OFF-STREAM WATER AND SALT REDUCE STREAM BANK DAMAGE IN GRAZED RIPARIAN PASTURES

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Summary

Stream bank damage associated with livestock grazing in riparian pastures is of concern to land managers. We tested the hypothesis that providing cattle with off-stream water and trace mineralized salt would reduce stream bank damage compared to pastures lacking these amenities. Three replications of each of three grazing treatments (ungrazed control; "W" for water and salt provided; and "NoW" for no water or salt) were established on Milk Creek at the Hall Ranch Unit of the Eastern Oregon Agricultural Research Center near Union, Oregon. Each treatment pasture was stocked with 10 cow-calf pairs for a stocking rate of 0.77 ha per AUM to achieve moderate grazing intensity of approximately 50 percent utilization of preferred grasses. Pastures were grazed for 42 days during each of 2 years (1996-1997) beginning in mid-July. Measurements of stream bank cover and stability were taken before (June) and after (September) cattle grazing. Treatment effects were compared using one-way ANOVA. Stream bank effects were consistent with observations of cattle distribution, with 26 percent of the stream bank in "W" pastures showing cattle presence (hoof prints), versus 31 percent for "NoW" pastures. These differences indicated that off-stream water attracted cattle into the uplands enough to significantly reduce the development of the worst condition stream banks (uncovered and unstable) from 9 to 3 percent. Similarly, 10 percent of the stream bank in "W" pastures changed from the best condition (covered/stable) to damaged categories, compared to 14 percent in the "NoW" pastures.

Introduction

Cattle management problems in the Intermountain Region are associated more often with improper distribution than abundance of livestock (Holechek et al., 1989). This is especially true in riparian areas (Platts, 1991), where water and shade attract livestock during the hottest months (Stuth, 1991). Roath and Krueger (1982) estimated 81 percent of forage used by livestock under a moderate stocking regime in an Intermountain riparian area came from a streamside meadow representing only 2 percent of the grazing area. In fact, several studies have shown wild ungulates and livestock use riparian areas disproportionately more than adjacent uplands (Kauffman and Krueger, 1984; Marlow and Pogacnik, 1985). Disproportionate use is an important management issue because abundant evidence indicates that heavy cattle grazing can cause deleterious effects on riparian habitats (Skovlin, 1984; Larsen et al., 1998), including changes in stream bank stability (Marlow et al., 1987), increased sedimentation (Duff, 1979), loss of riparian vegetation, stream widening, and shallowing (Platts, 1986). By comparison, there is far less information on ecological effects of moderate grazing, including the type of riparian use suggested by alternative grazing strategies such as deferred grazing, rest-rotation grazing, and off-stream water (Skovlin, 1984; Larsen et al., 1998).

This report is part of a larger study on the economics and environmental effects of a cattle dispersion management system in which off-stream water and trace mineralized salt was supplied in a controlled, replicated field experiment (Dickard, 1998; Stillings, 1998).

Economically, the system was judged a success because weight gains of young cattle more than offset the cost of establishing and maintaining the off-stream water system (Stillings, 1998). Differential weight gain was due in part to the use of high quality upland vegetation by cattle that were attracted there by water and salt supplements. Weight gains contributed an estimated $4,500 to $11,000 annual increase in net return for a 300 cow-calf operation, depending on cattle prices (Tanaka et al., 1999). Additionally, attraction of cattle to uplands in "managed distribution" pastures was confirmed by a small but significant change in overall cattle distribution relative to "unmanaged distribution" pastures lacking off-stream water and salt (Dickard, 1998).

Did the observed shift in cattle distribution (toward uplands) result in reduced ecological impact on the riparian zone? Stream bank cover and stability are two critical factors influencing water quality, water storage, stream channel morphology, erosion potential, and wildlife habitats in riparian areas (Kauffman and Krueger, 1984; Platts, 1986; Bohn, 1986; Elmore and Kauffman, 1994; Mosley et al., 1997). Our objective was to test the hypothesis that cattle in pastures provided with off-stream water and salt would have less impact on the riparian greenline (the area above the scour line but below bankful level) than cattle in the "unmanaged distribution" pastures.

