Management Strategies for Optimal Beef Cattle Distribution and Use of Mountain Riparian Meadows

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Abstract

Current concerns regarding water quality, biodiversity and threatened and endangered species, combined with the economical importance of livestock production in the Pacific Northwest, dictate a need for research addressing livestock impacts on riparian ecosystems. In the Pacific Northwest specific issues relative to the ultimate survival of Chinook salmon, bull trout and La Hontan cutthroat trout clearly demonstrate a need for additional research and education. More specifically, research evaluating management techniques which help improve livestock distribution relative to riparian areas may be a critical factor in the future of the Pacific Northwest beef cattle industry, as well as other areas of the western United States. In fact, the continued use of public rangelands in the western United States by livestock industries may depend on the ability of university and agency research efforts to prove that livestock grazing can maintain and/or improve the ecological integrity of rangeland resources. Information does exist that suggests livestock grazing can be conducted in a fashion that maintains and/or improves riparian ecosystem integrity. However, most of the data, to date, are observational in nature and does not lend itself well to scientific scrutiny. This paper reviews factors that influence distribution of cattle relative to riparian areas as well as discusses past, current and future research efforts in Northeastern Oregon regarding livestock grazing distribution in riparian ecosystems.

Introduction

Beef cattle production is the number one agricultural commodity in Idaho and Oregon, generating over $1 billion dollars in revenue in 1995 (Oregon Agricultural Statistics, 1996). Currently, the beef industry is dominated by commercial cow/calf production with over 1.1 million producing females in the two states. Nearly 80 % of these cows are managed on ranches located in the eastern half of Oregon and the southern half of Idaho. This area of land also represents production units that are in many cases dependent on public land grazing and areas where riparian habitat is under increased public scrutiny. Uneven use of rangeland by livestock has been and continues to be a major problem confronting range managers (Holechek et al. 1989). Several studies indicate that today's rangelands, in general, are in better condition than 20 years ago (Busby 1979), others indicate that upland areas have shown greater improvement compared to riparian areas (Platts 1991). While improved upland conditions are crucial to the function of the riparian area, and the watershed as a whole, riparian areas should not be sacrificed in favor of uplands. Increased soil erosion, greater early spring runoff contributing to a net loss of late season water holding capacity, decreased plant and animal biological diversity, and poor water quality are some of the critical problems of poor riparian area management. In contrast to drier upland areas, however, riparian zones are dynamic communities which respond relatively quickly to changes in rangeland management. Thus, research and outreach education is a critical need for ranchers and other land managers in the western United States with respectto livestock distribution issues. Likewise, potential improvements in resource management relative to livestock grazing and riparian ecosystem integrity are attainable goals.

The problem of acquiring timely improvement in riparian ecosystems is two-fold: 1) identifying and developing grazing systems that are economically and ecologically compatible with riparian ecosystems and 2) persuading land managers to implement cost effective, beneficial management practices (Kinch 1989, Chaney et al. 1990, Meehan 1991, and Platts 1991). Historically, grazing management has focused on optimum utilization of forage from upland areas for maximum livestock production. Research efforts concentrating on wetland and riparian habitats in relation to livestock grazing are limited in number and scope. Years of training land managers through traditional ranch management prac-

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tices have impeded the progress in improving riparian habitat. Proven, beneficial demonstrative and cost-effective management practices for grazing rangeland riparian areas are a critical need for ranchers and range managers.

Grazing Distribution and Behavior

Grazing management aimed at minimizing uneven use of rangeland requires an understanding of natural factors that influence the grazing patterns of livestock. A series of pasture characteristics that include but are not limited to slope, water availability, vegetation characteristics, shade, and a combination of one or more of these factors have been found to influence grazing distribution to a significant degree. Understanding the natural factors that influence distribution allows for more successful manipulation of distribution using alternate management strategies.

Slope and rangeland accessibility

Understanding distribution patterns on rangelands may begin with an evaluation of terrain and accessibility of the rangeland. In looking at both continuous and deferred-rotation grazing systems, Gillen et al. (1984) found that as slope increased cattle preference for a site decreased. This response was found throughout the grazing season, and may have been partially responsible for 75% utilization of riparian meadows vs. 10% utilization of uplands. Cattle in southeastern Oregon were generally found to prefer slopes less than 10%, and avoid slopes of greater than 20% (Ganskopp and Vavra 1987). These results were similar to those obtained by Pinchak et al. (1991) who discovered that cattle preferred slopes of less than 4% and found that over 90% of total use occurred on slopes of less than 7%.

