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Offstream water and trace mineral salt as management strategies for improved cattle distribution

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ABSTRACT: The objective of this study was to test the combined effect of offstream water and trace mineral salt on cattle distribution in a riparian meadow and its adjacent uplands. From July 15 to August 26, 1996 and 1997, three treatments were each randomly assigned to one pasture in each of three blocks. Sixty cow/calf pairs were then randomly allotted to the grazed pastures. The treatments included 1) stream access and access to offstream water and trace-mineral salt (offstream), 2) stream access and no access to offstream water or trace-mineral salt (no-offstream), and 3) ungrazed control. The response of cattle was measured through visual observations of cattle distribution, grazing activity and travel distance, cow/calf performance, and fecal deposit distribution. Distribution patterns of the cattle, measured as the distance of cattle from the stream, was characterized by a time of day $\times$ treatment

$\times$ time in grazing period $\times$ year interaction ($P < 0.05$). No-offstream cattle began the day further from the stream than offstream cattle but consistently moved closer to the stream after the morning grazing period (0600 to 0900). Differences in distribution patterns between the two treatments were more pronounced early in the grazing period than late in the grazing period. Grazing activity, fecal deposit distribution, and travel distance of cattle were not affected by the presence of offstream water and trace-mineral salt. Cows and calves with offstream water and trace-mineral salt gained 11.5 kg and 0.14 kg/d more, respectively, than no-offstream cows and calves averaged across years ($P < 0.05$). Overall, cattle distribution patterns and cow/calf performance were influenced by the presence of offstream water and trace-mineral salt. Changes in distribution were most pronounced early in the grazing season.

Key Words: Behavior, Distribution, Grazing, Livestock, Riparian Grassland, Water

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Introduction

Riparian systems are the assemblages of plant, animal, and aquatic communities whose presence can be either directly or indirectly attributed to factors that are water-induced or -related (Kauffman and Krueger, 1984). Although these areas make up only a small portion of the total land area, they are characterized by a high biomass of diverse vegetation that is valuable in streambank stabilization and sediment filtration (Kauffman and Krueger, 1984; Swanson, 1989; Burton and Kozel, 1995) and as forage and habitat for a diversity of wildlife species (Thomas et al., 1979).

Cattle are attracted to riparian areas and often use them at disproportionately higher rates than adjacent uplands (Gillen et al., 1984; Senft et al., 1985a; Howery et al., 1996; Kie and Boroski, 1996). Improper use of riparian areas by cattle can result in soil compaction, elimination of streamside vegetation, increased erosion, reduced water quality, and streambank breakdown (Buckhouse and Gifford, 1976; Thomas et al., 1979).

Management strategies are needed that limit cattle grazing pressure in riparian ecosystems. One such strategy may be the use of offstream water and trace-mineral salt. However, there is a lack of research that quantifies their effects on cattle grazing distribution.

This research was designed to provide a quantitative assessment of the effects of offstream water and trace mineral salt on cattle distribution. The hypothesis was that cattle distribution, performance, and behavior could be influenced by providing offstream water and

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Figure 1. Portion of Oregon State University's "Hall Ranch" used for the research project. Nine paddocks 10 to 15 ha in size were used in a replicated design evaluating three treatments over the 2-yr study period. All paddocks have riparian stream, riparian meadow, and adjacent uplands.

trace minerals to cattle grazing a riparian meadow and adjacent uplands.

Materials and Methods

Study Site

The study was conducted in the foothills of the Wallowa Mountains in northeastern Oregon on the Eastern Oregon Agriculture Research Center's Hall Ranch. Elevation of the site is about 1,015 m above sea level. The study was conducted between July 15 and August 26 of 1996 and 1997. Average annual precipitation for this area is 35 cm; average July and August rainfall totals 3.94 cm and average July and August evaporation totals 35.38 cm (Taylor et al., 1993).

The study site encompassed about 109 ha of riparian meadow and adjacent uplands bordering Milk Creek, which is a salmon-rearing stream and a tributary to Catherine Creek, a stream identified as anadromous fish habitat. The site was cross-fenced into nine pastures, each containing approximately 12 ha and a 260-m reach of Milk Creek (Figure 1). Treatments were blocked to limit environmental and vegetation differences along the reach of Milk Creek. Within each pasture the vegetation was classified into four types: riparian grass, riparian sedge/rush, gravel bar, and upland. Vegetation type makeup of grazed pastures with offstream water and trace-mineralized salt (**offstream**) were 28.5% riparian grass, 3.2% riparian sedge/rush, 6.2% gravel bar, and 62% upland whereas makeup of grazed pastures without the offstream water and trace-

mineralized salt (**no-offstream**) were 28% riparian grass, 2.2% riparian sedge/rush, 6.9% gravel bar, and 62.9% upland. Production and vegetation quality also were measured as descriptive site parameters (Table 1).