Materials and Methods

The study was conducted on the Hall Ranch Unit of the Eastern Oregon Agricultural Research Center (T5S, R41E, Willamette Meridian), approximately 19 km southeast of Union, Oregon. Mean annual precipitation is 66 cm, with approximately 60 percent occurring as snow. Elevation ranges from 1,050 to 1,250 m. The Hall Ranch includes two distinct riparian zones: the larger on Catherine Creek, a tributary of the Grande Ronde River; and the smaller on Milk Creek, a tributary of Catherine Creek. The 101 ha study area included the entire riparian zone of Milk Creek as it passes through the Hall Ranch, a 2.4-km section beginning at a private boundary on the north and ending at highway 203 a few hundred meters from its confluence with Catherine Creek. The study area was grazed lightly from mid-July to mid-August in each of the 5 years (1992-1996) prior to the beginning of this study at an average rate of 1.75 ha per AUM.

In May, 1996, nine experimental units of similar area in three blocks were delineated along the 2.4-km reach of Milk Creek (Figure 1). The blocks were established because of obvious differences in riparian habitat from the southern to northern section of Milk Creek: Block 1 was forested with Douglas hawthorn (*Crataegus douglasii* Lindl.) and ponderosa pine (*Pinus ponderosa* Dougl. Ex Loud.); Block 2 had components of both forest and meadow; and Block 3 was primarily meadow, dominated by Kentucky bluegrass (*Poa pratensis* L.), timothy (*Phleum pratense* L.), sedges (*Carex* spp.), and other dicots. Three treatments then were assigned randomly to experimental units within each block: (1) ungrazed control; (2) managed distribution, in which off-stream water and salt were provided ("W," for water provided); and (3) unmanaged distribution, in which no off-stream water or supplement was provided ("NoW"). The same treatments were assigned to experimental units for both the 1996 and 1997 grazing seasons. For the two grazing treatments, 10 cow-calf pairs were introduced into each of the six experimental units for 42 days beginning in mid-July 1996 and 1997 for a stocking rate of 0.77 ha per AUM, or a little more than twice the grazing intensity of the previous 5 years. The length of grazing time and the stocking rate were chosen with the objective of achieving a moderate intensity of approximately 50 percent utilization of grass within each experimental unit.

Measurements of stream banks were taken during the second grazing year (1997). Because the same treatment design was used for both years, measuring stream bank variables in the second year allowed assessment of the cumulative effect of 2 consecutive years of treatment.

The stream bank was measured before (June) and after (September) cattle grazing by pacing each side of Milk Creek and recording the appropriate stream bank cover and stability class within plots defined lengthwise as a step (0.5 m) taken parallel to the stream. Plot width was defined as the vegetative greenline located below the bankful level but above the scour line (Bauer and Burton, 1993). Plots were examined first for the presence of hoof prints and then assessed for bank cover and stability. Stream bank plots were rated "covered" if they contained any of the following features: (1) perennial vegetation ground cover greater than 50 percent; or (2) roots of deeply-rooted vegetation such as shrubs or sedges covering more than 50 percent of the bank; or (3) at least 50 percent of the bank surface protected by rocks of cobble size or larger; or (4) at least 50 percent of the bank surface protected by logs of 10 cm diameter or larger (Bauer and Burton, 1993). Otherwise banks were rated "uncovered."

Banks were rated "unstable" if they exhibited any of these features: (1) blocks of banks broken away and lying adjacent to the bank breakage ("breakdown"); (2) bank sloughed into stream channel ("slump"); (3) bank cracked and about to move into stream ("fracture"); (4) bank uncovered as defined above and exhibiting an angle visually estimated steeper than 80 ("vertical") (Bauer and Burton, 1993). Otherwise, banks were rated "stable."

Each step of the observer thus was rated according to stream bank cover and stability, and grouped into four classes: (1) covered/stable; (2) covered/unstable; (3) uncovered/stable; and (4) uncovered/unstable. A single observer conducted the survey. To test hypotheses about grazing impacts on stream bank cover and stability, data were summarized by grazing treatment (control, W, and NoW) with three replicates (one per block) per treatment.