Vegetation type

While the previous work dealt primarily with the direct effect of slope on utilization, other work has focused more generally on the tendency for livestock to gather in riparian areas. This may be a function of level terrain, increased quantity and quality of vegetation, presence of cover, and availability of water (Kauffman and Krueger 1984). Free-ranging cattle, like wildlife, often form semi-independent groups, known as home range groups, that tend to share habitat use and distribution patterns throughout the grazing season. In a study of home range groups, Howery et al. (1996) found that cows utilized riparian habitat more frequently than upland steppe or upland forest. A similar pattern was observed in the Sierra Nevada when riparian habitat was preferredto clearcut, second growth forests, and burned habitats (Kie and Boroski 1996). On the Great Plains, intermittent drainage channels and adjacent communities were heavily grazed during the growing season, receiving 54% of growing season grazing in just 38% of the pasture areas (Senft et al. 1985a). While these studies noted disproportionate use of riparian areas, they also documented a decrease in the use of riparian areas as the grazing season progressed and forage became depleted (Goodman et al. 1989, Hart et al. 1991, Howery et al. 1996, Kie and Boroski 1996, Pinchak et al. 1991, Senft et al. 1985a). They suggest this is due to the need to venture to less desirable habitat to find enough forage to meet their nutritional needs. In a different study, Marlow and Pogacnik (1986) looked at habitat use as a function of season and physiological stage of the vegetation rather than previous use. The study utilized an 8 pasture system in which pastures were stocked heavily for 2-3 weeks and then evacuated. Results showed that riparian areas received greater use later in the grazing season compared to early season use. They suggested that the change in habitat preference was probably due to physiological changes in the vegetation; as upland forage dries up, riparian forage becomes even more desirable in comparison. Owens et al. (1991) noted distribution randomness in response to biomass. In an attempt to look at distribution patterns in pastures of uniform landscape and range site, increased randomness in distribution was noted as biomass decreased. When total biomass was limited, factors such as physical design of the pasture and vegetation composition had a dominant impact on distribution. Under high biomass conditions, plant related factors, such as total amount of vegetation and amount of grass and brush, played the most significant role in determining distribution. Preference for specific vegetative communities, despite water and slope constraints, was noted in Wyoming when cattle demonstrated preference for wetland/subirrigated sites even when other plant communities were available with similar slope and the cattle had similar access to water (Pinchak et al. 1991).

Water

Water availability is another factor contributing to cattle distribution and behavior within a grazing system. Briske and Heitschmidt (1991) discuss the tendency for large herbivores to focus their foraging activity around water, stating that these ungulates seek the most energy-efficient sources of forage referenced to known water sources. This tendency was observed in cattle on a number of studies which evaluated grazing distribution relative to water sources. Cattle preferred to graze in areas within 215 yards of water while avoiding areas greater than 645 yards away from water under a continuous grazing system (Gillen et al. 1984). Under a deferred system in the same area, cattle avoided areas greater than 215 yards from water (Gillen et al. 1984). A similar trend was found when cattle on Wyoming foothill range concentrated 47% of their use within 320 yards of water (Hart et al. 1991). On the same foothill range, 69% of the available grazing land, which lies over 720 yards from water, sustained less than 12% of the use (Pinchak et al. 1991). In an area where most slopes were less than 20%, Kie and Boroski (1996) found that cattle observations were never farther than 240 yards from water during the two years of the study. Even though they described this area as being potentially available to cattle because of the moderate slopes, riparian areas played the dominant role in distribution.

Valentine (1947) determined that past range surveys and stocking rate levels were inaccurate because they had not taken distance from water into consideration. He noted that many studiesused valid production measures to determine stocking rates, but the ranges were still in decreasing trend. 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 18-25% 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. The importance of water as a factor in cattle distribution is apparent throughout these studies. Furthermore, it seems that, depending on variation of factors such as slope, shade, and vegetation, cattle tend to spend the majority of their time within about 322 yards of water.