Riparian grass communities were those areas that had at some time been influenced by water from Milk Creek. These areas included the active floodplain, and the plant community consisted of > 50% grass species by weight. Dominant species in these areas included timothy (*Phleum pratense* L.), Kentucky bluegrass (*Poa pratensis* L.), meadow foxtail (*Alopecurus pratensis* L.), brome (*Bromus* spp.), sedges (*Carex* spp.), and rushes (*Juncus* spp.). A variety of forbs also were present. Shrub and overstory species of hawthorne (*Crataegus douglasii* Lindl.), black cottonwood (*Populus trichocarpa* T.&G.), ponderosa pine (*Pinus ponderosa* Dougl.), snowberry (*Symphoricarpos albus* L.), and rose (*Rosa gymnocarpa* Nutt.) bordered the stream in some sections of the riparian grass community.

Riparian sedge/rush communities were located within the same area as the riparian grass communities. They were distinguished by the presence of > 50% sedges and/or rushes by weight. Other species present in this community were the same as in the riparian grass community.

Gravel bar communities were typically located in the riparian area and appeared to occupy former stream channels. These communities were dominated by cheatgrass (*Bromus tectorum* L.), Canada bluegrass (*Poa compressa* L.), and numerous annual forbs.

Upland communities were those that were outside the active flood plain. Grasses including timothy, brome

Table 1. Nutrient composition and dry matter production of forage sampled before (July 12) and after (August 26) grazing in 1996 and 1997

Item	Nutrient composition ^a			Vegetative production — kg/ha —
	CP	NDF	ADF	
1996	% of DM			
July				
Riparian grass	8.5	54.9	30.5	1,704
Riparian sedge/rush	9.3	61.9	32.0	2,748
Gravel bar	7.0	59.3	33.6	1,068
Upland	8.0	54.4	30.8	1,148
August				
Riparian grass	5.4	65.0	36.9	1,511
Riparian sedge/rush	6.7	65.2	37.3	3,138
Gravel bar	5.5	62.2	37.1	1,035
Upland	5.1	62.3	36.7	1,016
1997				
July				
Riparian grass	7.7	58.1	32.4	2,148
Riparian sedge/rush	8.1	66.4	33.0	3,540
Gravel bar	7.8	54.7	30.5	992
Upland	7.4	57.4	31.9	1,372
August				
Riparian grass	6.5	64.1	37.2	1,383
Riparian sedge/rush	7.1	65.7	35.6	2,880
Gravel bar	5.6	64.9	38.5	470
Upland	5.9	61.8	36.5	646

^aCP = crude protein (AOAC, 1990), NDF = neutral detergent fiber (Van Soest et al., 1991 as modified by Komarek, 1993), ADF = acid detergent fiber (AOAC, 1990 as modified by Komarek and Sirios, 1993).

spp., orchardgrass (*Dactylis glomerata* L.), needlegrass (*Stipa* spp.), blue wildrye (*Elymus glaucus* Buckl.), Idaho fescue (*Festuca idahoensis* Elmer), Kentucky bluegrass, pinegrass (*Calamagrostis rubescens* Buckl.), elk sedge (*Carex geyeri* Boott), numerous forbs, and some sedge/rush patches typically dominated these communities. Snowberry was also common in the uplands. Although some upland sites were open meadows, most uplands had an overstory of ponderosa pine. Nomenclature for all species followed Hitchcock et al. (1969).

