DESIGNING SUSTAINABLE LIVESTOCK GRAZING SYSTEMS

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Introduction

Agricultural production and the use of natural resources have had many vocal critics in recent years. The livestock industry has been challenged, particularly in the western U.S., in regards to its sustainability. The term "sustainability" has been used in several different contexts in recent years. It is one of the popular buzzwords of our time. What exactly do we mean by sustainability? The term really has evolved over time, in regard to application to the western livestock industry. It probably has its roots in the severe winter of 1885-1886 and the drought of 1891-1892. Livestock producers discovered, through disaster, that a free-ranging livestock system would not work in the western U.S. Hay production for winter feeding and fencing for distribution control began with the survivors of this period. However, the unattached public lands of the West continued to be abused. The Taylor Grazing Act of 1934 was championed by the livestock industry and put an end to unrestricted grazing use. Land administered by the Forest Service had already come under restricted use with the passage of the Forest Reserve Act of 1891.

Across the West, livestock production was put in balance with the perceived notion of sustainability: the long-term output of livestock products. The long-term offtake of livestock products did not decay the ability of the land to produce those products. This is how society defined sustainability at that time. While the productive ability of the land to produce commodities is protected under this definition, the integrity of the ecosystem (the interaction of native plants and animals and their environment) may not be. However, this definition is applicable to private lands with the sole purpose of livestock production. On public lands, grazing systems must be designed for multiple use by law (Multiple Use Act 1968).

Today, the term has evolved into a much more complex meaning. Considerable literature exists that attempts to define sustainability (Vavra, 1996). Sustainability may be defined as the overlap between what people collectively want, reflecting social values and economic concerns, and what is ecologically possible in the long term. Sustainability should be looked at, not as an end point, but as a direction or trajectory with certain bounds. Lee (1993) called sustainability a goal, like liberty or equality, not to be reached but a direction that guides constructive change.

The future use of public lands for livestock grazing may hinge on our ability to convince the public that grazing is a sustainable practice. Therefore, in this paper we hope to make the giant leap from this philosophical discussion to some ideas that may help livestock producers move further in the direction of sustainability.

The Range Resource

Given our definition of sustainability, a livestock grazing management system for rangelands must provide economic return for the producer and provide protection for the ecological function of that land. Ecological function includes the maintenance of such diverse entities as watershed health, native plant communities, mammals, birds, and fish.

Forage quality

First, let's take the easy one, economic return to the producer. Most of the West is semiarid. Rainfall is limited and highly variable from one year to the next. The window of opportunity to capture nutrients from the forage base and convert them into pounds of beef or lamb is limited (Figure 1). Forage quality exceeds the animals' (cow/calf or ewe/lamb pair) requirements for only a short period of time during the grazing season, perhaps as short as 90 days. Moving the animals to higher elevation can extend this time period. Forage at cooler, wetter, higher elevations is less mature and more nutritious on a given date than that at lower elevations. However, a general rule of thumb can be applied to the rangelands of the West: 75 percent of the livestock gain usually occurs in the first half of a May-through-September grazing season. Cows or ewes often actually lose weight during the last half, because they are "milking off their back." Calf and lamb weights are marginal or even negative. Changes from traditional management that provide for more efficient livestock production are possible. DelCurto et al. (this publication) discuss livestock management options that, coupled with specialized grazing practices, provide alternatives to conventional management.

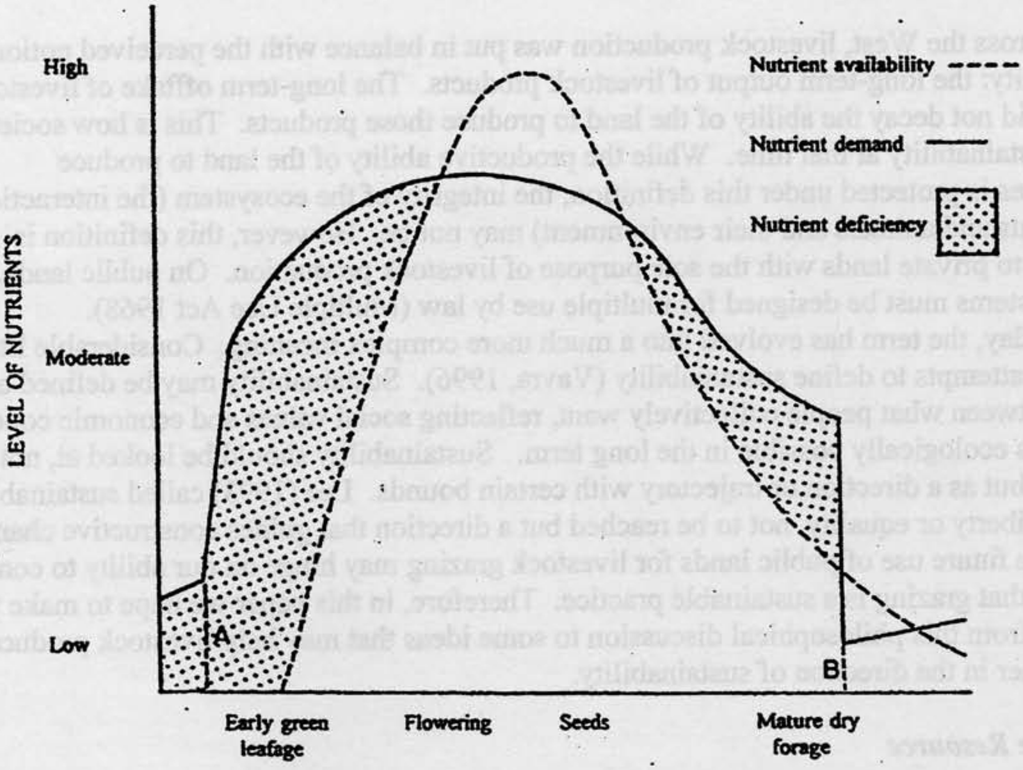

Figure 1. Generalized relationship between nutrients supplied by principal forages in the sagebrush-steppe and nutrients required by a breeding beef cow. Point A represents a hypothetical calving date of March 1, and point B represents a weaning date of October 23 (205 days postpartum). (McInnis and Vavra, 1997).

Grazing Management Considerations

An important factor in optimizing economic returns from grazing is developing the proper stocking rate, the amount of land allocated to each animal unit for the grazing period. Both gain per animal and gain per acre are important aspects in determining stocking rate (Figure 2). Generally, as stocking rate increases, gain per animal declines. This occurs because the highest quality forages are selected first, and, at higher stocking rates, they are removed from the system sooner, leaving forages of less nutrient quality and therefore less gain per animal. However, optimizing gain per animal may mean that animal numbers are too low to be profitable. Likewise, overstocking may lead to light weaning weights and decreased reproductive success, and be equally unprofitable. Stocking rates that optimize gain per acre and gain per animal should also provide adequate vegetation residue to sustain plant welfare and provide litter to the soil.

Optimizing nutrient consumption on rangelands means grazing during the active growth period of plants. Annual grazing during this time period can lead to a decrease in plant vigor and eventually degeneration of the resource. To prevent this, deferment or rest should be built into the grazing system. From May through July, some consideration should be given to incorporating two pastures into the system for use in any one year. Smaller pastures with adequate water sources should aid in optimizing distribution. A third pasture would be rested each year to provide for maintenance of the vigor of the plant communities.

In some areas, late fall or winter grazing may provide an option to feeding harvested forages. Supplementation programs usually are required, because dormant forages seldom meet animal requirements. For a more detailed description of such systems, see DelCurto in this publication.

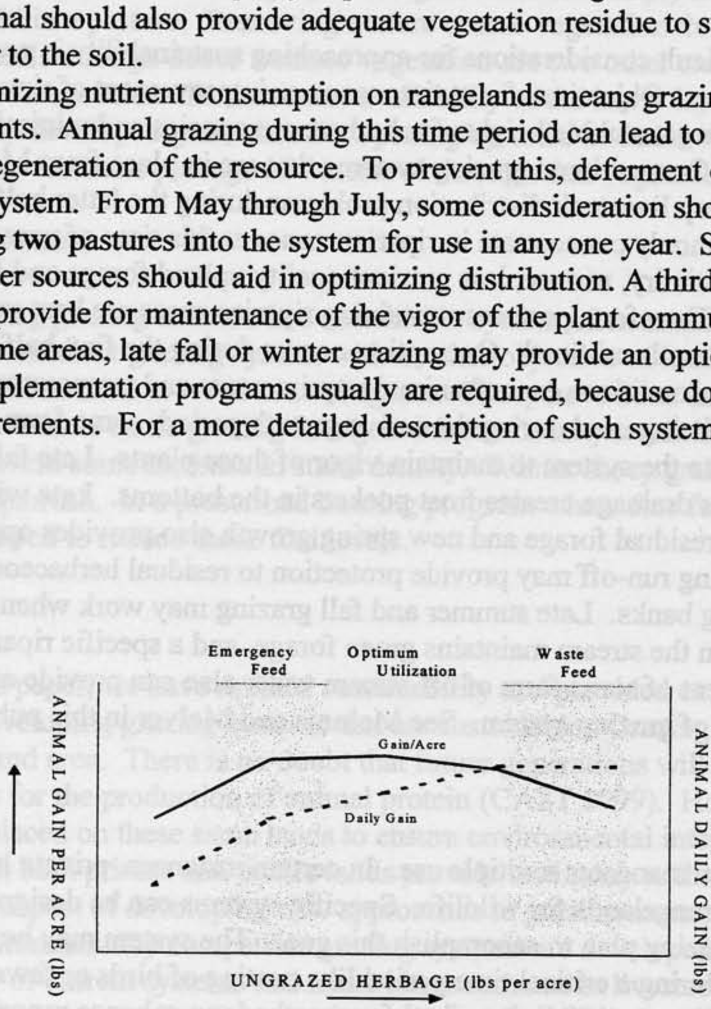

Figure 2. The relationship between daily gain per acre and daily gain per animal, and the amount of ungrazed herbage available. (From Bement, 1969).

Specific Management Systems

In the case of public lands, a sustainable system also means providing for other organisms that share the range. Protection of riparian areas and providing habitat for various wildlife species are common considerations. Generally, grazing systems can be assigned that provide habitat for a diversity of wildlife and other values, and also viable livestock production. In the case of riparian zones, knowledge of the specific needs of the target animals or resources is required. The system then can be designed to meet the needs identified. Following are some specific examples.

Riparian zones

One of the most difficult considerations for approaching sustainability is protection of riparian and aquatic resources. Objectives for maintenance or improvement of riparian vegetation usually include target stubble heights for herbaceous species and minimizing use of riparian woody vegetation. Conventional grazing systems that are in place from May through September commonly develop livestock distribution problems during the latter half of the grazing season. Cattle commonly concentrate in riparian zones at this time of year because of hot temperatures coupled with dry, mature, low nutrient quality upland forage and limited or poor quality upland water. Therefore, pastures containing riparian areas are best grazed when the riparian zone attractiveness is minimal. One option occurs during the first half of the grazing season, when upland forage conditions exceed animal requirements and temperatures are cooler. However, since grasses are being used during the active growth period, some form of rest or deferment has to be built into the system to maintain vigor of these plants. Late fall grazing may work in areas where cold air drainage creates frost pockets in the bottoms. Late winter and early spring grazing on a mix of residual forage and new spring growth also provides opportunities. High water levels from spring run-off may provide protection to residual herbaceous vegetation and woody vegetation along banks. Late summer and fall grazing may work when the floodplain is broad, sub-irrigation from the stream maintains green forage, and a specific riparian pasture can be created. Development of some form of off-stream water also can provide an additional distribution tool regardless of grazing system. See McInnis and McIver in this publication.

Wildlife Considerations

On public lands, law mandates multiple use. In certain instances, private landowners may wish to enhance their rangelands for wildlife. Specific systems can be designed and easily incorporated into a total grazing plan to accomplish this goal. The system may be as simple as deferring use of a pasture during a critical time period like nesting of birds or fawning of pronghorn. Severson and Urness (1994) described four methods to enhance rangelands for wildlife: (1) altering the composition of the vegetation, (2) increasing the productivity of selective species, (3) increasing the nutritive quality of the forage, and (4) increasing diversity of habitat by altering its structure.