Shade

McIlvain and Shoop (1971) addressed the role of shade in influencing cattle distribution on a site in northwestern Oklahoma with little natural shade. They looked at steers grazing with 1) artificial shade/shelter present, and 2) no shade or shelter present. Results showed that shade influenced distribution, as steers loafed under shade on cool days as well as hot days. Availability of shade was also credited for increased animal performance of 19 lbs over steers without access to shade. This response demonstrates the importance of shade in areas that typically receive little use.

Throughout this summary of research on the effects of varying range characteristics on cattle distribution, it is clear that no single characteristic is primarily responsible for explanation of cattle behavior and distribution. Cook (1966) demonstrated the complexity of cattle distribution and behavior in a study looking at the correlation between 21 factors in grazing distribution and utilization as measured by grass utilization on the site. Results showed that when all 21 factors were included in the analysis only 37-55% of variability was explained. It is apparent through the previous studies that water availability, shade, slope, and vegetation play a key role in cattle distribution. A combination of one or more of these factors would probably be most influential in determining distribution patterns. The complexity of cattle distribution demonstrates a need to evaluate interactions between all factors in creating and implementing management plans. Cook (1966) suggested that the utilization expected on mountain slopes can best be obtained by good management practices that involve herding animals and salting and watering appropriately. He emphasizes that no single factor can be used as a reliable index in predicting range utilization.

Management Strategies and Opportunities

Grazing management systems designed to protect the integrity of riparian systems while sustaining cattle production must consider: 1) distribution patterns of cattle, and 2) season and degree of use that would have minimal impact on that particular riparian area. In order to maintain a productive operation, the nutrient requirements of the cattle must also be satisfied.

Research has been conducted on management strategies that encourage more uniform livestock use throughout the pasture and potentially decreases riparian grazing pressure without fencing. While it seems that cattle exclusion through fencing is the common solution to protection of riparian areas, in most cases it is not economically feasible and inhibits movement of some species of wildlife. Fencing is expensive both in terms of the initial cost and annual maintenance of the fence, as well as the forage lost in the total exclusion of grazing from the riparian area (Bryant 1982). Some strategies that have been evaluated as a substitute for fencing included use of salt and supplement, alternate water, and manipulation of stocking rates and class of animal. Other strategies that have been used less extensively include herding, culling based on distribution tendencies, and the use of electronic eartags.

Salt and supplement

Ares (1953) looked at the effects of supplying a cottonseed meal-salt mixture to cattle grazing southwest ranges. Results showed that supplying the meal-salt mixture at water and away from water was not as effective as providing the mixture away from water only. Feeding the meal-salt mixture away from water eliminated areas of excessive use, as defined in his protocol, decreased areas of heavy use by 50%, increased areas of proper use by 84%, and decreased areas of light or no use by 29%. A similar study in the southwestern U.S. looked at use of 1) block salt at water, 2) block salt with meal-salt added (Nov.-Apr.) at water, 3) block salt away from water, and 4) block salt with meal-salt added (Oct.-June) away from water to increase uniformity of distribution throughout the pasture (Martin and Ward 1973). There was no significant difference in the treatments, however, trends of increased utilization in light use zones when the salt or meal salt was fed away from water were noted. The authors suggested that use of salt or meal-salt cannot be expected to cure a serious distribution problem. McDougald et al. (1989) investigated the effectiveness of strategically placed supplemental feeding locations in decreasing grazing pressure on the riparian areas of hardwood rangelands. Shifting supplementation sites resulted in residual dry matter changes in the riparian area. On a whole, the strategy reduced the area of low residual dry matter from 48% to 1%, and increased the area of high residual dry matter from 13% to 72% of the riparian area.

While these strategies may be effective in areas where supplementation is an integral part of grazing management, many areas do not require supplementation, other than a trace mineralized salt, to meet nutrient requirements during summer months. Also, supplementation may not be a feasible option due to the policies against the introduction of agricultural products such as alfalfa and other supplements onto public lands in some BLM and Forest Service allotments. Therefore, the use of supplementation may not be the most feasible option to increase the uniformity of grazing distribution throughout the pasture.