Design

The study used a randomized complete block design with three blocks of each of the following three treatments (Figure 1): 1) access to Milk Creek with offstream water and trace-mineral salt (offstream), 2) access to Milk Creek with no offstream water or trace-mineral salt (no-offstream), and 3) ungrazed control. Each treatment was randomly assigned to one pasture within each of the three blocks. Sixty Angus-cross cow/calf pairs, calving in February and March, were stratified by age (1996) and calf age (1996 and 1997) and within stratum were randomly assigned to the two grazed pastures within each of the three blocks, resulting in an average of 10 pairs per pasture. Cows used in 1996 ranged in age from 2 to 14 yr and were familiar with the site, whereas 1997 cows were all 2-yr-olds with the exception of two 3-yr-olds. Cows used in 1997 had limited exposure to the pasture and rangeland because of age and

experience. All cattle had free access to trace-mineral salt prior to the initiation of the study. Offstream water was provided to offstream pastures by a hydraulic ram pump (Gravi-Chek, San Diego, CA) installed next to Milk Creek. The pump pushed water upslope (450 to 520 linear meters with about 45 to 60 m elevation gain) to one water tank in each of two of the offstream pastures. A stockwater pond was used in the third offstream pasture as a source of offstream water. Feeders with trace-mineral salt were placed 4.5 m from the offstream water sources. Trace mineral salt composition was as follows: salt, not less than 96% and not more than 98.5%; Zn, 0.35%; Fe, 0.20%; Mn, 0.18%; Mg, 0.037%; Cu, 0.035%; I, 0.010%; and Co, 0.006%. Grazed pastures were stocked at 0.8 animal units per hectare for 42 d (1 animal unit = one cow/calf pair). Cow distribution and behavior data were collected during two 6-d intensive observation periods from d 9 to 14 after turnout onto that pasture (July 23 to 28, early in the grazing period) and from d 37 to 42 on the pasture (August 20 to 25, late in the grazing period). Measurements taken before and/or after grazing included cow weight and condition score, calf weight, fecal deposits, and diet quality.

Animal Distribution and Behavior

Visual observations, vibracorders (grazing activity), and pedometers (travel distance) were used to monitor animal distribution and behavior. Visual observations were used to measure physical distribution throughout

the day. Distribution data were collected during the daylight hours between 0600 and 2100. Grazing during the night was not considered a significant concern because past research suggested that little grazing activity occurs during the night of a summer grazing season (Sneva, 1969; Miner et al., 1992). Observations were made every 3 h during the 6-d intensive observation periods, for a total of 30 observations per period in each pasture. Starting times of 0600, 0700, and 0800 were each randomly assigned to 2 of the 6 d. Individual cow location was recorded on aerial photos for each observation by three observers, one observer in each block. Large numbers were painted on each cow to simplify identification.

Geographically corrected aerial photos were used in a Geographical Information Systems program (Idrisi For Windows, Clark Univ., Worcester, MA) to calculate the distance of each animal observation from the stream. Observations were grouped into five time periods for analysis: 0600 to 0900, 0901 to 1200, 1201 to 1500, 1501 to 1800, and 1801 to 2100.

Vibracorders (devices used to measure grazing time of free-ranging cattle; Stobbs, 1970) were placed on one randomly selected cow from each of four age strata within each pasture (1996) or on four randomly selected cows (1997). Vibracorders were placed on the same cows during each observation period within a year and recorded grazing activity for all 6 d of each period. Vibracorder charts were read as time spent grazing during each 3-h period. These time periods corresponded with those used in the analysis of distance from Milk Creek; however, three additional time periods corresponding to night hours were added for grazing activity: 2101 to 2400, 2401 to 0300, and 0301 to 0600.

Pedometers, used to monitor travel distance of the cows within each pasture, were placed on the same randomly selected cows that received vibracorders. These devices recorded travel distance for the 6-d period and were calibrated by herding cattle a measured distance at the end of each year (Anderson and Kothmann, 1977).

Animal Performance

Animal performance variables measured were calf average daily gain, cow weight change, and cow body condition score change during the 42-d grazing period. Animals were placed in a drylot, with no access to feed or water, overnight, prior to weighing and condition-scoring. Animals were weighed before and after grazing, and initial and final cow body conditions scores (1 to 9, 1 = extremely emaciated and 9 = extremely fat; Wagner et al., 1988) were assigned.

Water Temperature

Water temperature was monitored in both water sources in the offstream pastures as a descriptive parameter. Temperatures were taken during the two 6-d

intensive observation periods each year. Temperature readings were taken three times daily, during the morning, early afternoon, and evening observation periods.