Cattle tend to favor grasses in their diet, so pastures grazed by them may be altered if grazing puts physiological stress on those grasses. Forbs and/or shrubs then may increase. Likewise, grasses eventually may dominate a pasture containing a dominant but palatable shrub component, if the browsing pressure is heavy. In the same way, cattle can be used to improve productivity of shrubs again, by putting physiological pressure on the grasses.

Nutritive quality of grasses can be improved by spring grazing with cattle, followed by removal of those cattle when sufficient soil moisture remains to allow regrowth. This regrowth is commonly of superior nutritive value when compared to ungrazed plants. The regrowth is then available for fall and winter use by wild herbivores. However, forage production is compromised, dependent on soil moisture and resulting regrowth. The Oregon Department of Fish and Wildlife uses such a system in the Bridge Creek Wildlife Management Area to improve winter forage for elk. This system also can be used to provide fall forage for another cattle entry (Hyder & Sneva, 1963).

Improving habitat diversity by altering its structure simply may mean uneven patterns of utilization within a pasture. Removing mature coarse vegetation through grazing or haying and opening up trails through dense wetland vegetation are two other examples. Removing the top layer of coarse vegetation also increases availability of the lower layers that may contain small forbs or newly developed grass shoots. Opening up trails in dense wetland vegetation provides open areas that facilitate passage of waterfowl through that vegetation.

Other Opportunities

Utilizing grazing animals in a sustainable system often means combining an economically efficient grazing system with another objective of land management. Grazing animals have been used as weed control agents. Sheep have been used effectively to control leafy spurge. Winter cattle grazing in sagebrush stands may result in mechanical damage to the brush and prevent some increase in stand density. Winter sheep grazing also may reduce some species of sagebrush. In a prescribed burning program where fine fuel loads are high, grazing may be employed to reduce those fuel levels.

Conclusions

In this paper, we have defined sustainability and provided examples that may furnish insight for developing grazing systems that are sustainable. Grazing livestock use 35 percent of the world's land area. There is no doubt that future generations will continue to depend on grazing lands for the production of animal protein (CAST 1999). However, increased scrutiny also will be placed on these same lands to ensure environmental integrity. The ever-increasing regulations on both private and public lands provide testimony to the previous statement. One very positive aspect of developing new approaches to grazing management exists. At the same time that environmentally compatible grazing systems are developed, we can look critically at the efficiency of current systems and make improvements in livestock production. Utilizing our knowledge of the seasonally changing forage base, alternative forage possibilities, and the changing nutritional needs of livestock, improved livestock production and/or improved efficiency of production should be possible.

Suggested Readings

(Copies can be obtained from EOARC)

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CHARACTERISTICS AND CHALLENGES OF SUSTAINABLE BEEF PRODUCTION IN THE WESTERN U.S.

Tim DelCurto, David Bohnert, and Callan Ackerman

Introduction

Beef cattle producers in the western U.S. are faced with never-ending dilemmas of maintaining economic viability during times of low market values and, more recently, increased public criticism of beef product quality and industry compatibility with the environment. Unlike other meat animal industries such as swine and poultry, the beef industry in the western United States is very dynamic, ever adapting to changing arid environments and subsequent effects on forage quality, quantity, and associated relationships to beef cattle nutritional requirements. As a result, the western beef cattle industry is very extensive, with optimal production being a function of the resources each ranching unit has available, and how successfully the manager can match the type of cow and/or production expectations to the available resources. Successful beef producers are not necessarily the ones who wean the heaviest calves, obtain 95 percent conception, or provide the most optimal winter nutrition. Instead, the successful producers are the ones who demonstrate economic viability despite the economic and public pressures that can and will continue to plague the industry.

Rangeland Forage Resources

The western United States has several unique geographic features that shape and influence the beef cattle industry. First, much of the land area fits the general classification of "rangeland"; that is, land not suitable for tillage, due to arid environments, shallow/rocky soils, high elevations, and short growing seasons. From arid rangelands in the Northern Great Basin (cold desert) to arid rangelands in Southern New Mexico, ranchers are faced with limited forage resources and challenging nutritional calendars. Arid/high elevation rangelands also are characterized by dynamic, highly variable climates that change drastically from season to season and year to year. For example, the crude protein (CP) content of diets selected by cattle in the Northern Great Basin differs dramatically across seasons and years (Figure 1). The extremes in CP content are, in turn, related to wide ranges of crop year precipitation averaging 158, 246, 231,

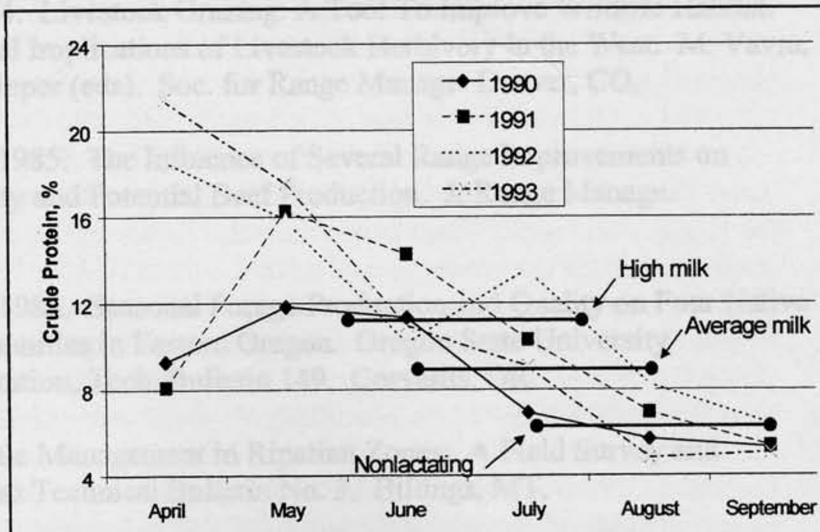

Figure 1. Crude protein content of diets selected by cattle grazing Northern Great Basin native rangelands. Crude protein requirements (NRC, 1984) are indicated for a high milking (20 lb/day), average milking (10 lb/day) and nonlactating gestating beef cow (1,100 lb).

and 524 mm for 1990, 1991, 1992, and 1993, respectively (40-yr average = 277 mm). The extreme fluctuations of precipitation also significantly affect forage available, with 1990 to 1992 averaging 240 kg/ha, whereas 1993 forage availability was 580 kg/ha. Thus, the Beef Manager has to adapt to wide ranges of forage quality and quantity.

Because of the dynamic nature of arid/high elevation rangelands in terms of forage quality, forage availability, and environmental extremes (snow cover, precipitation, temperature, etc.), cattle body weight and condition changes during winter grazing supplementation studies show similar ranges in variation. DelCurto and coworkers (1991) found similar patterns of cow weight and body condition change when supplemented graded levels of alfalfa to beef cattle winter grazing sagebrush steppe rangelands (Figure 2). However, the magnitude of response was dramatically different between consecutive years due to observed changes in forage quality, forage availability, and environmental stress imposed on the grazing cattle. Likewise, other researchers in the western U.S. have indicated variable results with supplementing free-ranging beef cattle consuming stockpiled forage due to dramatic changes in forage resources and (or) environmental conditions. While these examples do not describe adequately all the considerations needed for supplementing grazing livestock, they do point out some of the complexities in achieving optimal response to supplementation strategies. In addition, these examples suggest that further research is needed to describe the interaction of environment, forage quality/quantity, and livestock nutrient demands so that optimal use of the forage resources, minimal use of supplements, and acceptable levels of beef cattle production can be obtained.

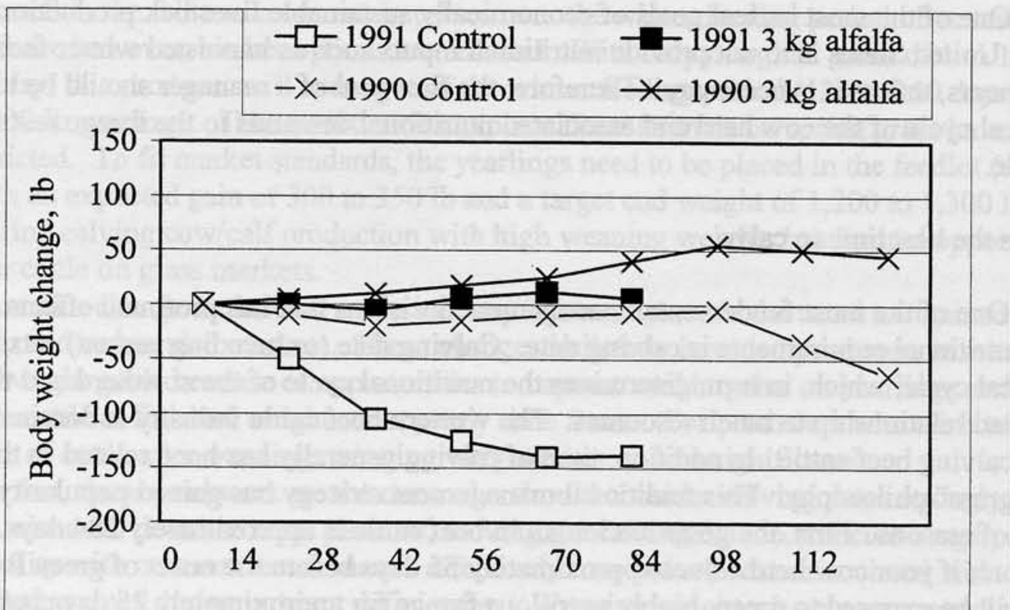

Figure 2. Body weight change in beef cattle winter grazing intermountain rangelands. Study was conducted over two years with and without supplemental alfalfa.

Winter Feed Needs

Perhaps the greatest challenge to western beef producers relates to the need for supplemental inputs. Seasonal deficiencies of nutrients (protein/energy) are high in arid and high elevation rangelands. Producers dependent on rangelands forage resources have to develop strategies to maximize the use of the forage resources and minimize supplemental inputs while maintaining acceptable levels of beef cattle production. Likewise, high elevation and high latitude beef cattle operations are likely to have significant periods of snow accumulations, which necessitates feeding harvested forages. In the Pacific Northwest and Intermountain West, many producers feed 1,500 to 3,000 kg of hay to their mature cows during the winter feeding period. The success of producers in these regions may depend on their ability to find an economical alternative to winter-feeding of hays, such as stock-piled forages and crop residues. However, like dormant range forages, stock-piled forage and crop residues are low-quality roughages that require nutritional inputs for optimal use.

What follows is a general discussion of potential management strategies that may offer economic advantages to western range livestock producers. Many scenarios or strategies may not be appropriate for your environment or production goals. Instead, most of the following information should be considered potential management alternatives that **may** offer economic advantages by decreasing input costs per cow.

Management to Reduce Nutritional Inputs and Costs

One of the most logical goals of economically sustainable livestock production in the western United States is to not provide nutritional inputs such as harvested winter feeds and supplements, unless it is necessary. Therefore, the first goal of a manager should be to match the biological cycle of the cow herd and associated nutritional demands to the forage resources available.

When is the best time to calve

One of the most fundamental management decisions that has profound effects on beef cattle nutritional requirements is calving date. Calving date (or breeding season) sets the biological cycle, which, in turn, determines the nutritional cycle of the cow herd and the associated relationship to ranch resources. The western beef cattle industry is dominated by spring-calving beef cattle. In addition, time of calving generally has been related to the "55 days before grass" philosophy. This traditional management strategy has gained popularity for a variety of reasons. First, the gestation length in beef cattle is approximately 284 days. Therefore, if your cow herd calves approximately 55 days before the onset of green forage, the cows will be exposed to green, highly nutritious forage for approximately 25 days before they need to conceive and stay on a 365-day calving interval. In a sense, the 25 days of high forage quality is a natural "flushing" mechanism that usually prompts a cow to begin cycling, provided she had adequate body condition to begin with. Obviously, if your goal is to match the cows' nutritional requirements to the range forage quality, a producer might coincide calving with the onset of green forage (McInnis and Vavra, 1997). However, the "55 days before grass" philosophy has another advantage: the calf. A typical beef calf does not become a functioning ruminant until approximately 90 to 120 days of age. This event usually takes place when the cow has passed its peak lactation period (day 70 to 90). As a result, calf performance depends, to a greater degree, on the forage quality available to the calf. Thus, a calf born March 1 will be effectively utilizing forage available in June. In contrast, a calf born May 1 will not be effectively utilizing forage resources until August. Because of the vast difference in calf nutrition from day 90 to weaning, the earlier born calf will have weaning weight advantages that greatly outweigh the 60-day difference in age. Obviously, if higher weaning weights are a measure of economic importance (you market calves in the fall), then the "55 days before grass" philosophy may be the best approach.