Stocking rate and class of animal

Data has also been collected on effectiveness of altering stocking rates and class of animal in improving distribution. Because improper riparian grazing often results in decreased stocking rates in future seasons, Huber et al. (1995) attempted to determine the effects of decreased stocking, and its effectiveness in protecting riparian areas. They reported that cattle stocked at a low stocking rate spent more time grazing in the streamside vegetation than those stocked at a moderate rate. The authors suggested that during drought conditions low stocking could cause cattle to spend a greater amount of time grazing and loafing in streamside vegetation; however,because of the greater number of animals at the moderate stocking rate, total use of the streamside vegetation may have been equal or greater. Bryant (1982) reported that both cows and yearlings spent disproportionate amounts of time in riparian communities but cows used a wider range of slope classes and plant community types overall than yearlings. Bryant (1982) also suggested that greater maintenance requirements of cows may force them to travel farther in search of available forage. He attributes the tendency for cows to remain closer to the stream compared to yearlings during the early part of the grazing season to a greater water requirement by lactating cows.

Offstream water

The use of offstream water to alter distribution of animals and decrease riparian grazing pressure is a management strategy that would intuitively have positive effects; however, few studies have evaluated the effects of offstream water on cattle distribution relative to the stream. Miner et al. (1992) looked at the effects of using an offstream water source during winter feeding in a riparian meadow to reduce time spent in the stream by cows. During the winter feeding period, cattle responded to the alternative water source by spending less time loafing in the stream. The tank was over 99% effective in attracting animals away from the stream during the times of day when thirst was the attractant, and 80% effective during the rest of the day when cattle were loafing. In a separate study, Godwin and Miner (1996) used an animal-operated pasture pump to determine the effectiveness of providing an offstream water source in reducing water quality impacts. Animals with access to alternate water spent significantly less time at the stream than those with no water trough. This response decreases direct fecal contamination of the stream, due to the fact that more fecal matter is deposited further away from the stream. It also creates a better opportunity for filtering of the bacteria, nitrogen, and phosphorus present in the fecal matter, by riparian vegetation.

While these studies each evaluated the effect of an alternate water source on cattle distribution relative to the stream, they dealt with winter feeding situations, and small riparian pastures. Little, if any, research has been devoted to the effects of an alternate water source on cattle distribution in herds grazing summer rangeland.

Grazing Systems and Season of Use

Strategies aimed at minimizing damaging effects to riparian areas from livestock grazing include manipulation of stocking rate, grazing system, and season of grazing. Results from a study looking directly at sediment loss from 1) heavy, continuous grazing (HCG), 2) moderate continuous grazing (MCG), and 3) short duration grazing (SDG) in both shortgrass and midgrass communities indicated sediment loss from the midgrass community in the MCG pasture was relatively stable throughout the study and sediment loss from the shortgrass pasture decreased throughout the study (McCalla et al. 1984). This demonstrates the potential for pastures with different vegetative communities to respond differently to the same management strategies aimed at the protection of riparian and stream ecosystems. In a similar study, Gamougoun et al. (1984) looked at the effects of 1) no grazing, 2) heavy continuous grazing, 3) moderate continuous grazing, and 4) two pastures from a four-pasture heavy rotation system on infiltration rates insouth-central New Mexico. This study indicated that exclusion of grazing did not create responses significantly different from moderate stocking. Although the heavy continuous and moderate continuous systems had higher infiltration rates than the rotation pastures, it was suggested that the heavy continuous pastures had undergone a shift in species composition toward more forbs, and evidence of disturbance was more apparent in the vegetation shift than the infiltration rate.

A study conducted in northeastern Oregon examined the effects of grazing cattle on riparian areas from late-August to mid-September (Kauffman et al. 1983). Examination of succession, composition, productivity, and structure between riparian communities that were grazed and ungrazed indicated that fall grazing did influence some communities while not affecting others. Kauffman et al. (1983) suggested that late season grazing may be acceptable as a management strategy but this is dependent on the objectives of the management system. Sedgwick and Knopf (1991) conducted a similar study in Colorado that evaluated the effects of October and November grazing on moderately stocked riparian communities compared to ungrazed pastures. They reported no difference between treatments in total biomass production following fall grazing, and only three species (prairie cordgrass, *Spartina pectinata*; and willow, *Salix exigua and Salix interior*) showed any response to grazing. The resilience to grazing under these conditions was attributed to 1) grazing at moderate levels, and 2) grazing late in the year during the dormant season.