Fecal Deposits

Fecal deposits were recorded in all treatments to represent relative amounts of time spent along the streambank, as well as the potential for fecal contamination of the stream. Fecal coliform counts were minimal in runoff 1 m from a month-old fecal deposit following a high-intensity simulated storm (Buckhouse and Gifford, 1976). Based on this information, fecal deposits located within 1 m of the water's edge were counted on both sides of the stream in each grazed pasture. Counts were taken as cows were removed from the pasture each year.

Water and Trace-Mineral Salt Consumption

Daily water disappearance and consumption of trace-mineral salt in offstream pastures was measured over a 6-d period during wk 4 of grazing (August 5 to 11). To accommodate measurement of water disappearance, use of the water pump was terminated during this period, and water levels in each tank were measured daily at 0500 before and after filling with a water truck. Measurements were then calibrated to measure the liters of water in each inch of the tank. The difference between the filled water level and the level of the water before filling on two consecutive days was considered disappearance. Water was measured as daily disappearance because evaporation was not accounted for in the measurements. Water disappearance was measured only in Block 1 and Block 2 because the use of a stockwater pond as the alternate water source in Block 3 did not facilitate measurement of water disappearance.

Consumption of trace-mineral salt was monitored during the same 6-d period; however, trace-mineral salt was weighed at the beginning and end of the 6-d period only. The difference between these weights was the total consumption for the 6-d period.

Statistical Analysis

Data were analyzed as a randomized complete block-repeated measures design using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). Block was treated as the random variable in all GLM procedures, and pasture was the experimental unit. Cattle distribution and grazing activity were analyzed with block and treatment as whole-plot variables and year, time in grazing period, and time of day as repeated measures. Analysis of distance traveled used year and time in grazing period as repeated measures, with block and treatment as whole-plot variables. Year was the only repeated measure variable for animal performance and fecal counts. Analysis of water temperature data was conducted using block and water source as whole-plot vari-

ables and year, time in grazing period, and time of day as repeated measures. A level of $P < 0.05$ was used to designate significant effects for all data, and where higher-order interactions occurred they took precedence over lower-order interactions and main effects.

Results and Discussion

Cattle Distribution and Behavior

Distinct treatment differences in cattle distribution patterns were observed throughout the study. Distribution patterns, represented by distance from the stream, displayed a year $\times$ time in grazing period $\times$ time of day $\times$ treatment interaction ($P < 0.01$, Figure 2). In cattle

observations taken during the early portion of the grazing period in both 1996 and 1997, no-offstream cattle displayed a very distinct distribution pattern in which they began the day either as far from the stream as offstream cattle (1996) or further from the stream than offstream cattle (1997). As the morning progressed they moved closer to the stream and spent the afternoon and early evening hours closer to the stream than offstream cattle ($P < 0.05$) before moving away from the stream in the later hours of the day. In contrast, during the latter portions of the grazing period, no-offstream cattle displayed less predictability in distribution pattern. In 1996, they began the day further from the stream than offstream cattle and remained there until afternoon,

Figure 2. Distance from the stream as influenced by time of day. Distance from the stream displayed a year $\times$ time in grazing period $\times$ time of day $\times$ treatment interaction ($P < 0.05$). As a result, treatment means were separated by year (A,B vs C,D) and time in grazing period (A,C vs B,D) for ease of interpretation. Treatments include 1) W = cattle with access to offstream water and trace-mineral salt and NW = cattle without access to offstream water and trace-mineral salt. For each graph values within a time period with different superscripts ^y_z differ at $P < 0.05$. Treatment means ($n = 3$) had a pooled SE of 11.25.

when they moved closer than offstream animals ($P < 0.05$). However, no-offstream animals did not move as close or remain close for as long as they did early in the grazing period. During the latter part of the grazing period of 1997, no-offstream cattle displayed a grazing pattern that did not differ significantly from that of the offstream cattle.

Effects of offstream water and trace-mineral salt on cow/calf grazing distribution patterns were also reflected through the percentage of cattle observations in the uplands compared to the riparian area, demonstrated by a time of day $\times$ time in grazing period $\times$ treatment interaction ($P < 0.05$, Figure 3). For this anal-

ysis, the riparian area was defined as that area composed of riparian grass, riparian sedge/rush, and gravel bar communities that had at some time been influenced by water from Milk Creek. A larger proportion of offstream cattle were in the riparian area from 0600 to 0900 ($P < 0.05$), whereas in the afternoon a larger proportion of no-offstream cattle were in the riparian area ($P < 0.05$). This same pattern occurred during both observation periods; however, toward the end of the grazing period distribution differences were less pronounced than they were earlier in the grazing period. No significant response to year was observed in either treatment group throughout the day.