Are Weaning Weights Really Important

The beef cattle industry in the United States has seen dramatic changes in production efficiencies over the last 30 years. In particular, weaning weights have increased from approximately 400 lb in 1967 to greater than 600 lb in 1997. The increase in weaning weights is related to increased use of continental breeds, greater selection on growth traits, and general improvements in management efficiency. If your goal is to market your spring calves in the fall, then this change in production efficiency has improved your economic potential.

However, the increase in weaning weights is an improvement in production efficiency that has some indirect problems. First, the target slaughter weight of market cattle has not changed dramatically during this time period. As a result, the opportunities to put on post-weaning weight have become more limited with the heavier weaning weight cattle. For example, if a spring calving beef cow/calf producer weans his cattle in late October at 600 lb, he/she may choose to sell in the fall market or retain calves over the winter feeding period. Because of the bigger calves, however, his/her options are reduced. With only marginal gains of 1 to 1.5 lb per head per day, this producer will come out of the winter feeding period (120 to 150 days) with 700- to 800-lb yearlings. The opportunities to place these animals on spring grass have become very restricted. To fit market standards, the yearlings need to be placed in the feedlot (avg. 90 days) with an expected gain of 300 to 350 lb and a target end weight of 1,200 to 1,300 lb. As a result, spring calving cow/calf production with high weaning weights has limited opportunities as stocker cattle on grass markets.

Another change in the beef cattle industry in recent years is the trend to retained ownership and/or branded markets. These changes indirectly have led producers to reevaluate weaning weight goals because of opportunities to capture weight gains on yearlings and the need to provide cattle at finished weights on a yearly time frame. For producers who wish to retain ownership of cattle after weaning, weaning weight takes on less significance.

In fact, these producers are the ones who should consider calving dates strongly. If a producer wishes to decrease costs per cow, moving the calving date to coincide range/pasture forage quality with cow nutrient demands effectively may reduce costs associated with supplementing cows during nutrient deficiencies. Weaning weight advantages are reduced, but the producer has more opportunities to capture gains in the stocker, backgrounding, and finishing phases.

Preparing the Cow Herd for the Winter Period

Because the winter period represents a time of high feed costs for beef cow-calf production, management strategies should emphasize decreasing the needed inputs. Getting your cow-herd in good fleshy condition going into the winter period should be a year-round management goal. Obviously, this involves monitoring your range and/or pasture forage conditions with particular attention to the quantity and quality of late summer and early fall forage (Figure 2). Forage resources in the Pacific Northwest are influenced strongly by the Mediterranean climate and, as a result, cool season forages. With the majority of precipitation coming in winter months and summers being relatively dry, forage quality and quantity may be limited and, at the very least, highly variable during the late summer and fall period. Therefore, a manager should monitor body condition and calf performance in late summer. When cows start losing body condition and/or calf performance begins to decline, the producer should consider nutritional or management strategies to optimize cow condition going into the winter period. A cow in good condition (5 or better) going into the winter period will be easier to feed and can lose some body condition without adversely effecting subsequent calving and rebreeding potential.

Early Weaning as a Management Tool

Traditionally, beef producers in the Great Basin region have weaned calves at approximately 7 months of age, which usually coincides to late October or November for spring calving herds. However, gains of calves and cows are often poor by late August, particularly during years of poor forage quality/quantity. By removing these calves early, they can be put on better feed with the cows remaining on range. Dry cows do well on range forage during the fall, and without suckling calf, will come into winter in better condition. Improved body condition, in turn, translates into a cow that is easier to maintain during the winter period and that has a higher chance of breeding back on a 365-day calving interval.

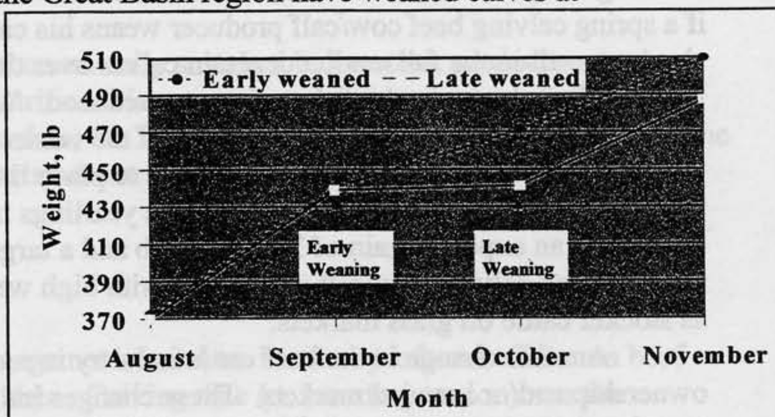

Figure 3. Influence of weaning date on calf weights (Turner and DelCurto, 1991).

Figure 3 presents some early weaning data from the Eastern Oregon Agricultural Research Center herd (Turner and DelCurto, 1991). Early-weaned calves were removed from their dams on September 12 and put on meadow aftermath and regrowth plus supplemented with 2 pounds of barley and 1 pound of cottonseed meal. Late-weaned calves remained on range with their dams until October 12 and then were managed with the early-weaned calves. On November 12, all calves were fed meadow hay and received 2 pounds of barley and 1 pound of cottonseed meal throughout the winter.

Early-weaned calves out-gained late-weaned calves by 20 pounds from September 12 to October 12, despite going through the stress of weaning and adjusting to new feed. During the next time period, October 12 to November 12, the early-weaned calves out-gained late-weaned calves by an additional 31 pounds and were now 51 pounds heavier. Late-weaned calves compensated somewhat over the remainder of the winter, but were still 24 pounds lighter on April 12.

A number of factors need to be considered when deciding if early weaning is appropriate. First, forage quality must be limiting to the point that calf gain will be reduced and cows likely will lose body condition from late-August to the October or November weaning date. If forage quality and quantity is not limiting, then there is really no advantage to early weaning. The real advantage of early weaning is to improve the weight and body condition of the cows from late summer to the beginning of the winter feeding period. In addition, the producer must provide adequate forage/nutrition to the early-weaned calf. For producers who frequently have limited nutritional options during the late-summer and fall period, however, early weaning may provide an alternative that allows for more efficient management of mature cows' body condition relative to a dynamic arid rangeland environment.

Alternative Winter Nutritional Management Strategies

Beef cattle producers in the western U.S. and, more specifically, intermountain and Pacific Northwest, compete at an economic disadvantage relative to other regions in North America due to high winter feed costs. Many producers currently feed 1.5 to 2.5 tons of hay to their mature cows during the winter feeding period. This represents costs of $75 to $150 per cow per year and may be greater than 50 percent of the input costs per cow per year. Obviously, our ability to compete with other regions of North America may relate to how effectively we can reduce winter feed costs while still maintaining acceptable levels of beef cattle production.

Rake Bunch Hay

The Eastern Oregon Agricultural Research Center conducted approximately 10 years of research evaluating rake bunch hay as an alternative to traditional winter management. With this system, hay is cut, then raked into small piles (80 to 120 lb) with a bunch rake, and left in the field. The forage then is strip grazed, using New Zealand-type electric fences, throughout the winter. A general summary of 10 years of data demonstrated that cows wintered on rake bunch hay came out of the winter period in better condition than traditionally fed cows and did not require supplements or additional hay. Likewise, conception rates, calving interval, weaning weights, and attrition rates were equal between control and treatment groups. In addition, the costs of winter feeding rake bunch hay has been $30 to $40 less per head than the traditional feeding of harvested hay. For additional information relative to rake bunch hay feeding, please refer to Turner (1987) and Turner and DelCurto, 1991.

Winter Grazing

Another alternative to traditional winter-feeding may be the winter grazing of "stockpiled" forage. To use this alternative effectively, the producer must defer grazing of irrigated pasture or native range to the fall or winter months. The range forage base will be dormant and, as a result, likely will need some level of supplementation depending on quality of selected diets, body condition status of mature cows, and stage of gestation. More thorough discussions of winter grazing (Brandyberry et al., 1994) are available.

Like rake-bunch hay, winter grazing may decrease winter feed cost by $20 to $30 per cow during mild to average years. To utilize winter grazing effectively in your management program, the producer must have access to the animals to accommodate supplementation programs. Water must be available throughout the fall or winter grazing period, although the cow can utilize snow effectively. In addition, the grazing area must be relatively free of snow accumulation during most years.

Indirect benefits of winter grazing relate to the increased management opportunities of traditional hay meadows for spring and early summer grazing. In addition, fall and winter grazing is an alternative use of native rangelands that may provide some significant advantages. First, grazing dormant forage presumably will have minimal impact on the plant as compared to traditional spring and summer grazing. Second, grazing, nonlactating-gestating cows will be better distributed over the grazing area, demonstrating greater distance traveled from water, better use of slopes, and more uniform use of the grazed area.

Grass Seed Residues

Another alternative to traditional winter management would be the use of grass seed residues produced as a bi-product of Oregon's grass seed industry. Currently, Oregon's grass seed industry produces over 1 million tons of crop residues. While only 50 percent of these residues appear to be a viable livestock feed resource, there are a number of reasons producers should consider these feeds as a winter alternative. First, many of these grass species are perennial forages (Kentucky bluegrass, tall fescue, perennial ryegrass, bentgrass, etc.) and, as a result, are substantially better than annual cereal grain straws. Second, burning, previously used as a tool to sanitize fields and remove residues, has been eliminated as the primary tool for grass seed producers. As a result, there is a critical need to find an effective use for these residues. Third, the Japanese export market has become "soft" in recent years, making delivery of grass seed residues to the eastern portions of Oregon more economically viable.

In most cases, grass seed residues should not be considered a complete feed for wintering mature beef cows. Instead, grass seed straws should be tested and supplements formulated to meet the cows' nutritional requirements while maximizing the use of the low-quality roughage. For more thorough reviews of grass seed residues and associated supplementation, refer to Chamberlain and DelCurto (1991) and Turner et al., 1995.

Currently, grass seed straw is being delivered to Eastern Oregon for approximately $40 to $50 per ton. The economic viability of this feed resource should not only be compared to costs associated with meadow hay production, but also other potential benefits. First, feeding grass straw frees up meadows for grazing and/or other uses. Second, grass seed residues represent a clean feed with limited weeds, with the exception of the seeds from the residue itself. In many cases, however, seeds from bluegrass, tall fescue, and perennial ryegrass germinating on disturbed winter feed grounds should not be considered a problem. Third, feeding residues on winter-feed grounds or traditional hay meadows represents an increase in nutrients added to the site. Decreased fertilizer costs and improved organic matter of the soil may result from long-term feeding of grass seed residues.

Other Considerations

Research at the Eastern Oregon Agricultural Research Center has shown that ionophores, specifically rumensin, can improve winter beef cow performance or reduce winter feed needs (Turner et al., 1977; Turner et al., 1980). Cows fed a full diet of meadow hay plus 200 mg of monensin had daily gains of 0.2 pounds higher than cows fed meadow hay alone. In studies where cow weights were kept equal between control cows receiving meadow hay and cows receiving meadow hay plus monensin, hay savings of up to 13 percent were realized. This represents another management tool for improving cow condition or reducing feed requirements while maintaining cow condition through the winter feeding period.

There are several other potential tools or management strategies that may help reduce winter feed costs. Obviously, if you are using low-quality roughages such as stockpiled forage and crop residues, your supplementation strategy must emphasize minimizing supplement costs while maintaining acceptable beef cattle performance.