The previous review of literature focuses on a number of management strategies aimed at either increasing the uniformity of livestock use over a pasture or decreasing livestock pressure on the riparian area specifically. Research reveals that a number of factors including class of animal, grazing experience of animal, terrain of the land, climatic conditions, and vegetation composition can have a significant impact on the success of various management strategies. These interactions add to the complexity of riparian area management. Seldom will single management practices alleviate long-term, overutilization of riparian habitat. Grazing practices that are beneficial for one region may not prove successful for all areas, as management is often specific to local environments. While some of the studies have documented grazing distribution as it pertains to the time livestock spent grazing specific areas, there is virtually no quantification as to how cattle distribution affects riparian ecosystems.

Riparian Grazing Research in Northeastern Oregon

Oregon State University and numerous cooperators have been actively evaluating riparian grazing systems for a number of years. Several articles have been published relative to riparian grazing systems, livestock performance and vegetation responses of riparian grazing relative to research conducted at "Meadow Creek" in the Starkey Experimental Forest in the Blue Mountains (Bryant 1982, Holechek and Vavra 1982, Holechek et al. 1982, Kauffman and Krueger 1984,Vavra 1984); or "Catherine Creek" on Oregon State University's Hall Ranch at the base of the Wallowa Mountains (Kauffman et al. 1983, Vavra 1984). In addition changes in channel morphology of Catherine Creek have been documented with and without cattle grazing over a 20-year period (Johnson et al. 1995).

Recent research in Northeastern Oregon

We recently completed a study that evaluated offstream water and salting for altering cattle distribution. Oregon State University's Hall Ranch was the research location. Vegetation types were grand fir (*abies grandis*) forest on the north slopes, mixed conifer forest, wet meadow and riparian. Dominant plant species are grand fir, Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), ninebark (*Physocarpus malvaceus*), ocean spray (*Holodisus discolor*), snowberry (*Symphoricarpos albus*), pine grass (*Calamagrostis rubescens*), elk sedge (*Carex geyeri*), and Kentucky bluegrass (P*oa pratensis*).

In this study, three treatments were compared: 1) non-grazed control; 2) grazed without offstream water/ salt; and 3) grazed with offstream water and trace mineral salt (TMS) to alter distribution. The study period spanned from mid-July to late-August with two intensive monitoring periods within the 42-day period (days 14-21, and 35-42). The study was conducted over a two-year period.

Distinct differences in cattle distribution patterns were observed between cattle with offstream water and TMS and those without (Fig. 1). Cattle with offstream water and TMS (W) displayed a more uniform average

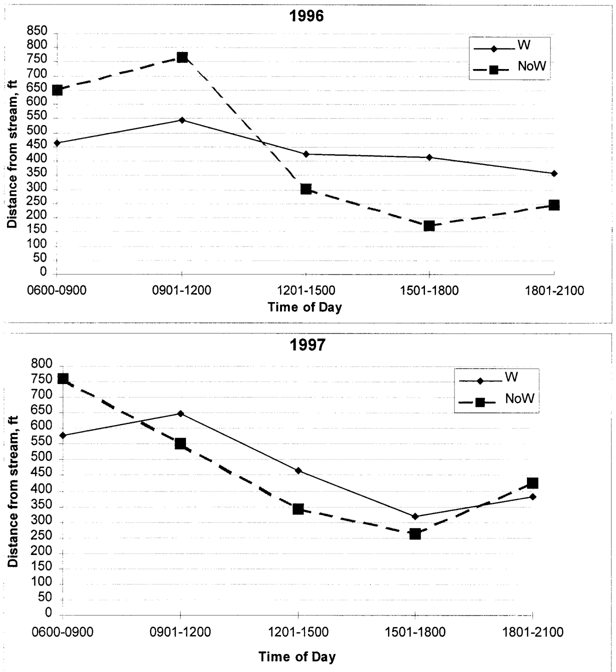

Figure. 1. Effects of offstream water and trace mineralized salt on the distance of cattle from the stream throughout the day during 1996 and 1997. Values are averaged over early and late season. Treatments include: 1) W = cattle with access to offstream water and trace mineral salt, and 2) NoW = cattle without access to offstream water and trace mineral salt.