Uncovered or unstable banks can lead to accelerated erosion (Marlow and Pogacnik, 1985). To assess erosion potential of stream banks, an "erosion index" was calculated by first assigning a numerical score to each cover/stability class as follows:

Cover/Stability Class	Erosion Index
covered/stable	1
uncovered/stable or covered/unstable	2
uncovered/unstable	3

The erosion index then was calculated for each treatment pasture:

$$\text{Erosion Index} = \frac{(1xn_1)+(2xn_2)+(3xn_3)}{N_{total}}$$

The erosion index could vary from 1.0 (least erosion potential) to 3.0 (highest erosion potential). Five greenline variables were the observed changes between June and September in: covered/stable, covered/unstable, uncovered/stable, uncovered/unstable, and the erosion index. These variables were analyzed using one-way ANOVA with block as a fixed factor and treatment as the random factor (total df = 8). Means were compared using lsd ($P < 0.05$).

Results

Following removal of cattle in September, the percentage of greenline having cattle hoof prints averaged 0, 26, and 31 percent in control, "W," and "NoW" pastures, respectively. While there was a significant ($P < 0.05$) overall treatment effect for presence of cattle hoof prints, the "W" and "NoW" units did not differ statistically. Significant treatment effects on cover and stability of the greenline included changes in proportions of the covered/stable, covered/unstable, uncovered/unstable, and the erosion index (Table 1). There were no block effects or block x treatment interaction effects. The greatest change due to grazing, compared to ungrazed controls, was the significant decrease in the proportion of stream bank classified as both covered and stable (Figure 2). Although the "NoW" units averaged 14 percent decrease in the covered/stable class, compared to just 10 percent for the "W" units, the two grazing treatments did not differ statistically (Table 1). The pattern of change, however, did differ between the two grazing treatments, with the "NoW" units gaining significantly more of the uncovered/unstable class. Overall, decreases in stability contributed more to change than decreases in cover, reflected by the fact that the uncovered/stable class did not change in relation to controls, while the covered/unstable class changed significantly. While erosion potential (reflected by the erosion index) increased significantly due to grazing, there was no significant difference in this metric between the two grazing strategies.

Discussion and Management Implications

Results support our hypothesis that providing off-stream water and salt lessens the impact of cattle grazing on the riparian greenline. Grazing per se resulted in a decline in the covered/stable stream bank class and concomitant increase in the uncovered/unstable class and soil erosion potential. However, off-stream water and salt attracted cattle toward uplands (Dickard, 1998) enough to reduce significantly the development of the worst condition stream banks (uncovered/unstable) to only 3 percent compared to 9 percent in "no water" pastures. Similarly, 10 percent of the greenline in "managed distribution" pastures changed from the best condition (covered/stable) to damaged categories, compared to 14 percent in "unmanaged distribution" pastures. The implication is that managers can obtain some protection from grazing of sensitive riparian areas if livestock are attracted into uplands. The degree to which livestock can be attracted away from riparian areas depends on season, topography, vegetation, weather, and behavioral differences (Bryant, 1982; Stuth, 1991). For example, successful use of off-stream water to adjust distribution late in the season may not be observed for early season grazing (Miner et al., 1992), due to changes in weather and forage quality. Pastures with steep slopes may be less amenable to provisioning with off-stream water (Bryant, 1982; Dickard, 1998). The relative quality of forage between riparian and upslope portions of a pasture also may be more important for determining livestock distribution patterns (Skovlin, 1984). Finally, individual cattle can be expected to respond in a variety of ways, based on innate as well as learned behaviors (Bryant, 1982; Skovlin, 1984).

The significant greenline effects observed in our study beg the question: would the magnitude of these effects result in eventual changes in channel morphology, to contribute to declines in native fish populations? The answer to this question depends upon whether or not stream banks recover over the course of the year, and whether or not the 26 to 31 percent bank breakdown along Milk Creek created enough sediment to cause permanent changes in aquatic habitat quality. Several studies have reported significant channel morphology effects as a consequence of chronic, heavy livestock grazing (Marlow et al., 1987; Rinne, 1988), but few have attempted to follow recovery rates year to year, especially after more moderate grazing intensity. Kauffman et al. (1983), working on a stream adjacent to Milk Creek (Catherine Creek), found that stocking rates of 1.3-1.7 ha/AUM (compared to 0.77 ha/AUM measured in our study) caused significantly greater bank erosion compared to ungrazed controls during two seasons of grazing. They also found that while over-winter erosion did not differ among treatments, livestock grazing was enough to cause an overall increase in stream bank losses over the study period. Conversely, some suggest natural processes mitigate moderate bank damage the following year. Buckhouse et al. (1981) reported that while moderate cattle grazing caused measurable bank effects in a single season, any differences between grazed and ungrazed treatments were erased the following year by ice effects and peak flows. While their experiment did not isolate cattle grazing effect per se, results underscore the difficulty in understanding the role of grazing for sediment production in the context of the annual cycle of sediment release. Similarly, Marlow et al. (1987) reported that streamflow and cattle use both were correlated with degree of change in stream channel profile. In particular, stream bank alteration resulted from a combination of high soil moisture, high streamflow, and cattle use. Thus, cattle impacts could be judged only within the context of the annual cycle of natural events typical of their study site. In general, because at least 30 variables are involved in the sediment transport process (Heede, 1980), few studies have isolated the effects of ungulate grazing from the natural background of erosion that occurs over the course of a year (Skovlin, 1984). Given these considerations, it would be interesting to measure the extent of bank recovery in the years following moderate grazing at the Milk Creek study site.