The difference in distribution patterns of the two treatments appeared to be a response to the tendency for cows to graze during the early morning hours, then seek water, and finally seek shade or graze less intensively during hot afternoon hours. During the search for water, offstream animals were given a choice of two water sources, whereas no-offstream animals were forced to use the stream. Based on the daily distribution patterns, cattle appeared to spend the afternoon in the same area as they drank, then move away during the cooler evening period. Trace-mineral salt consumption and water disappearance from stock tanks measured during a 6-d period in early August showed that trace-mineral salt consumption averaged $135.8 \text{ g} \cdot \text{pair}^{-1} \cdot \text{d}^{-1}$ and average daily disappearance of water from the tank was $21.65 \text{ L} \cdot \text{pair}^{-1} \cdot \text{d}^{-1}$, or 45% of daily consumption based on the following assumptions and calculations. Expected water intake of a given class of cattle in a specific management regimen is a function of dry matter intake and ambient air temperature (NRC, 1996). Ambient air temperatures for the grazing periods in this study averaged 33.8°C . At these temperatures, a 450-kg lactating beef cow requires about 61 L of water daily (NRC, 1996). Assuming 2.5% of body weight intake and an average forage DM of 55% in the midsummer, based on the calculations of Parsons et al. (2001) using measured forage DM of 40% early summer and 70% late summer on the same study site, a 450-kg cow will consume 28 kg of forage. Of this 28 kg, 12.6 kg is water, providing 13 L of required water, leaving 48 L to meet the cow's daily requirement. If the cattle with access to offstream water and trace-mineral salt consumed $21.65 \text{ L} \cdot \text{pair}^{-1} \cdot \text{d}^{-1}$ of water from the water tank, then 45% of the 48 L needed came from the offstream water source. These figures showed that despite mean water temperatures of 20.7°C in the tank, compared with 15.5°C in the stream, cattle used the two water sources almost equally.

Vibracorders revealed no response of grazing activity to the time of day $\times$ treatment interaction. Cattle in both treatments followed a daily schedule in which peak grazing occurred from 0601 to 0900 (19.9% of total) and 1801 to 2100 (20.9% of total). The period from 1201 to 1800 accounted for about 34% of the daily grazing activity. This period coincides with the period of highest riparian area occupation for no-offstream animals, indi-

Figure 3. Effects of offstream water and trace-mineral salt on the proportion of cattle observations in the riparian area during the early (July 23 to 28) and late (August 20 to 25) part of the grazing period. Values are averaged over 1996 and 1997. Treatments include 1) W = cattle with access to offstream water and trace-mineral salt and NW = cattle without access to offstream water and trace-mineral salt. For each graph differences within a time period are denoted by ^{yz} ($P < 0.05$). Treatment means ($n = 3$) had a pooled SE of 0.027.

Figure 4. Effect of time in the grazing period (early = July 23 to 28; late = August 20 to 25) on cow grazing activity over a 24-h period. Values are averaged over both treatment 1) access to offstream water and trace-mineral salt and 2) no offstream water and trace-mineral salt) and year (1996 and 1997). Values within a time period with different superscripts ^{yz} differ at $P < 0.05$. Treatment means ($n = 24$) had a pooled SE of 3.92.

cating that riparian areas in no-offstream pastures were receiving greater grazing pressure than offstream pastures during the afternoon. Total daily grazing time did not differ between treatments; offstream cattle grazed 652 min/d and no-offstream cattle grazed 678 min/d. A time of day $\times$ time in grazing period interaction was observed in cattle grazing patterns ($P < 0.01$, Figure 4). Early in the grazing period cattle grazed more from 0301 to 0600 than late in the grazing period; conversely, grazing time from 0601 to 0900 was greater late in the grazing period than during the early observation period. The time in grazing period difference in daily grazing time distribution was probably a consequence of decreasing daylight later in the summer. This finding supports the contention that daylight observations are sufficient for describing cattle location during grazing. Mean grazing time did not differ significantly as a response to year. Grazing time between 2101 and 0600 accounted for only 15.2 and 12.3% of the total grazing time for offstream and no-offstream cattle, respectively. Travel distance, measured with pedometers, indicated that use of offstream water and trace-mineral salt did not affect daily travel distance ($P = 0.55$); animals in both treatments traveled about 3.54 km/d. Travel distance was also not significantly different between years or time in grazing period.