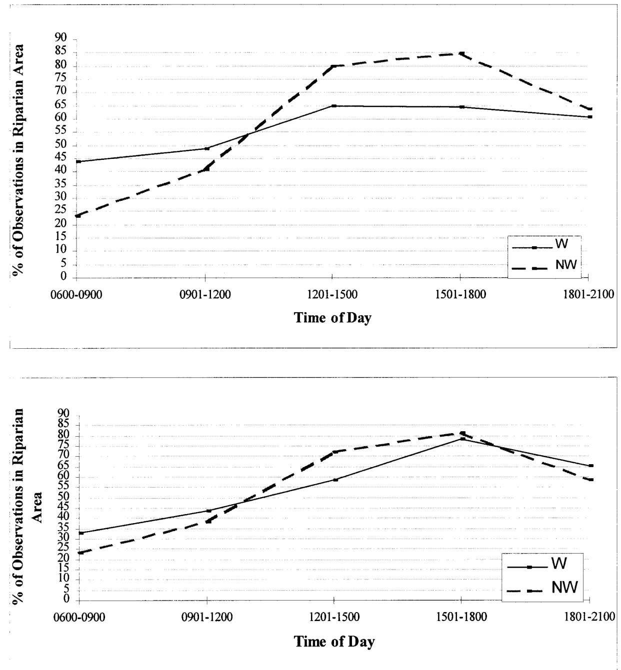

Figure. 2. Effects of offstream water and trace mineralized salt on the proportion of cattle observations in the riparian area during the early (22-28 July) and late (19-25 August) part of the grazing season. Values are averaged over 1996 and 1997. Treatments include: 1) W = cattle with access to offstream water and trace mineral salt, and NW = cattle without access to offstream water and trace mineral salt.

distance from the stream throughout the day, while cattle without offstream water and TMS (NoW) began the day further from the stream ($P < 0.05$), but moved closer to the stream as the day progressed. During the early evening hours NoW cattle began to move away from the stream again. Differences in daily grazing patterns between treatment groups were most pronounced during 1996, although similar patterns were observed in both years. The less pronounced response in 1997 may have been a response to slightly cooler weather.

Effects of offstream water and TMS on cow/calf distribution patterns were also reflected through the percentage of cattle observations in the riparian areas compared to the uplands (Figure 2). Distribution in the different areas of the pasture followed the same pattern as average distance from the stream, as a larger proportion of W cattle were observed in the riparian area from 0600-0900 ($P < 0.05$), while in the afternoon a larger proportion of NoW cattle were observed in the riparian area ($P < 0.05$). This pattern occurred during early and late season; however, late season distribution differences were less pronounced than early season differences.

The difference in distribution patterns of the two treatments appears to be a response to the tendency for cows to graze during the early morning hours, then search for water and finally seek shade, or graze less intensively during hot afternoon hours. During the search for water W animals were given a choice of two water sources, while NoW animals were forced to use the stream for water. Cattle tended to spend the afternoon in the same areas as they drank, then move away during the evening period. Documentation of water disappearance from stock tanks during a 6-day period in early August showed that despite mean water temperatures of 69.3°F in the tank compared with 59.9°F in the stream, average daily disappearance of water from the tank was 5.7gal/pair per day and TMS consumption averaged 0.30 lbs/pair per day.

The amount of time spent grazing did not differ between W and NoW cattle ($P = 0.25$). Cattle in both treatments followed a daily grazing pattern in which peak grazing occurred from 0601-0900 and 1801-2100. The period from 1201-1800 seemed to be part of the late afternoon/evening grazing period, accounting for about 34 % of the daily grazing activity. This period coincides with the period of highest riparian area occupation for NoW animals, indicating that riparian areas in NoW pastures were receiving greater grazing pressure than W pastures during this afternoon period. Total daily grazing time did not differ between treatments ($P < 0.60$) as cattle grazed about 664.8 minutes/day. Cattle in both treatments appeared to graze more from 0301-0600 during the early season than the late season, and during the late season they grazed more from 0601-0900 than they did in the early season. This is probably a response to the decrease in daylight during the late season. Travel distance, measured with pedometers, indicated that use of offstream water and TMS had no effect on daily travel distance ($P = 0.55$).

Cow and calf weight gains were improved by the presence of offstream water and TMS. Cows with access to offstream water and TMS gained 25.3 lbs more over the 42-day grazing period than cows without offstream water and TMS ($P < 0.05$; Table 1). Calves had a similar response, gaining 0.31 lbs/day more in the pastures with offstream water and TMS ($P < 0.05$). Body condition score was not affected by the presence of offstream water and TMS.

The reason for increased weight gain by W animals is unclear; however, more uniform grazing and less patch grazing may have occurred in W pastures. Additionally, greater vegetation production in W pastures compared to NoW pastures may have contributed to the weight differences.