It is clear that heavy livestock grazing can reduce aquatic community integrity and water quality by removing vegetation (Leege et al., 1981) and by increasing bank instability through trampling (Moring et al., 1985; Platts, 1986; Marlow et al., 1987). While studies on grazing effects of more moderate intensities are rare (Blackburn, 1984), Hanson et al. (1970) showed that increasing grazing intensity from "light" to "heavy" resulted in a near doubling of annual runoff, suggesting that managed grazing systems are an improvement over unrestricted grazing. Indication that light to moderate cattle grazing may be compatible with healthy riparian systems was noted by Clary (1999), who found that previously degraded riparian systems recovered equally well in ungrazed, lightly grazed, and moderately grazed treatments, in terms of vegetation and stream bank stability. While these studies and others suggest that cattle grazing strategies can reduce impact on sensitive riparian areas, what really is needed are experiments that link cattle grazing intensity, bank breakdown, sediment release and in-stream habitat effects. Such studies are essential if we are to understand the thresholds beyond which cattle-induced bank breakdown becomes a problem.

Literature Cited

Bauer, S.B. and T.A. Burton. 1993. Monitoring protocols to evaluate water quality effects of grazing management on western rangeland streams. USEPA 910/R-93-017, U.S. Environ. Protection Agency, Water Div., Region 10, Seattle, WA.

Blackburn, W.H. 1984. Impacts of grazing intensity and specialized grazing systems on watershed characteristics and responses. *In:* NRC/NAS, Developing strategies for rangeland management. Westview Press, Boulder, CO, pp. 927-983.

Bohn, C. 1986. Biological importance of stream bank stability. Rangelands. 8:55-56.

Bryant, L.D. 1982. Livestock response to riparian zone exclusion. J. Range Manage. 35:780-785.

Buckhouse, J.C., J.M. Skovlin, and R.W. Knight. 1981. Stream bank erosion and ungulate grazing relationships. J. Range Manage. 34:339-340.

Clary, W.P. 1999. Stream channel and vegetation responses to late spring cattle grazing. J. Range Manage. 52:218-227.

Dickard, M.L. 1998. Offstream water and salt as management strategies for improved cattle distribution and subsequent riparian health. M.S. Thesis, Univ. Idaho, Moscow, ID.

Duff, D.A. 1979. Riparian habitat recovery on Big Creek, Rick County, UT. *In:* Proc. Forum on grazing and riparian/stream ecosystems, Vienna, VA, Trout Unlimited, p. 91.

Elmore, W. and J.B. Kauffman. 1994. Riparian and watershed systems: Degradation and restoration. *In:* Ecological implications of livestock herbivory in the west. M. Vavra, W.A. Laycock, and R.D. Pieper (eds.) Soc. Range Manage., Denver, CO. pp. 212-231.

Hanson C.L., A.R. Kuhlman, C.J. Erickson, and J.K. Lewis. 1970. Grazing effects on runoff and vegetation on western South Dakota rangeland. J. Range Manage. 23:418-420.

Heede, B.H. 1980. Stream dynamics: An overview for land managers. USDA For. Serv. Gen. Tech. Rep. RM-72. Rocky Mtn. For. And Range Exp. Sta., Ft. Collins, CO.

Holechek, J.L., R.D. Pieper, and C.H. Herbel. 1989. Range management: Principles and practices, 2nd ed., Prentice Hall, Upper Saddle River, N.J.