Grazing patterns observed in this study were similar to those reported by other researchers (Sneva, 1969; Marlow and Pogacnik, 1986; Howerly et al., 1996). Discovery of relatively low grazing activity from 2100 to 0600 resembled results from previous work that sug-

gested that there is little grazing activity during the night (Miner et al., 1992). Reports by Gillen et al. (1984) paralleled our results in that cattle occupation of the riparian area was low in the morning, increased around 1100, and dropped near dusk. This appeared to correspond with daily temperature patterns; cattle sought water as the cool morning period ended and the heat of the day began to set in. The consistency of these grazing patterns supported observations made by a number of authors that distance from and location of water was a key factor in cattle distribution patterns (Roath and Krueger, 1982; Gillen et al., 1984; Senft et al., 1985a). Roath and Krueger (1982) observed that a square root transformation of distance from water accounted for 38% of variation in utilization, while a combination of distance from salt and water accounted for 62% of the variation in utilization. Kie and Boroski (1996) reported that cattle grazing in the Sierra Nevada stayed within 221 m of water, even though most slopes were less than 20%.

As was demonstrated through the daily distribution patterns, the location where cattle consumed water during the late morning/early afternoon was important in determining where cattle would spend the afternoon hours. Sneva (1969) reported that 75% of the day's travel time occurred during the 3-h period around watering, but only 20% of the grazing took place during this time. Cattle traveled 15 min during the hour before drinking and 21 min during the hour of drinking, whereas only 7 min were spent traveling in the hour after drinking. This indicates that cattle most likely did

not move far away from their water source immediately after drinking. Over 55% of the observations between 1201 and 1800 occurred in the riparian zone. Roath and Krueger (1982) observed that cattle would bed down after the early morning feeding period before searching for water. After finding water they sought shade in the vicinity of water; however, contrary to our observations, Roath and Krueger (1982) noted that shading in the daylight hours rarely occurred in the riparian area and that adjacent slopes were preferred for bedding. Although these grazing and distribution patterns emphasized the role of water in livestock distribution, other research emphasizes the importance of a number of other characteristics in influencing cattle distribution. Owens et al. (1991) observed that vegetation biomass as well as green herbage availability, brush abundance, road location, water availability, fence proximity, and a number of other factors influenced vegetation utilization. Cook (1966) also listed a number of factors including percentage of slope adjacent to bottomland and percentage of maximum slope from grazing site to water as contributors to cattle distribution and utilization patterns. Observation of cattle behavior can be used in manipulating distribution.

The less-distinct treatment differences in percentage of observations in the riparian area late in the grazing period correspond with the trends observed in the distance from stream data. Both data sets show increased pressure closer to the stream later in the grazing period by offstream cows. Greater riparian occupation by offstream cows occurred from 1501 to 1800, and these cattle were also closer to the stream, according to distance from stream data, during the afternoon hours in the end of the grazing period of 1997. This may have been due to the presence of more desirable forage in the riparian area. Marlow and Pogacnik (1986) observed that cattle grazing fresh pastures every 2 to 3 wk throughout the year put greater grazing pressure on the riparian areas during the late summer and early fall. They attributed this to the change in forage quality, and the presence of more lush vegetation in the riparian area. In contrast to offstream cattle, no-offstream cattle exhibited a slightly lower riparian occupation during the afternoon. This observation was reinforced in the distance from the stream data that showed no-offstream cattle late in the 1996 grazing period beginning the day further from the stream than offstream cattle and not spending the afternoon period as close to the stream as in the early part of the grazing period. Late in the grazing period of 1997, distribution of no-offstream cattle did not differ from that of offstream cattle ($P < 0.05$); however, no-offstream cattle did not spend the afternoon hours as close to the stream as they were during the early part of the grazing period. The late-season grazing period response by no-offstream cattle may have been a result of the higher utilization occurring in the riparian areas of no-offstream pastures during the earlier observation period and the need for cattle to move further away from the stream to find

adequate vegetation during the latter part of the grazing season. Water and salt influenced distribution early in the grazing period; however, during the latter part of the grazing period it appeared that vegetation availability may have played a dominant role in determining distribution patterns. Previous research has evaluated the role of vegetation in determining cattle distribution and behavior. Marlow and Pogacnik (1986) observed differences in distribution due to physiological stage of the vegetation, and Owens et al. (1991) listed grass quantity as a factor that influenced utilization in areas of both high and low vegetation biomass. Likewise, Cook (1966) identified percentage of use of the valley bottom immediately below the grazing site as a factor affecting the use of slope by cattle. These studies support the hypothesis that no-offstream animals may have utilized the uplands later in the rotation because of lower availability of riparian forage, and simultaneously offstream cattle used the riparian area more in the latter part of the grazing period because of the availability of more lush and palatable forage.