Summary

The ability of western beef cattle producers to compete effectively with other regions of North America may depend on management strategies that emphasize profit margins rather than weaning weights. The above information only "scratches the surface" of potential alternative management strategies that may offer economic advantages. Keep in mind, however, that western beef cattle producers and resources are dynamic, and incorporation of any of these strategies must fit your production philosophy, production goals, and holistic ranch management plan.

Many of the management strategies described in this paper, as well as future opportunities for beef production in the Pacific and intermountain west, necessarily will involve the use of supplementation to utilize low-quality feed resources. Producers will have to evaluate which supplements are most economically viable in their region, as well as which strategy best fits their needs, nutritional calendar, and management style.

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EFFECTS OF SEASON OF USE ON BEEF CATTLE DISTRIBUTION PATTERNS AND SUBSEQUENT VEGETATION USE IN MOUNTAIN RIPARIAN AREAS

Cory T. Parsons, Patrick A. Momont, Timothy DelCurto, and Jeff L. Sharp

Summary

To quantify the effects of season of use on beef cattle distribution relative to the riparian area, 52 cow/calf pairs were assigned randomly to 2 years of three replications of the following treatments: (1) early season (ES) grazing (mid-June to mid-July), and (2) late season (LS) grazing (mid-August to mid-September). Based on previous years, DM production estimates, pastures were stocked to achieve 50 percent utilization after 28 days of grazing. Livestock observation points, livestock activities, and ambient temperatures were recorded hourly during two 4-day periods in each season of use. Locations then were transcribed to a geographical information system (GIS) for the study area on Oregon State University's Hall Ranch in northeastern Oregon. Cow weight and body condition score (BCS), calf weight, ocular vegetation utilization estimates, forage quality, and fecal deposits within 1 meter of the stream were recorded pre- and/or post-grazing. During ES, cattle were further from the stream ($P < 0.01$) than during LS grazing, averaging 161.41 and 99.4 m for ES and LS, respectively. Grazing distribution also displayed a diurnal response ($P < 0.01$) with increasing ambient temperatures resulting in decreased cattle distance from the stream. Fecal deposits within 1 m of the stream tended ($P = 0.13$) to be greater following LS than ES grazing. Forage quality varied ($P < 0.01$) between seasons, with ES forage having lower DM, greater CP, lower fiber, and greater IVDMD compared with LS forage. Livestock activity (grazing, ruminating, or drinking) and grazing times, min/day, were not affected by season of use. However, forage utilization was influenced by season of use, with ES grazing having lower riparian vegetation use and higher upland vegetation use as compared to LS grazing ($P < 0.05$). In summary, grazing season affected cattle distribution relative to the riparian area, with LS having more concentrated use of riparian vegetation.

Introduction

Improper use of riparian areas by livestock can result in removal of woody vegetation, over-utilization of streamside vegetation, soil compaction, increased soil erosion, reduced water quality, as well as streambank degradation (Buckhouse and Gifford, 1976; Thomas et al., 1979). Federal laws such as the Threatened and Endangered Species Act (1973) and the Federal Water Pollution Control Act (1972) are making it increasingly difficult for enterprises such as logging, mining, recreation, and ranching to utilize our natural resources. These factors make it increasingly important to create management strategies that promote improved livestock distribution patterns, more uniform vegetation utilization, and sustainable riparian ecosystems. One such strategy may be grazing of riparian areas early in the spring while forage quality is high and ambient air temperatures are still low. However, there is currently a lack of quantifiable research data detailing the effects of this strategy on livestock grazing distribution patterns and subsequent use of riparian vegetation.

This project was designed to provide a replicated, quantitative assessment of the effects of season of use on beef cattle distribution patterns relative to the riparian area. The hypothesis of this study was that livestock distribution, behavior, and performance, and associated vegetation utilization patterns, could be influenced by the time of year that a riparian meadow and adjacent uplands were grazed.

Materials and Methods

This study was conducted in the foothills of the Wallowa Mountains in northeastern Oregon on the Eastern Oregon Agricultural Research Center's Hall Ranch. The elevation of this site is approximately 1,015 meters above sea level, with average annual precipitation of 35 cm, with the majority occurring between October and June. This results in very dry summers allowing for very limited vegetative re-growth during the months of July through September.

The portion of the Hall Ranch that was utilized for this research project consisted of 109 hectares of riparian meadows and adjacent uplands bordering Milk Creek. The site was cross-fenced, with electric fences, into nine pastures. Each pasture contained approximately 12 hectares and a 260-meter stretch of Milk Creek. The vegetation was classified within each pasture into four vegetation types: riparian grass (RG), riparian sedge rush (RS), gravel bar (GB), and upland (U).

The study consisted of a randomized complete block design with repeated measures. There were three pastures of each of the following two treatments: (1) early season (ES) grazing (mid-June to mid-July), (2) late season (LS) grazing (mid-August to mid-September), and (3) control (C) with no grazing. Each treatment was assigned randomly to one pasture during each season of use within each of the three blocks. Fifty-two cow/calf pairs were assigned randomly to one of three pastures per season of use per year. Cows used in the 1998 trial were all 2-year-old primiparous crossbred heifers. During 1999, we also used 2-year-old primiparous crossbred heifers, with the exception of three mutiparious 3-year-olds. All cows averaged roughly 500 kg at the beginning of the trial. Based on previous years' DM production estimates, pastures were stocked to achieve 50 percent utilization after 28 days of grazing. Stocking rates averaged 0.68 AU/ha.

Data collected during two 4-day periods (second and third week of each grazing season) included livestock observation points (recorded on geographically corrected aerial photos), livestock activities and ambient temperatures all recorded hourly, and minutes per hour spent grazing measured with vibracorders (grazing clocks). Measurements taken pre- and/or post-grazing include cow weight and body condition score (BCS), calf weight, ocular vegetation utilization estimates, and fecal deposits within 1 meter of the stream. Ocular vegetation utilization estimates were collected using modified methods set forth by BLM (1996). The following were the utilization breakdowns: 0 = 0 percent use; 1 = 1 to 25 percent use; 2 = 26 to 50 percent use; 3 = 51 to 75 percent use; and 4 = 76 to 100 percent use. Forage quality samples were collected at the end of the third week of each grazing period. Livestock distance from the stream and forage type occupied at each hourly observation were calculated using *Idrisi for windows*$_{Tm}$, an onscreen digitizing program.

Data were analyzed as a randomized complete block-repeated measures design using the GLM procedure of SAS (1996). Block was treated as the random variable in all GLM procedures, with pasture being the experimental unit and season of use being the treatment. Data were considered significant at the ($P < 0.05$) level.

Results and Discussion

Season of use had an affect on livestock distribution patterns, with ES cattle spending more time away from the stream than LS cattle. During ES, cattle were observed further from the stream ($P < 0.01$) than LS cattle, averaging 161.4 and 99.4 m for ES and LS respectively. Grazing distribution displayed a diurnal response ($P < 0.01$), with increasing ambient temperatures resulting in decreased cattle distance from the stream (Figure 1). There was a trend ($P = 0.13$) for the number of fecal deposits within 1 meter of the stream, a measurement of livestock density, to be lower following the ES season than LS grazing, averaging 0.13 and 0.28 fecal deposits per meter, respectively.

Ambient daytime temperatures had a significant impact ($P < 0.01$) on distribution patterns of cattle (Figure 1), as well as when and how long cattle grazed (Figure 2). During LS grazing, cattle tended to congregate closer to the riparian area and grazed later into the morning while temperatures were still low.

Water intake of a given class of cattle in a specific management regime is a function of dry matter intake and ambient temperature (Kellems and Church, 1998). Early season ambient temperatures averaged 16.4° C while LS temperatures averaged 21.4° C. At these temperatures, a 450-kg lactating beef cow requires 55 and 64 liters of water per day respectively (NRC 1984). At 2.5 percent of body weight intake and 40 percent forage DM (ES), a 450-kg cow is consuming 27 kg of forage, as fed. Of this 27 kg, 11.3 kg are dry forage and the remaining 15.7 kg are water. So ES forage is providing 15.7 kg, or 16.5 liters of water per day, leaving 38.5 liters of water needed to meet a cow's requirement. During LS grazing with increased temperatures and increased forage DM (70 percent), a 450-kg lactating cow requires 64 liters of water (NRC 1984), and because of higher forage DM, the forage is providing only 4.7 liters of water. Therefore, LS cattle must utilize the stream for most if not all of their required water.

Livestock performance measured by cow weight change, and BCS change along with calf ADG, did not differ between seasons of use even though there was a forage quality difference between seasons.

Forage quality varied ($P < 0.01$) between seasons with ES forage having lower DM, greater CP, lower fiber (NDF, ADF and lignin), and greater IVDMD compared with LS forage (Table 1). Livestock activity (grazing, ruminating or drinking) and grazing time, measured as minutes per day, were not affected by season of use. However, grazing time, measured as minutes per hour, did differ between seasons (Figure 2). Vegetation utilization patterns differed ($P < 0.05$) between seasons of use, with ES having lower riparian vegetation use and higher upland vegetation use as compared to LS grazing (Table 2; Figure 3). Likewise, vegetation utilization within the riparian area increased and vegetation utilization in the uplands decreased with decreased cattle distance observed with late season grazing. Vegetation stubble height inversely mirrored ocular vegetation utilization estimates, suggesting stubble height measures can be accurate in estimating utilization of forage providing a sufficient number of samples are taken.

Implications

Implementation of early season grazing of riparian areas into a grazing management system can be very effective in altering the distribution patterns of cattle grazing a riparian area and its adjacent uplands. During the early season, when forage quantity and quality are not limiting and daily ambient temperatures are low, livestock distribution patterns are more evenly distributed and vegetation utilization patterns are more uniform. As the grazing season progresses, however, daily ambient temperatures increase, forage DM increases, livestock distance from the stream decreases, and fecal deposits within 1 meter of the stream increase. These factors could lead to over-utilization of riparian vegetation and woody browse, increased bank trampling, and potentially decreased water quality. In summary, as long as early use does not cause problems due to wet saturated soils, early season grazing of riparian areas may be less detrimental to riparian areas due to improved livestock distribution and more uniform vegetation use.

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Table 1. Effect of season of use and pasture vegetation classification on quality and quantity of available forage.

	Early		Late			Orthogonal Contrast[h]		
Item	Rip[a]	Uplnd[b]	Rip	Uplnd	SE[c]	Sea[d]	Veg[e]	Sea[d] x Veg[e]
Dry Matter	42.98	40.68	68.23	70.29	3.57	0.01	0.97	0.56
Neutral Detergent Fiber	61.94	61.35	68.40	67.13	1.01	0.01	0.39	0.74
Acid Detergent Fiber	32.69	34.04	38.83	37.40	0.73	0.01	0.96	0.11
Crude Protein	8.23	7.44	4.48	4.23	0.22	0.01	0.06	0.28
Lignin	4.24	5.91	7.12	6.51	0.65	0.04	0.44	0.13
ISDMD[f]	49.17	50.44	42.43	42.89	0.85	0.01	0.35	0.65
ISNDFD[g]	28.29	29.98	25.86	25.83	0.68	0.01	0.27	0.25
Forage Availability[i]	1654	972	1726	1065	239	0.74	0.03	0.97

[a] Rip = riparian vegetation
[b] Uplnd = upland vegetation
[c] SE = standard error (n=24)
[d] Sea = Early (mid June – mid July), Late (mid August – mid September)
[e] Veg = vegetation site (riparian or upland)
[f] ISDMD = in situ dry matter disappearance
[g] ISNDFD = in situ neutral detergent fiber disappearance
[h] Orthogonal contrasts expressed as probability (p-value)
[i] Forage Availability = random clip plots mid-way through grazing season (kg/ha)

Milk Creek study site at EOARC's Hall Ranch

Table 2. Influence of season of use on the utilization and post-season stubble height of upland and riparian vegetation.