Kauffman, J.B., W.C. Krueger, and M. Vavra. 1983. Impacts of cattle on stream banks in northeastern Oregon. J. Range Manage. 36:683-685.

Kauffman, J.B. and W.C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications: A review. J. Range Manage. 37:430-438.

Larsen, R.E., W.C. Krueger, M.R. George, M.R. Barrington, J.C. Buckhouse, and D.E. Johnson. 1998. Livestock influences on riparian zones and fish habitat: Viewpoint. J. Range Manage. 51:661-664.

Leege, T.A., D.J. Herman, and B. Zamora. 1981. Effects of cattle grazing on mountain meadows in Idaho. J. Range Manage. 34:324-328.

Marlow, C.B. and T.M. Pogacnik. 1985. Cattle feeding and resulting patterns in a foothills riparian zone. J. Range Manage. 39:212-217.

Marlow, C.B., T.M. Pogacnik, and S.D. Quinsey. 1987. Stream bank stability and cattle grazing in southwestern Montana. J. Soil and Water Cons. 42:291-296.

Miner, J.R., J.C. Buckhouse, and J.A. Moore. 1992. Will a water trough reduce the amount of time hay-fed livestock spend in the stream (and therefore improve water quality)? Rangelands 14:35-38.

Moring, J.R., G.C. Garman, and D.M. Mullen. 1985. The value of riparian zones for protecting aquatic systems: General concerns and recent studies in Maine. *In:* Riparian ecosystems and their management: Reconciling conflicting uses. Johnson, R., C.D. Zieball, D.R. Patton, P.F. Ffolliott, R.H. Hamre (Tech. Coordinators). First No. Amer. Riparian conference, April 16-18, 1985, Ft. Collins, CO. USDA For. Serv., Rocky Mt. For. And Range Exp. Sta., pp. 315-319.

Mosley, J.C., P.S. Cook, A.J. Griffis, and J. O'Laughlin. 1997. Guidelines for managing cattle in riparian areas to protect water quality: Review of research and best management practices policy. Idaho For., Wildl., Range Policy Analysis Group, Rep. 15. College For., Wildl. and Range Sci., Univ. Idaho, Moscow, ID.

Platts, W.S. 1986. Riparian stream management. Trans. West Sect. Wildl. Soc. 22:90-93.

Platts, W.S. 1991. Livestock grazing. *In:* Influences of forest and rangeland management on salmonid fishes and their habitats. Natl. Cl. 472, Amer. Fish Soc., pp. 389-423.

Rinne, J.N. 1988. Grazing effects on stream habitat and fishes: Research design considerations. No. Amer. J. Fish. Manage. 8:240-247.

Roath, L.R. and W.C. Krueger. 1982. Cattle grazing influence on a mountain riparian zone. J. Range Manage. 35:100-103.

Skovlin, J.M. 1984. Impacts of grazing on wetlands and riparian habitats: A review. *In:* NRC/NAS, Developing strategies for rangeland management. Westview Press, Boulder, CO, pp. 1,001-1,103.

Stillings, A.M. 1998. The economic feasibility of offstream water and salt to reduce grazing pressure in riparian areas. M.S. Thesis, Oregon State Univ., Corvallis, OR.

Stuth, J.W. 1991. Foraging behavior. *In:* Grazing management: An ecological perspective. R.K. Heitschmidt and J.W. Stuth (eds.), Timber Press, Portland, OR. pp. 65-83.

Tanaka, J.A., N.R. Rimbey, and A.M. Stillings. 1999. Economics of grazing management in riparian areas. Abstract of Papers, 52nd Annual Mtg., Soc. Range Manage., Omaha, NE.

Cattle grazing at Hall Ranch

Table 1. Proportions of stream bank class (m /100 m of stream bank) before grazing (June), after grazing (September), and change. Means within rows with different superscripts are significantly different (lsd; $P < 0.05$; $n = 3$).