Animal Performance

Cow and calf weight gains, averaged across both years, were influenced by the presence of offstream water and trace-mineral salt ($P < 0.01$, Table 2). However, cow condition score did not differ significantly between treatments. Cows with access to offstream water and trace-mineral salt gained 11.5 kg more over the 42-d grazing period. Calves had a similar response, gaining 0.14 kg/d more than calves with the stream as their only water source.

The reason for increased weight gain by offstream animals is unclear. However, distribution patterns indicate that more uniform grazing and less patch grazing, grazing the regrowth of areas that were previously grazed, may have occurred in offstream pastures. Regrazing of patches can improve diet quality but decrease grazing efficiency because less forage is available in previously grazed patches. Assessment of diet quality did not indicate superior nutritional value of one vegetation type over another; however, our methods of measuring diet quality probably would not have been sensitive to patch grazing, because total collection of vegetation within a plot frame was used rather than selective collection based on actual diet selected.

Access to trace mineral salt by offstream cattle is not credited for increased weight gain. Previous research in northeastern Oregon involving the use of trace-mineral salt in spring-summer grazing systems shows summer gains for yearling steers were not improved with trace-mineral salt compared with iodized salt, averaging 0.92 kg/d (Turner and Whanger, 1995). Although the aforementioned research compared the use of trace-mineral salt with iodized salt, unrelated work by Morris et al. (1980) found that providing salt free choice to one group of cattle in pastures with low Na concentration but providing no supplemental salt to the control group

Table 2. Effects of offstream water and trace-mineral salt on cow weight gain and condition score and calf weight gain over the 42-d study period (mean $\pm$ SE)

Item	Treatment ^a	
	Offstream	No-offstream
Cow weight change, kg	29.20 $\pm$ 0.82 ^y	17.7 $\pm$ 0.75 ^z
Cow condition score change ^b	0.18 $\pm$ 0.10 ^y	0.09 $\pm$ 0.09 ^y
Calf weight gain, kg/d	1.01 $\pm$ 0.006 ^y	0.87 $\pm$ 0.005 ^z

^aOff-stream = cattle with access to Milk Creek and offstream water and trace mineral salt, No-offstream = cattle with access to Milk Creek with no offstream water and trace mineral salt. Values are the average of both years, n = 6.

^b1 to 9, 1 = extremely emaciated (Wagner et al., 1988).

^{y,z}Within a row, means without a common superscript letter differ ($P < 0.05$).

produced no significant differences between treatments in the body weight changes of the cows, number of calves born, or birth or weaning weight of the calves. Cattle in this study had an average daily intake of 27 g·animal⁻¹·d⁻¹ of salt over the entire study period; means over a 7-d period ranged from 0 to 65 g·animal⁻¹·d⁻¹. Turner and DelCurto (1991) suggested that supplementing minerals and vitamins does not substantially improve performance, unless grazing is in a deficient area. Additionally, all cattle were provided with trace-mineral salt prior to initiation of the 42-d study. Overall, increased weight gain of offstream cattle compared with no-offstream cattle may be attributed to a combination of factors, including increased forage production in offstream pastures, intake of a more nutritious diet due to less patch grazing, and more uniform distribution.