Utilization %		1998		1999			Contrast[b]		
	Veg Type	Early[a]	Late[a]	Early	Late	SE[c]	Yr	Sea	Sea x Yr
Riparian Vegetation	Green Line	27.9	56.8	44.3	62.2	2.82	0.01	0.01	0.05
	Gravel Bar	36.1	28.5	43.1	61.7	4.9	0.01	0.29	0.01
	Grass	37.1	41.7	44.0	51.9	1.89	0.01	0.01	0.16
	Sedge/Rush	21.7	37.7	32.5	43.5	2.49	0.01	0.01	0.29
Upland Vegetation	Open	42.5	35.6	43.9	38.1	0.86	0.02	0.01	0.54
	Covered	31.5	31.1	35.3	30.4	1.01	0.12	0.01	0.03
Stubble Height (cm)		1998		1999			Contrast[b]		
	Veg Type	Early	Late	Early	Late	SE[c]	Yr	Sea	Sea x Yr
Riparian Vegetation	Green Line	13.5	12.2	10.9	8.6	1.45	0.04	0.21	0.81
	Gravel Bar	13.2	10.2	9.9	6.9	1.57	0.01	0.75	0.09
	Grass	14.9	20.6	10.2	9.4	0.71	0.01	0.01	0.01
	Sedge/Rush	33.3	25.9	21.1	17.0	2.13	0.01	0.01	0.44
Upland Vegetation	Open	12.9	16.3	11.4	14.2	0.36	0.01	0.01	0.49
	Covered	17.5	20.6	13.2	16.3	0.53	0.01	0.01	0.77

[a]Early (mid-June to mid-July), Late (mid-August to mid-September)
[b]Orthogonal contrast expressed as probability (P-value)
[c]SE = Standard error (n = 48)

Cory Parsons fitting cows with *Vibracorders* (grazing clocks) before turnout.

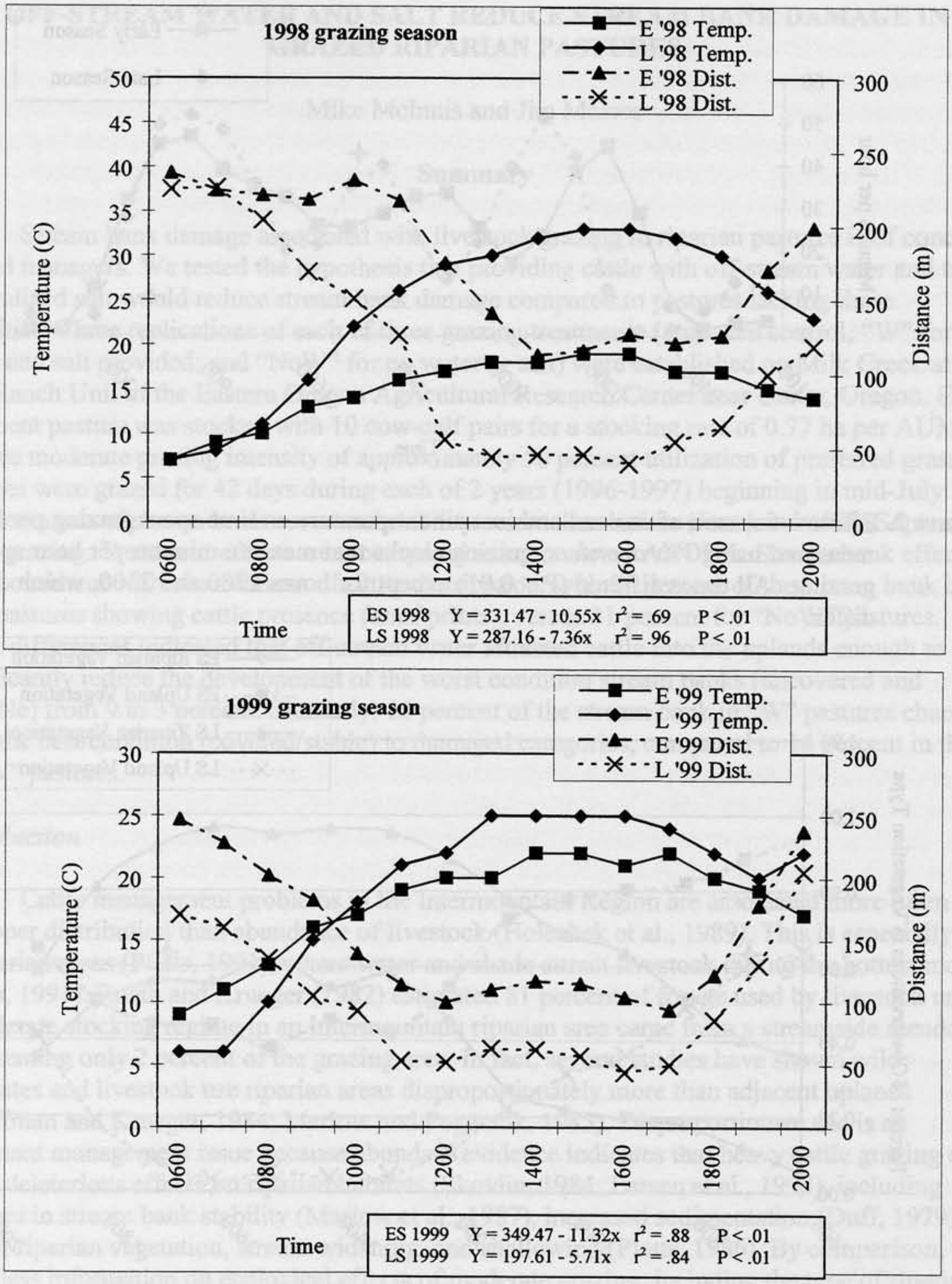

Figure 1. Effects of season of use and ambient air temperature on distance of cattle from stream. In the 1998 grazing season, all hourly distances differed ($P < 0.05$) except hours 600 and 700 which were not different. In the 1999 grazing season, all hourly distances differed ($P < .05$).

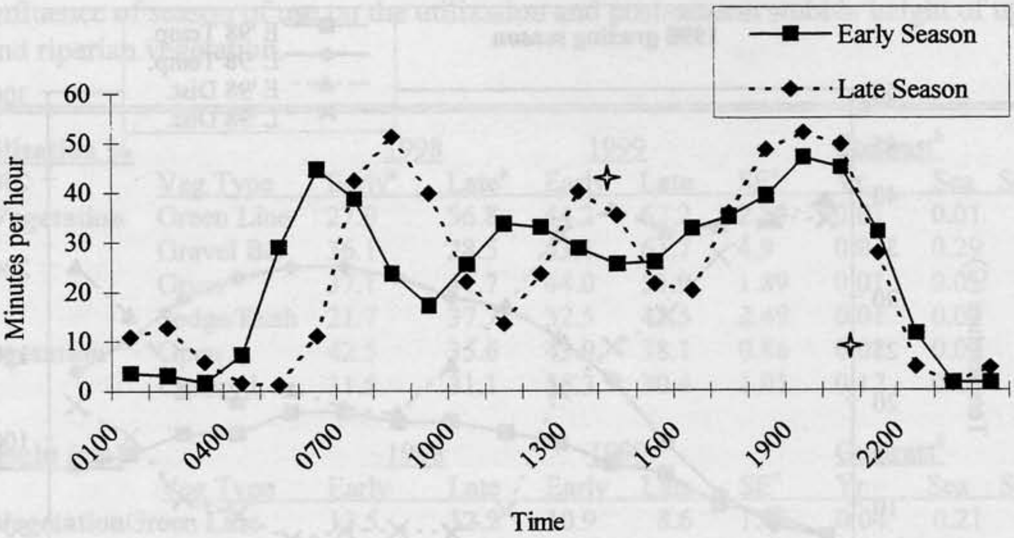

Figure 2. Effects of season of use and ambient air temperature on time spent grazing per hour, measured using *Vibracorders,* grazing clocks that measure minutes per hour spent grazing. All times differed (P < 0.01) except for hours 1700 and 2300, which did not differ.

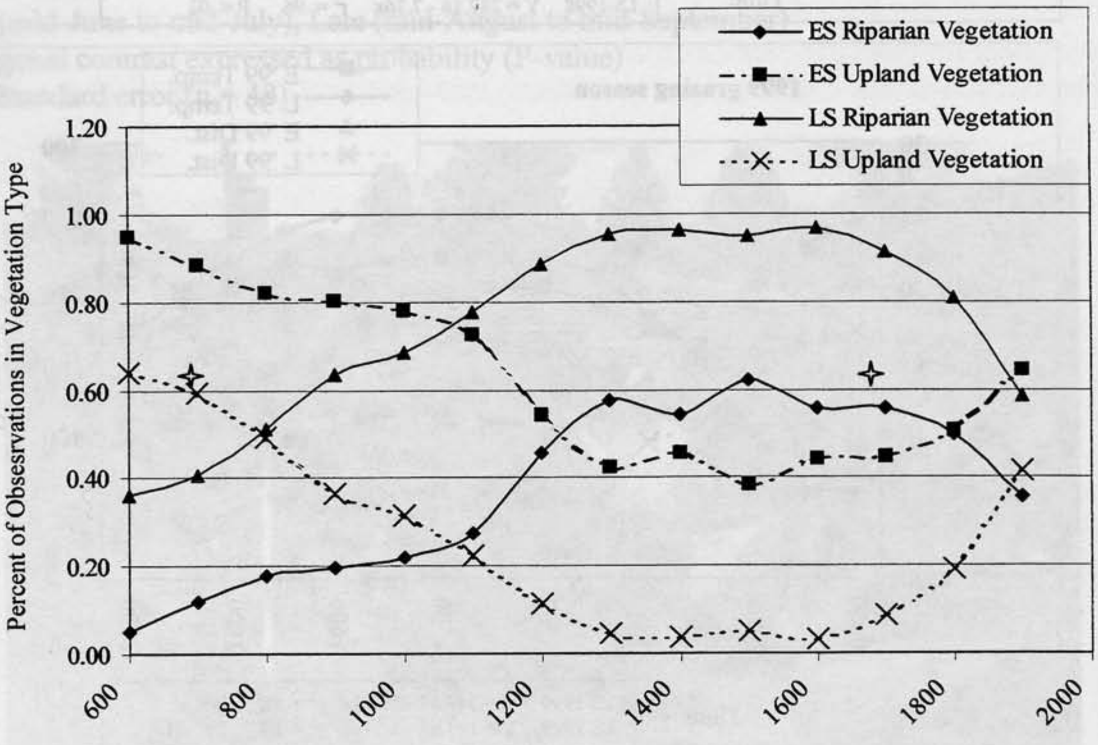

Figure 3. Effects of season of use and ambient air temperature on hourly beef cattle observations relative to occupied vegetation type. All times differed (P < 0.05) except for hours 800 (ES) and 1800 (LS), which did not differ.

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

Mike McInnis and Jim McIver

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.