Class	Non-grazed Pastures			W[1] Pastures (m /100 m of stream bank)			NoW[1] Pastures		
	Before	After	Change	Before	After	Change	Before	After	Change
Covered/Stable	90	90	0 ^{a}	89	79	-10 ^{b}	82	68	-14 ^{b}
Uncovered/Stable	3	3	0 ^{a}	5	6	+1 ^{a}	10	8	-2 ^{a}
Covered/Unstable	5	5	0 ^{a}	5	11	+6 ^{ab}	8	15	7 ^{b}
Uncovered/Unstable	2	2	0 ^{a}	1	4	+3 ^{b}	0	9	+9 ^{c}
Erosion Index	1.18	1.18	0 ^{a}	1.10	1.23	+0.13 ^{b}	1.17	1.39	+0.22 ^{b}

[1]Cattle grazing W pastures were provided off-stream water and mineral supplement; cattle grazing NoW pastures received no off-stream water or mineral supplements.

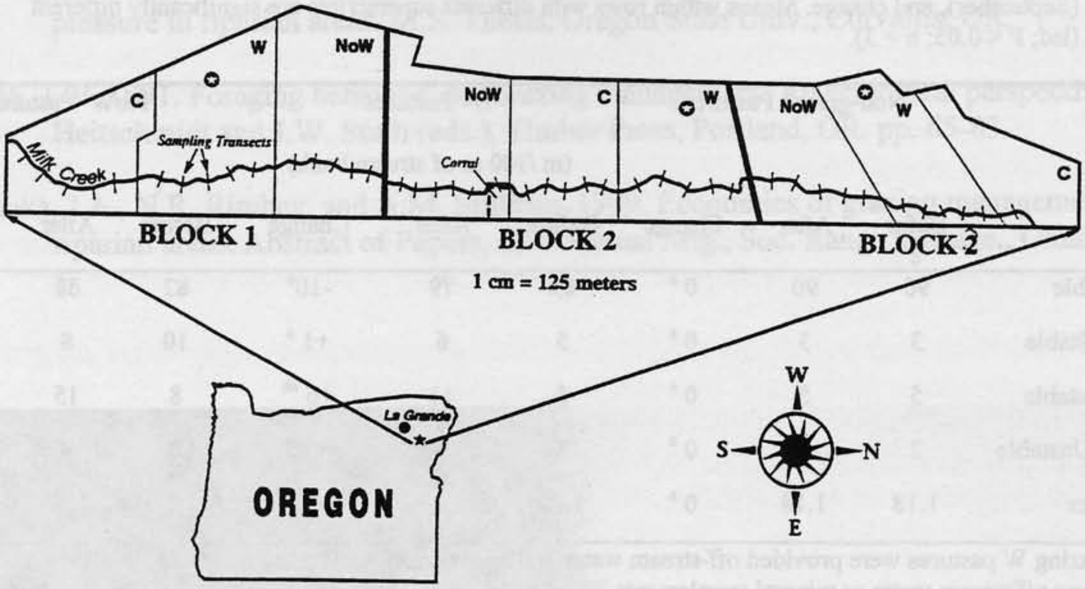
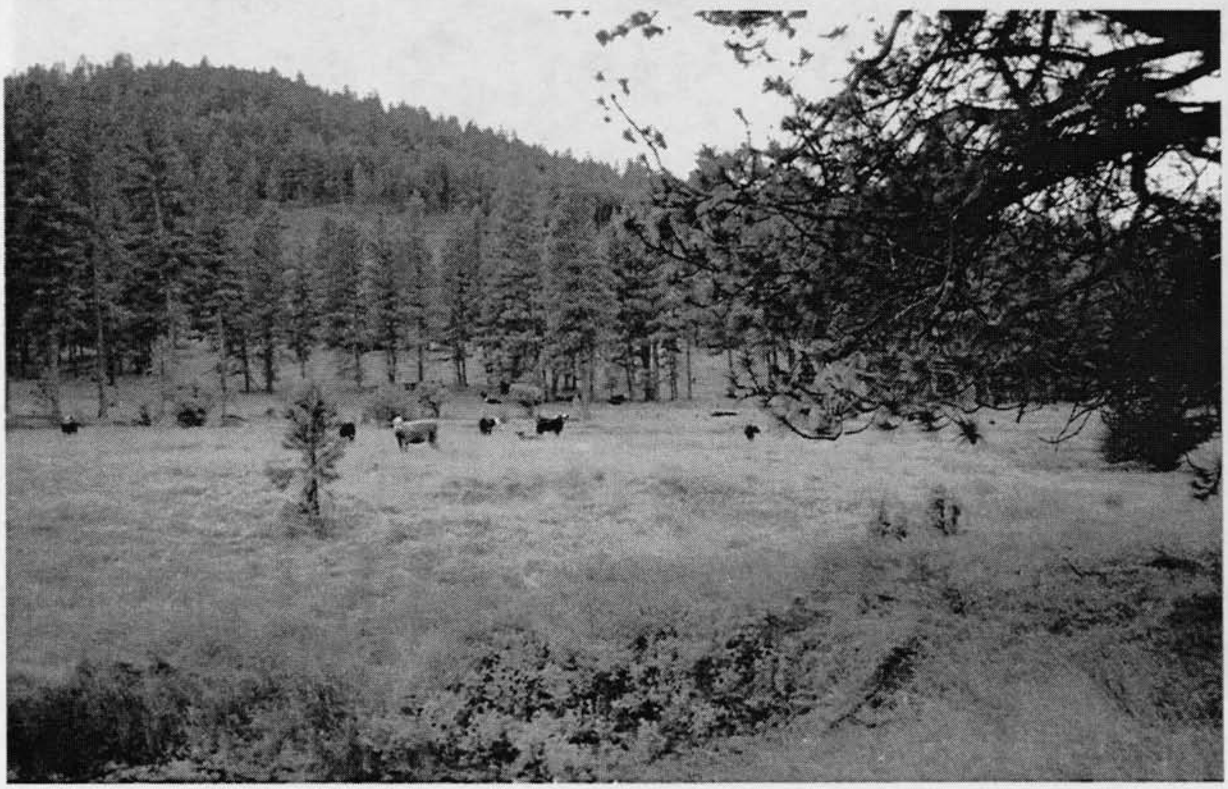