Inappropriate management of livestock grazing in riparian areas can contribute to declines in water quality by removing protective vegetation and decreasing streambank stability through trampling. We also tested the hypothesis that W cattle would have less of an impact on streambank stability and cover than NoW. Measurements of streambank cover and stability followed protocol of Platts et al. (1983) as modified by Bauer and Burton (1993). Results are summarized in Table 2.

The proportion of covered/stable streambank declined due to grazing but was not different ($P< 0.05$) between W and NoW pastures. The uncovered/stable class did not vary among grazing treatments. Proportions of the covered/unstable class did not differ between non-grazed and W pastures. However, pastures lacking off-stream water and minerals had a higher proportion of streambanks in this class compared to non-grazed controls. The amount of uncovered/unstable streambank increased due to grazing, but was less in W pastures compared to NoW pastures. No differences ($P>0.05$) were observed in streambank cover between non-grazed and W pastures, but in pastures lacking off-stream water, cover declined six percent compared to control pastures. Streambank stability was not different between non-grazed and intensively-managed pastures. However, streambanks were less stable in pastures lacking off-stream water and mineral supplements compared to non-grazed pastures.

Table 1. Effects of offstream water and trace mineral salt on cow weight and condition change, and calf weight gain over the 42-day study period (mean S.E.). Values are the average of both years.

Item	Treatment[1] W	Treatment[1] NoW
Cow		
Weight change (lbs)	64.24 ± 1.80[a]	38.94 ± 1.65[b]
Condition score change	0.18 ± 0.10	0.09 ± 0.09
Calf		
Weight gain (lbs/day)	2.22 ± 0.013[a]	1.91 ± 0.011[b]

[1]W= cattle with access to Milk Creek and offstream water and trace mineral salt, NoW= cattle with access to Milk Creek with no offstream water and trace mineral salt.
[ab]Values within a row with different superscripts differ ($P < 0.05$).

Table 2. Percent change in streambank parameters between initiation of grazing (June) and removal of cattle (August).[1]

Parameter	No Grazing	Percent Change (± SE) W	NoW
Covered/Stable	0[a] (0)	-9.9[b] (3.5)	-14.1[b] (3.8)
Uncovered/Stable	0 (0)	-0.4 (0.8)	-2.5 (1.5)
Covered/Unstable	0[a] (0)	6.0[ab] (3.3)	8.1[b] (2.4)
Uncovered/Unstable	0[a] (0)	3.5[b] (0.9)	8.6[c] (1.2)
Bank Cover	0[a] (0)	-3.9[ab] (0.2)	-6.0[b] (2.7)
Bank Stability	0[a] (0)	-9.5[ab] (4.2)	-16.6[b] (3.0)

[1] Negative values indicate a decrease and positive values indicate an increase. Means within rows with different superscripts are significantly different (LSD, $p\leq 0.05$); n=3.

There was a shift from covered/stable to uncovered/unstable streambanks due to grazing (Table 2). The increase in uncovered/unstable streambank in W pastures (3.5%) was less ($P> 0.05$) than in NoW pastures (8.6%), indicating off-stream water and mineral supplement was effective inreducing the impact of cattle on streambanks.

This project has also documented water quality attributes before and after grazing with measurements including total phosphorus, ortho phosphorus, total coliform, and E. coli. Water quality attributes have been, in turn, related to the concentration of cattle feces within a 3-ft distance from the stream.

Current research in Northeastern Oregon

Our current research is evaluating the influence of timing of grazing on the distribution of cattle relative to riparian areas. Early grazing (28 days from mid-June to mid-July) is being compared to late grazing (28 days from mid-August to mid-September). We are beginning the second year of a two-year project. Like the offstream water and salting study, the goal is to provide useful information about management strategies for sustainable riparian systems and viable grazing management alternatives to exclusion fencing. We hope our methodologies are being improved as we continue with this research program.

Another project conducted on Oregon State University's Hall Ranch involves the use of radio transmitters and receivers to control livestock movement and distribution (Quigley et al. 1990). The concept of the transmitters and receivers is similar to a shock collar used for training dogs. The cattle wear a radio receiver eartag that is the size of a small transistor radio. In turn, a battery operated transmitter is placed in a area of desired livestock exclusion and is manually set to send out a signal that creates an exclusion zone to the animals wearing the eartag receivers (Figure 3). When an animal wearing an ear tag receiver approaches the signal boundary from the transmitter (exclusion zone), the animal receives an audio signal and, if they do not return to the grazing zone, a maximum of four electronic signals. The signal from the transmitter and subsequent stimulus received by the eartag trains the animals to avoid exclusion areas.