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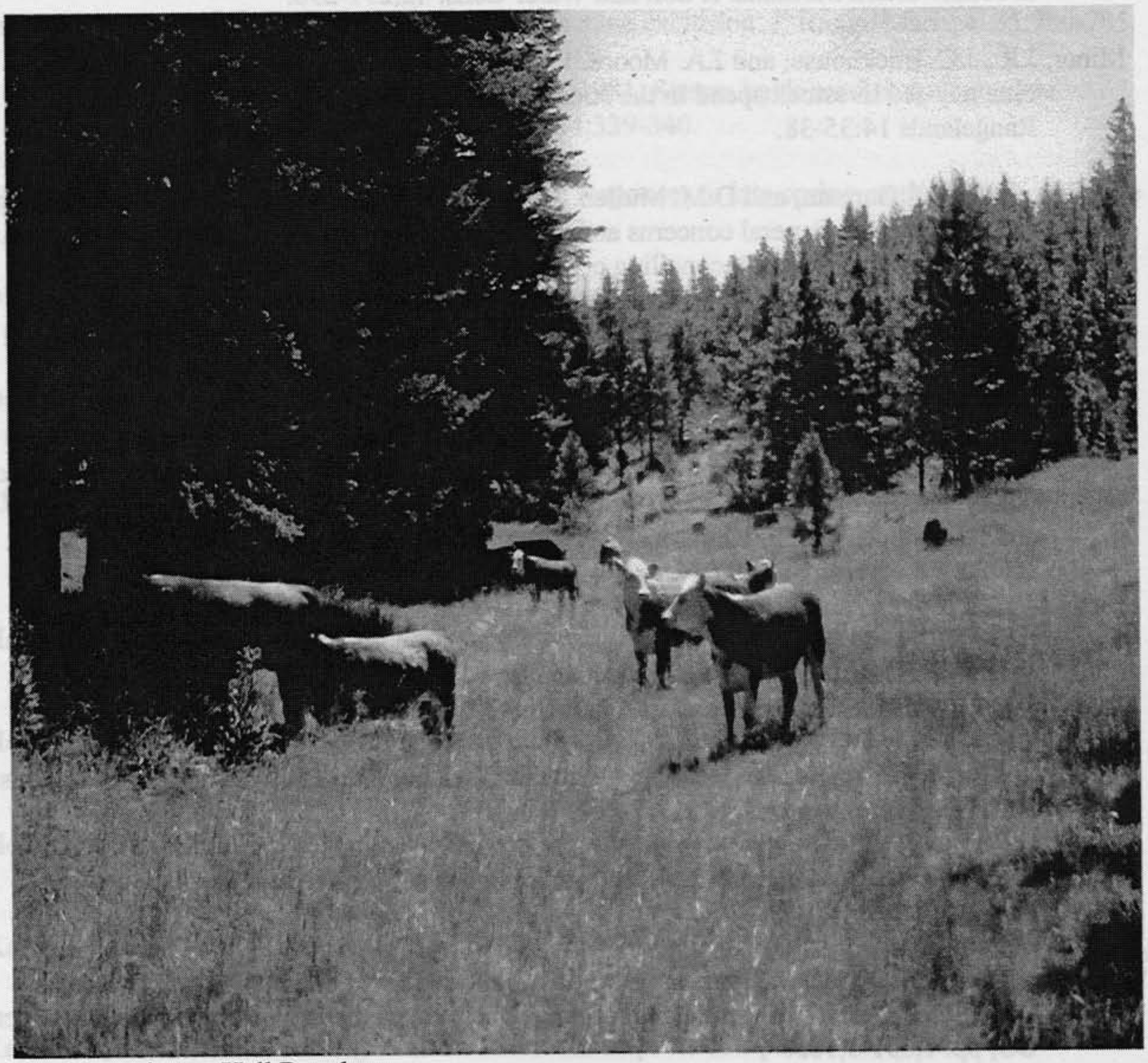


Cattle grazing at Hall Ranch

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			NoW[1] Pastures		
	(m /100 m of stream bank)								
	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.

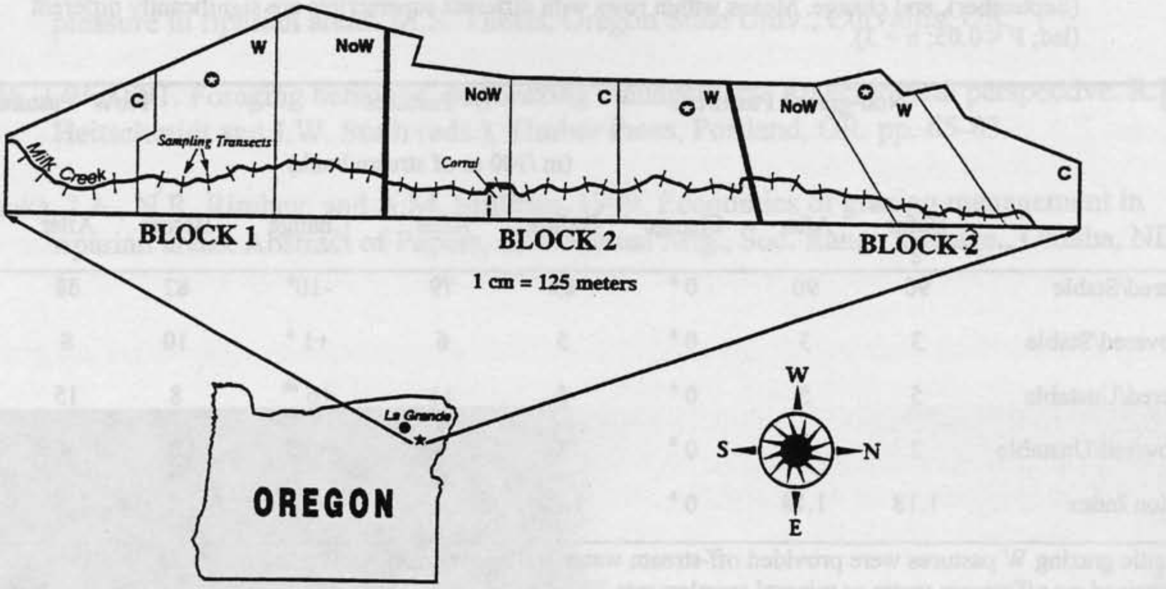
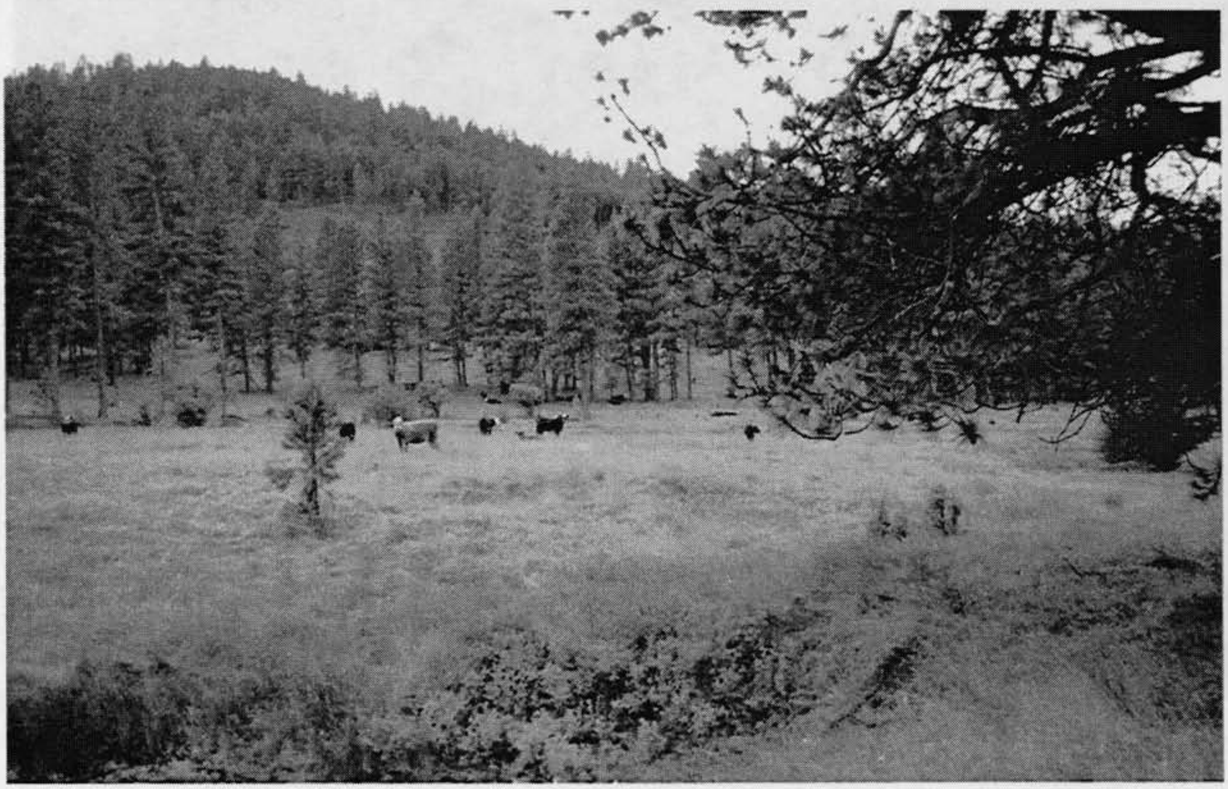


Figure 1. Map of Milk Creek study area showing block design, position of grazing treatments (C = ungrazed contro; W = grazed with off-stream water and salt provided; NoW = grazed with no off-stream water or salt provided), location of corral and watering troughs (★).



Cattle grazing at the Hall Ranch

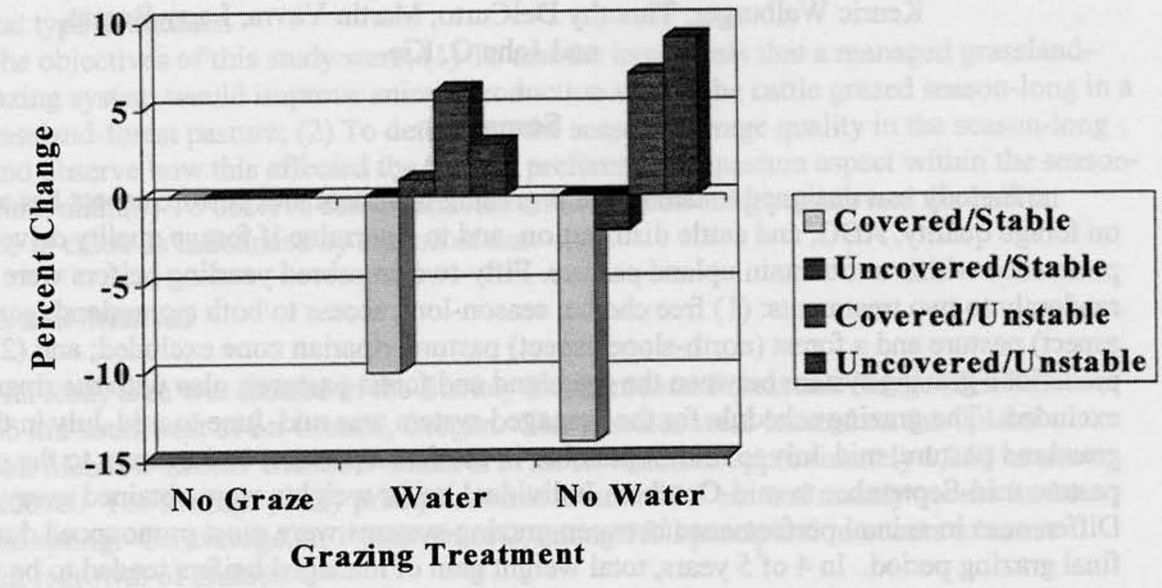


Figure 2. Percent change in stream bank cover and stability classes due to grazing treatments.

INFLUENCE OF A GRAZING SYSTEM AND ASPECT, NORTH VS. SOUTH, ON THE NUTRITIONAL QUALITY OF FORAGES, AND PERFORMANCE AND DISTRIBUTION OF CATTLE GRAZING FORESTED RANGELANDS

Kenric Walburger, Timothy DelCurto, Martin Vavra, Larry Bryant, and John G. Kie

Summary

A study was designed to determine if grazing treatment and pasture aspect has an effect on forage quality, ADG, and cattle distribution, and to determine if forage quality drives pasture preference within a mountain upland pasture. Fifty-two crossbred yearling heifers were assigned randomly to two treatments: (1) free choice, season-long access to both a grassland (south-slope aspect) pasture and a forest (north-slope aspect) pasture, riparian zone excluded; and (2) a predefined grazing system between the grassland and forest pastures, also with the riparian zone excluded. The grazing schedule for the managed system was mid-June to mid-July in the grassland pasture, mid-July to mid-September in the forest pasture, and a return to the grassland pasture mid-September to mid-October. Individual heifer weights were obtained every 28 days. Differences in animal performance between grazing systems were most pronounced during the final grazing period. In 4 of 5 years, total weight gain of managed heifers tended to be greater than the weight gain of free choice heifers. However, this difference was only significant ($P < 0.05$) in 2 of 5 years, averaging 9.1 kg. As the grazing season progressed, forage CP and IVDMD decreased ($P < 0.05$). As a result, weight gains decreased in the later periods as compared to gains early in the summer season ($P < 0.05$). Forage quality also was influenced by aspect ($P < 0.10$). Specifically, Idaho fescue (*Festuca idahoensis*) CP and IVDMD were greater for north vs. south facing aspects. Bluebunch wheatgrass (*Agropyron spicatum*) CP was higher ($P < 0.05$) for north aspects in 1 of the 2 years only. In this study, beef cattle performance and diet quality declined over time. Distribution patterns favored north aspects later in the grazing season.