Figure 1. Map of Milk Creek study area showing block design, position of grazing treatments (C = ungrazed contro; W = grazed with off-stream water and salt provided; NoW = grazed with no off-stream water or salt provided), location of corral and watering troughs (★).



Cattle grazing at the Hall Ranch

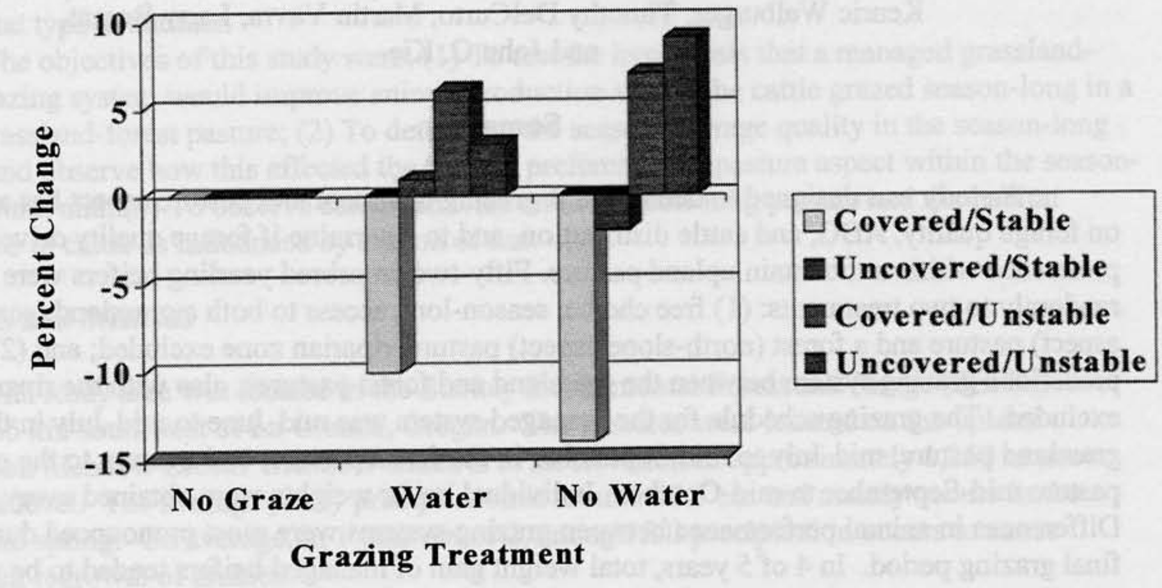


Figure 2. Percent change in stream bank cover and stability classes due to grazing treatments.