Research to date has indicated that this technology has substantial potential in discouraging livestock use of riparian areas. In short, the electronic eartags have been shown to effective change grazing patterns (Quigley et al. 1990). Furthermore, our research suggests that this technique does not adversely stress animals. In a 56 day project, animals diverted from riparian areas with electronic ear tags had lower weight gains as compared to nondiverted control heifers (Table 3). The lower weight gains, however, appear to be associated with lower nutritional qualities of upslope vegetation diets, rather than stress induced performance depressions.

Currently, patents have been granted relative to this technology. The major hurdles to use the widespread of this technology are related to making the equipment practical to actual ranch and grazing land managers. The ear tags are too heavy, difficult to maintain an animal's ear and the transmitters are somewhat inconsistent in establishing a stable zone of exclusion. A development company is currently working on new and better prototypes and grants proposals are currently pending that would provide significant funds for the development of this equipment. If these grants are obtained, we have made tentative plans to conduct field tests evaluating the effectiveness of this technology and the impact on animal nutrition and stress physiology.

The future use of this technology is encouraging. Fenceless livestock control has significant advantages to exclusion fencing particularly related to other uses of public lands (ie. Recreation and wildlife, esthetics, etc.). The advent of global positioning technology and its potential use in technology such as electronic diversion may open up even greater potential in the near future.

Conclusions and Implications

Our past research, as well as current projects, provide valuable insight to managed livestock grazing and maintenance and/or improvement of riparian ecosystems. Controlled research with replicated designs, multi-disciplinary teams and multi-agency participation will provide a critical vehicle to ease conflict over future management of riparian areas in the western United States. We believe that our research and outreach education program has begun to accomplish two general goals: 1) encourage and educate land managers to improve distributional management of livestock associated with critical riparian areas, and 2) educate other stakeholders relative to the compatibility of managed livestock grazing with riparian ecological integrity.

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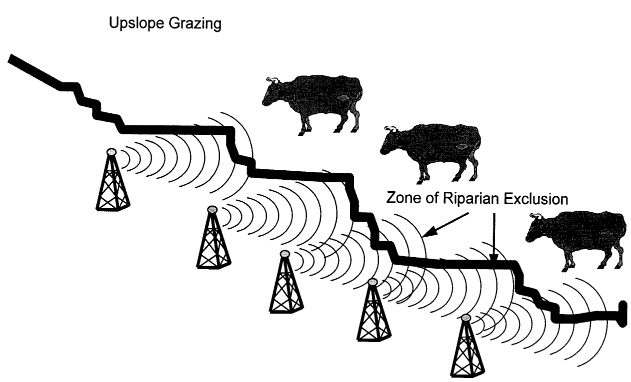

Figure 3. Electronic diversion of livestock involves setting up an exclusion zone established by radio transmitters. Cattle are equipped with eartags that, when within the zone, will emit audio followed by electronic stimuli that effectively discourages riparian grazing.

Table 3. Influence of electronic diversion form riparian areas on livestock grazing behavior, nutritional physiology, stress physiology and performance.[1]

Item	Treatments: Diverted	Treatments: Control	SE	P-value
Heifer performance:	1.46	1.76		
Weight gain, lb/day	1.46	1.76	.09	.02
Body condition score change	1.05	.86	.11	.23
Intake, lb/day	14.12	15.12	.58	.19
Distance traveled, miles/day	3.23	3.51	.31	.53
Grazing time, hr/day	7.26	7.68	.40	.60
Diet composition:				
Crude protein, %	13.40	16.90	.74	.03
Acid detergent fiber, %	41.80	41.30	.66	.60
Physiological performance:				
T3, ng/ml	1.61	1.62	5.37	.96
T4, ng/ml	55	53	.12	.33
Cortisol, ng/ml	57	51	.69	.59
Serum urea N, mg/dl	12.1	13.2	.40	.19

[1] Diverted heifers had electronic eartags, whereas, control heifers were in adjacent pastures with free access to riparian vegetation. Thirty-six heifers were randomly allotted to three replications of the above two treatments (n = 3).

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