Introduction

With increasing pressure for ranchers to use sustainable grazing management, grazing systems are being implemented to better utilize the plant communities present on the site and to better distribute the cattle across the landscape. It has been documented that as the grazing season advances, the energy content of grasses decreases, but levels tend to remain above requirements (Cook and Harris, 1968). Protein content of grasses tends to decrease as the season progresses, and levels usually dip below the requirements of the animal (Cook and Harris, 1968). Holechek et al. (1982a & b) observed that cattle on south exposure slopes tended to consume grasses throughout the year, whereas cattle grazing north-facing slopes had a greater diversity of grasses, forbs, and shrubs available. This, in turn, was reflected in their respective diets throughout the year. Because of influence of aspect on range vegetation diversity, the decreases of plant nutrient quality that we see may occur at different times of the year depending on site characteristics. Therefore, animal performance should be increased if a grazing system could take advantage of these possible differences.

In general, south facing slopes tend to be drier and contain more open areas, and north facing slopes are ecologically wetter and have a higher proportion of canopy cover. With these differences, forage quality and utilization by cattle would differ between north and south facing slopes (Harris, 1954; Vavra and Phillips, 1979). Because of these differences, cattle may prefer one habitat type to another.

The objectives of this study were: (1) To test the hypothesis that a managed grassland-forest grazing system would improve animal production versus the cattle grazed season-long in a mixed grassland-forest pasture; (2) To determine the seasonal forage quality in the season-long pasture and observe how this effected the cattle's preference for pasture aspect within the season-long pasture; and, (3) To observe cattle behavior on the season-long pasture and the habitat preference of cattle as influenced by season of use.

Materials and Methods

The study area was located in the Starkey Experimental Forest and Range (SEFR), located 35 km southwest of La Grande, Oregon. The pastures were located on the upland pastures on Meadow Creek. Meadow Creek is at an elevation of approximately 1,250 m above mean sea level. The average yearly precipitation is around 41.5 cm and mainly occurs in the winter and spring. On average, in 1 year out of 2, enough fall precipitation occurs to cause significant regrowth of grasses.

Beginning in mid-June, 52 yearling heifers were assigned randomly to one of two treatments, and grazing continued until mid-October. The grazing study commenced in 1982 and ended in 1986. In treatment 1, a grassland pasture and a forest pasture were used as the free choice, season-long grazing pasture. The free choice, season-long pasture was connected by a water gap to allow easy access to both pastures. The heifers were allowed free choice to decide which pasture they would graze in at any given day or time. Other than the water gap, heifers were excluded from the riparian zone. In treatment 2, the remaining grassland and forest pastures were used as the managed system of grazing. The forest and grassland pastures are of similar capacity. The managed group began on the grassland pasture in mid-June and then moved to the forest pasture in mid-July. They remained in the forest pasture until mid-September and then moved back to the grassland pasture for the remainder of the grazing season. Other than access to the creek for water, these heifers also were excluded from the riparian zone.

Heifer weights were obtained approximately every 28 days. Non-shrunk weights were taken due to the remoteness of the study area. All heifers were weighed after they had been allowed to drink in the morning to minimize the effects of water consumption/fill on heifer weights.

Holechek et al. (1982a & b) discovered that cattle on these pastures had a preference for Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Agropyron spicatum*). These plants are located in the grassland pastures and forest pastures, and they are in relatively similar abundance within aspect or habitat type. Samples were taken every week through the grazing season in 1982 and 1983 to determine crude protein and *In vitro* dry matter digestibility (IVDMD). Ten plots were clipped randomly and combined into a single sample for analysis.

Throughout the 1982 and 1983 grazing seasons, visual observations were conducted to determine the location of the heifers in the free choice pastures. Within an observation period, we recorded in which pasture heifers were located, grassland or forest. At the end of each day, total heifer hours were calculated for each pasture. Observations were conducted 4 days out of every week, and times observed were broken down into the following periods: 0500 to 1000 hr, 1000 to 1500 hr, and 1500 to 2000 hr.

Heifer performance was analyzed as a repeated measures design within year (SAS, 1997). Linear regression was used to determine the effects of season on forage quality. In addition, forage quality was analyzed using a completely randomized design and a 2x2x3 factorial arrangement of treatments contrasting year, aspect, and season within year.

Discussion

The heifers in the study showed varying gains throughout the grazing season (Table 1). In general, as the season progressed, cattle performance decreased. In 2 of the 5 years, heifers in the managed grazing system outperformed the free choice grazing system heifers by an increased total gain of 9 to 10 percent ($P < 0.05$).

When looking at heifer performance within the 28-day intervals, the variation in fill because of nonshrunk weights made it difficult to assess the true effects of the grazing treatment. However, the greatest amounts of variation of heifer weights tended to occur during the last two grazing periods. This would imply that during this time, nutritional stress is the highest and most variable.

The CP and IVDMD levels of Idaho fescue and bluebunch wheatgrass (Table 2) decreased as the season progressed ($P < 0.05$; Figures 1-4). In both years and in both pastures, the quality of the grasses was higher in the forested pasture than in the grassland pasture. The only exception was the crude protein content of Idaho fescue in 1982. In this year, the crude protein values were higher in the grassland pasture. When looking at differences between aspect, the only significant difference for bluebunch wheatgrass was for crude protein levels in 1982 ($P < 0.05$). However, all of the other values for bluebunch wheatgrass suggest the quality in the forested pasture tended to be greater than for the grassland pasture. Crude protein of Idaho fescue was significantly higher in 1982 ($P < 0.05$) and had significantly higher values of IVDMD in 1982 and 1983 ($P < 0.05$) for the forested pasture. IVDMD values of Idaho fescue over the 2 years showed two different trends. In 1982, as the season was progressing, the differences in IVDMD values between pastures became larger; but in 1983, the opposite trend was seen: differences in IVDMD values between pastures were getting smaller. These two differing trends could be due to intensity, duration, or timing of precipitation events, and/or the amount of regrowth following initial grazing of the plant.

Implications

Influence of forage quality can be a major factor in determining animal condition at the end of the grazing season. Toward the end of the grazing season, as forage quality begins to decline, animal performance declines, and variability of performance increases. Designing grazing systems that utilize forage quality calendars could increase kilograms of beef produced while keeping the stocking rate and land area the same. Grassland, south aspect slopes had their highest nutritive quality in the early season, and as the season progressed, quality dropped below animal requirements. Forested, north aspect slopes tended to have better quality later in the season and should be used at this time.

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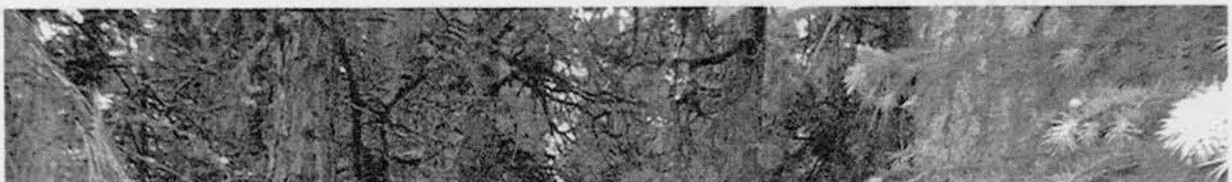

Cattle grazing at Hall Ranch

Table 1. Influence of season of use and grazing treatment on the gains of yearling heifer grazing forested rangelands in northeastern Oregon.

Year		Init. Wt. (kg)	Period gains (kg/d) 1	2	3	4	Total gain (kg)
1982	Managed	327	1.46	0.77	0.77[a]	0.38	96.4[a]
	Free choice	328	1.44	0.78	0.45[a]	0.39	88.2[a]
	SE[b]	7.97	0.05	0.05	0.09	0.04	2.34
1983	Managed	376	0.69	0.86	0.71	0.55[a]	77.7
	Free choice	376	0.68	0.80	0.71	0.29[a]	71.0
	SE	6.04	0.07	0.07	0.05	0.05	2.76
1984	Managed	334		1.34[a]	0.60[a]	0.97[a]	103[a]
	Free choice	333	0.53	1.56[a]	0.47[a]	0.73[a]	93.5[a]
	SE	4.70	0.04	0.07	0.04	0.05	2.57
1985	Managed	378	0.68[a]	0.33[a]	0.64	-0.26[a]	72.0
	Free choice	382	1.06[a]	0.54[a]	0.54	0.06[a]	68.1
	SE	5.45	0.06	0.07	0.04	0.08	2.23
1986	Managed	398	0.69	0.87[a]	0.44	-0.40[a]	49.4
	Free choice	398	0.78	0.68[a]	0.30	-0.08[a]	52.7
	SE	6.32	0.06	0.05	0.07	0.07	2.26

[a] Means within columns for specific years are different ($P < 0.05$).
[b] SE = Standard error of the mean ($n = 26$).

Table 2. Influence of season of use, and south (grassland) and north (forested) aspect on the nutritional quality of bluebunch wheatgrass and Idaho fescue in northeastern Oregon.

Item	Treatments: Early South	Early North	Mid South	Mid North	Late South	Late North	SE[b]	Contrasts[a]: Aspect	Season	Aspect x season
Bluebunch wheatgrass:										
1982:										
Crude protein, %	8.75	9.5	7.28	7.60	5.46	6.72	0.41	0.03	0.01	0.53
IVDMD, %	54.4	54.8	47.6	48.9	43.4	46.0	1.24	0.16	0.01	0.68
1983:										
Crude protein, %	7.32	8.04	5.67	6.70	4.34	4.87	0.55	0.10	0.01	0.89
IVDMD, %	50.4	50.6	42.3	45.0	36.5	40.1	1.90	0.17	0.01	0.65
Idaho fescue:										
1982:										
Crude protein, %	8.33	7.86	7.53	7.22	6.11	5.81	0.25	0.09	0.01	0.93
IVDMD, %	43.5	44.5	35.5	40.1	33.5	40.7	1.49	0.01	0.01	0.11
1983:										
Crude protein, %	6.48	7.66	5.76	7.16	6.07	6.54	0.25	0.01	0.01	0.18
IVDMD, %	37.1	42.9	33.9	36.5	35.6	36.4	1.15	0.01	0.01	0.11

[a] Preplanned contrasts evaluating aspect, season, and aspect by season interaction

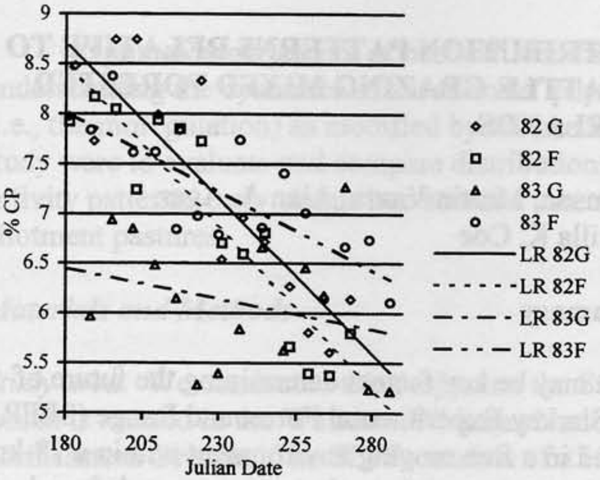

Figure 1. Influence of grassland (south) and forested (north) aspect on crude protein content of Idaho fescue.

