MOD cattle showed significant changes in their use of the forest edge by increasing ($P < .05$) the time spent in that area. Our data seem to suggest that as the season progressed, cattle in LOW stocked pastures shifted their total time budget away from the streamside and toward the mid-meadow and forest edge, whereas cattle in the MOD stocked pastures significantly doubled their use of the forest edge but did not change their use of the streamside and mid-meadow areas. Results of total time use of each area within the pastures reflect the differences noted with loafing use. Loafing time was the greatest single time expenditure by the steers and therefore may be the primary factor controlling differences noted with total time use for each area of the pasture.

Implications

After winter drought conditions, forage growth in ungrazed pastures was initially suppressed by litter build-up. By the conclusion of grazing, however, low stocking density pastures had similar amounts of forage remaining, whereas pastures stocked at moderate densities had less standing forage remaining compared with ungrazed pastures. These differences were not apparent after abundant winter precipitation. Diet selection, forage intake, and digesta kinetics were not affected by stocking density. Grazing behavior and area of use within the pasture for loafing and grazing were altered by stocking density and date of use. In general, our data suggest that management decisions to reduce stocking densities may force cattle to congregate along streambanks and to concentrate grazing and loafing activities in those areas.

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