Fecal Deposits

No significant difference in fecal deposits along the streambank was noted between grazed treatments in either year (Table 3). The mean concentration of fecal deposits within 1 m of the stream was 0.25/linear meter of stream averaged over years and treatments. Based on the assumption that a cow consumes about 2.5% of its body weight in dry matter per day and that the basal diet is about 60% digestible, we can assume that on average an 500-kg cow deposits a total of about 5 kg of fecal DM·cow⁻¹·d⁻¹. Church (1969) estimated that a cow defecates about 12 times/d. If this is the case, each flop would equal approximately 0.42 kg of DM. If applied

to our pastures, which had an average stream length of 263 linear meters and an average stocking rate of 10 pairs/pasture, the 0.25 flocs/linear meter of stream equates to approximately 28 kg of fecal dry matter/pasture, or 2.76 kg/pair for a period of 42 d. This is equivalent to only 1.31% of the total fecal output for one cow for 42 d. The above discussion involves numerous assumptions, but taken within this context indicates that a very small proportion of defecation occurs close enough to the stream to significantly increase coliform runoff and stream contamination. Previous studies revealed very similar results. Buckhouse and Gifford (1976) found a lack of differences in fecal indicator bacteria in runoff of grazed and ungrazed pastures. These authors further indicated that not only is a low percentage of a grazed watershed covered with fecal deposits, but that a minimal amount of fecal bacteria was observed at 1 m from a 1-mo-old fecal deposit after a severe storm event. In a study looking at fecal coliform and fecal streptococcus, concentration of runoff from grazed and ungrazed pastures was not directly related to the presence of animal manure or grazing (Edwards et al., 1997). Other factors that contribute to contamination of a stream by fecal bacteria include intensity of runoff events, soil temperature, and soil type (Bohn and Buckhouse, 1985).

Pasture and Herd Size

This research was conducted in relatively small pastures with small herd sizes in order to allow for a replicated and blocked design. Although the pastures were

Table 3. Effect of offstream water and trace-mineral salt on distribution as measured by fecal deposits located within 1 m of the stream (mean $\pm$ SE)

Item	Treatment ^a	
	Offstream	No-offstream
fecal deposits, meter of stream		
1996	0.450 $\pm$ 0.12	0.299 $\pm$ 0.10
1997	0.135 $\pm$ 0.02	0.135 $\pm$ 0.02

^aOffstream = access to stream with offstream water and trace-mineral salt; no-offstream = access to stream without offstream water or trace-mineral salt (n = 6).

small, each pasture represented a meadow-to-upland variation in terrain and vegetation very similar to what would be represented by a large pasture covering a much longer reach of the stream and associated uplands. Additional considerations in the extrapolation of this data stem from extensive research documenting the tendency for large herbivores to focus their foraging activity around water. Research showing that cattle preferred to graze in areas within 200 m of water (Gillen et al. 1984), concentrate 47% of their use within 300 m of water on Wyoming foothill range (Hart et al. 1991), and utilize the range in such a pattern that 69% of the available grazing land, which lies over 723 m from water, sustained less than 12% of use (Pinchak et al., 1991) supports the extrapolation of this data, because the distance between the stream and the alternate water in our study averaged between 242 and 394 m. Additionally, grazing and resting behavior patterns similar to what we observed have been observed on large-scale grazing operations; Senft et al. (1985b) pointed out that resting behavior, as it relates to water location, is also important when looking at distribution patterns because of its potential to occupy up to 50% of animal activity time. He concluded that 18 to 25% of resting in a Great Plains pasture occurred near the stock watering facility at all times of the year. In a related study on grazing patterns Senft et al. (1985a) noted that a zone immediately surrounding watering areas was preferred for grazing at all times of the year. Although it appears that numerous similarities exist in grazing behavior and in cattle distribution in relation to water between small and large pastures, travel distance may have differed due to the smaller pasture size. Low et al. (1981) observed travel distances of 9.3 km/d, whereas we observed travel distances of 3.54 km/d. It is apparent that there may be some limitations in extrapolating this data to the much larger pastures that are common on western rangelands; however, it is clear through a review of the above research as well as through research cited in the Results and Discussion section of this paper that cattle grazing in larger pasture situations exhibit behavior patterns similar to those observed in our research.

Implications

Implementing offstream water and trace-mineral salt into a grazing system can be effective in altering distribution patterns of cattle grazing a riparian meadow and its adjacent uplands and also can result in increased weight gain. The success of this and other management strategies can be tied to the behavioral patterns of the cattle and to the characteristics of the rangeland. Results from this study indicate that offstream water and trace-mineral salt are most effective in decreasing riparian grazing pressure during the beginning of the rotation when forage is plentiful and during the afternoon hours when temperatures are warmer and water availability is crucial. Although

these patterns were apparent during this study, each situation is unique and management should be implemented accordingly. Grazing management is complex and should consider location and availability of water, shade, and trace-mineral salt; season; time of day; temperature; and vegetation type and abundance.

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