G = Grassland
F = Forest
LR = Linear regression trend line
LR 82G ($y = -0.031x + 14.3$; $R^2 = 0.77$)
LR 82F ($y = -0.032x + 14.3$; $R^2 = 0.83$)
LR 83G ($y = -0.005x + 7.34$; $R^2 = 0.05$)
LR 83F ($y = -0.016x + 10.9$; $R^2 = 0.60$)

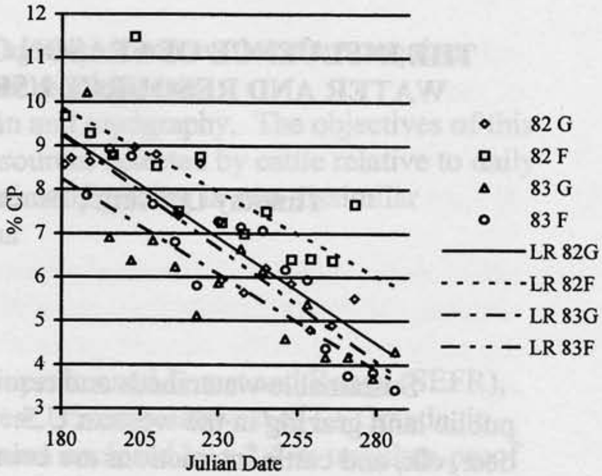

Figure 2. Influence of grassland (south) and forested (north) on the crude protein content of bluebunch wheatgrass.

G = Grassland
F = Forest
LR = Linear regression trend line
LR 82G ($y = -0.048x + 18.0$; $R^2 = 0.81$)
LR 82F ($y = -0.046x + 18.1$; $R^2 = 0.45$)
LR 83G ($y = -0.045x + 16.3$; $R^2 = 0.71$)
LR 83F ($y = -0.053x + 18.8$; $R^2 = 0.82$)

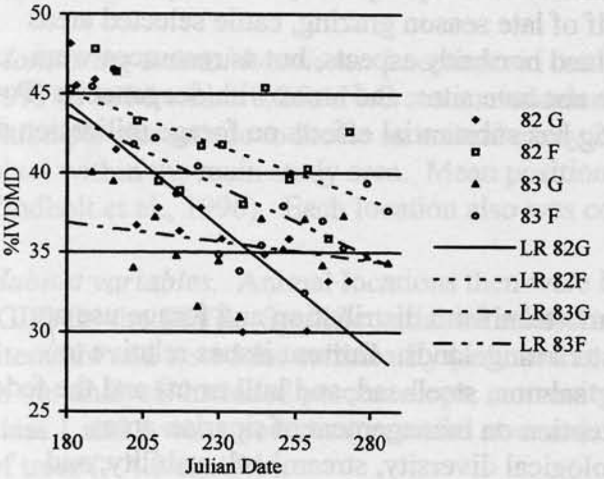

Figure 3. Influence of grassland (south) and forested (north) aspect on IVDMD content of Idaho fescue.

G = Grassland
F = Forest
LR = Linear regression trend line
LR 82G ($y = -0.156x + 72.3$; $R^2 = 0.74$)
LR 82F ($y = -0.068x + 57.4$; $R^2 = 0.34$)
LR 83G ($y = -0.024x + 41.3$; $R^2 = 0.08$)
LR 83F ($y = -0.091x + 60.2$; $R^2 = 0.46$)

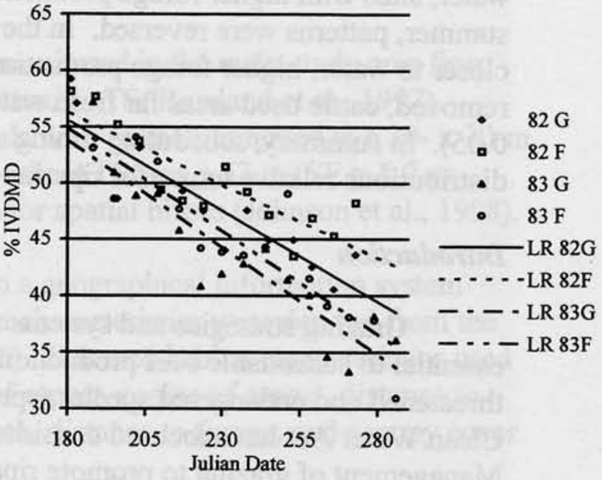

Figure 4. Influence of grassland (south) and forested (north) aspect on IVDMD content of bluebunch wheatgrass.

G = Grassland
F = Forest
LR = Linear regression trend line
LR 82G ($y = -0.168x + 85.9$; $R^2 = 0.84$)
LR 82F ($y = -0.130x + 79.9$; $R^2 = 0.74$)
LR 83G ($y = -0.194x + 88.9$; $R^2 = 0.84$)
LR 83F ($y = -0.185x + 88.3$; $R^2 = 0.79$)

THE INFLUENCE OF SEASON ON DISTRIBUTION PATTERNS RELATIVE TO WATER AND RESOURCE USE BY CATTLE GRAZING MIXED FORESTED RANGELANDS

Timothy DelCurto, Bruce K. Johnson, Martin Vavra, Alan A. Ager, and Priscilla K. Coe

Summary

Sustainable watersheds and resource use may be key factors determining the future of public land grazing in the western U.S. At the Starkey Experimental Forest and Range (SEFR), deer, elk, and cattle interactions are being studied in a free ranging environment within a 78-km^2 study area enclosed by a 2.4-m-high fence. Cattle are moved through pastures on a deferred-rotation schedule. Pastures grazed early in one year will be grazed late the following year. We evaluated distribution relative to water and vegetation resource use by cattle in two pastures that, depending on rotation, were grazed either early or late. We linked cattle locations (n = 52,536) determined with an automated telemetry system from 1991 to 1996 to a geographic information system (GIS) of the SEFR. Between and within seasons, cattle displayed strong patterns of spatial distributions and selection of resources on an hourly basis. Feeding sites for cattle were significantly different ($P < 0.05$) between seasons relative to distance to water, structure of the vegetation, and canopy cover. In late summer, cattle were closer to water and grazed in stands with higher percent canopy cover. Cattle grazing early summer pastures, as resources were consumed and vegetation dried, shifted distributions to more concave slopes, moved closer to water, sites with higher forage production, and more northerly aspects ($P < 0.05$). In late summer, patterns were reversed. In the first half of late season grazing, cattle selected areas closer to water, higher forage production areas, and northerly aspects, but as resources were removed, cattle used areas far from water, more concave sites, and areas with deeper soils ($P < 0.05$). In summary, scheduling timing of grazing has substantial effects on forage utilization and distributions relative to use for riparian areas.

Introduction

Grazing strategies and systems that promote uniform distribution and forage use are essential to sustainable beef production on western rangelands. Current issues relative to threatened and endangered species (specifically salmon, steelhead, and bull trout) and the federal Clean Water Act have focused considerable attention on management of riparian areas. Management of grazing to promote riparian biological diversity, streambank stability, and overall sustainability holds potential keys to continued use of public lands by the livestock industry.

Numerous factors influence the distribution of cattle relative to riparian areas. Topography characteristics such as slope, aspect, canopy, and vegetation all influence and drive animal distribution. Animal factors such as age, lactation, stage of lactation and possibly breed type also may modify the distribution of beef cattle in range environments. Likewise, ambient air temperatures and subsequent water requirements that effectively help regulate body temperature and meet metabolic demands also influence the relative needs of beef cattle for riparian areas and associated habitat.

Optimal management of beef cattle in free-ranging environments, therefore, requires understanding the dynamics of the animals' physiological requirements (i.e., thermoregulation) as modified by diverse vegetation and topography. The objectives of this study were to evaluate and compare distributions and resources selected by cattle relative to daily activity patterns, early versus late summer use, and duration of grazing in two dissimilar allotment pastures.

Materials and Methods

Study area. We conducted this project on the Starkey Experimental Forest and Range (SEFR), which is located in the Wallowa-Whitman National Forest, 35 km southwest of La Grande, in northeastern Oregon. The SEFR consists of a 101-km^2 area enclosed by a 2.4-m ungulate-proof fence. The site is typical of mixed forested rangelands in the intermountain west with vegetation consisting of bunchgrasses, ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menzienzii*), grand fir (*Abies grandis*), and lodgepole pine (*P. contorta*). Elevations range between 1,100 and 1,400 m with annual precipitation averaging 64 cm, 60 percent coming during the winter period. The main study area (77.6 km^2, Figure 1) used for this project consisted of four pastures used in a deferred rotation grazing system. Specifically, during odd-numbered years, cattle (500 head allotment) graze the pastures in the following order. Smith-Bally, Halfmoon, Bear, and Campbell. In contrast, during even-numbered years, cattle are grazed in reverse order beginning with the Campbell pasture (mid-June to mid-July) and ending with the Smith-Bally pasture (early-September to mid-October). For this project, we limited our analysis to the Smith-Bally and Campbell pastures because they were grazed either early or late, depending on year.

Monitoring animal locations. Locations of cattle were monitored in the main study area from 1991 to 1996 with a LORAN-C automated telemetry system (ATS; Rowland et al., 1997). Attempts were made to locate an animal every 20 seconds with animals assigned to a 30- x 30-m pixel within the main study area. Mean position error of the ATS was $\pm$ 53 m (SE = 5.9 m; Findholt et al., 1996). Each location also was corrected for spatial biases (Johnson et al., 1998).

Habitat variables. Animal locations then were linked to a geographical information system (GIS) for the SEFR. Specific variables related to habitat characteristics were derived from the literature and tested for collinearity (Johnson et al., 2000). Selected habitat characteristics used in our analysis included percent slope, convexity, sine of aspect, cosine of aspect, distance to class 1 and 3 water sources (perennial streams), soil depth, distance to forage, and canopy cover of trees (> 4.9 cm dbh).

Statistical analysis. To estimate resource selection, we used locations obtained within 4 hr after sunrise and 4 hr before sunset, and we restricted our analysis to animals with greater than 29 locations within the time intervals we analyzed. We used logistic regression (SAS, 1997) in a stepwise backwards-approach to identify variables to calculate resource selection functions specific to season of grazing and time within a given pasture (first half of grazing versus second half). Additionally, a jackknife process was used to test the significance of the coefficients by repeating the analysis and sequentially dropping a different animal from the data set for each iteration. Variables with the highest P value were dropped sequentially from the model, until only significant variables ($P < 0.05$) remained. To examine for differences between the first half of the early summer grazing season and the first half of the late summer grazing season, we tested for interaction with each variable that was significant in either of the initial models.

Results

Smith-Bally Pasture. Contrasting patterns in resource selection were evident between and within seasons, and resource selection was influenced strongly by season of use. During the first half of the early season, cattle selected gentle slopes, southerly aspects, areas close to water, deep soils, and areas with low canopy ($P < 0.05$; Table 1). In contrast, cattle selected in the first half of the late season northerly aspects, concave sites, more productive sites as indicated by greater coefficients relative to soil depth, and areas close to forage ($P < 0.05$; Table 1). During the late season of use, cattle did not select resources based on distance from water ($P > 0.10$), but late season cattle were closer to water than early season distributions of cattle throughout the day (Figure 2).

The second halves of both early and late season grazing periods displayed contrasting relationships, as well, with forage utilization presumably resulting in shifts in resources selection. Specifically, during the second half of early season grazing, cattle shifted away from water and selected more steep slopes and less concave slopes (Table 1; $P < 0.05$). In contrast, as forage became limited during the late season, cattle selected steeper concave slopes, northerly aspects, and areas further from water (Table 1; $P < 0.05$). Comparing resources selected during the first halves of early and late season grazing, sine of aspect, cosine of aspect, convexity, distance from water, distance from forage, and tree canopy cover all differed ($P < 0.10$).

Campbell Pasture. Like the Smith-Bally pasture, cattle distribution was influenced strongly by season of use. Specifically, when evaluating the interaction of early versus late season grazing (during the first half of the grazing period), distance from water, distance from forage, and tree canopy cover all were different ($P < 0.10$) in terms of mediating cattle distribution. Specifically, cattle tended to select areas closer to water and with higher percent canopy cover (Table 2). As forage was removed from the pastures during both early and late season grazing, resource selection shifted. Cattle grazing early season moved toward water, more northerly aspects, and areas of higher forage production ($P < 0.05$) as forage availability became limited in the second half of allotment pasture grazing. In contrast, cattle grazing late season pastures moved away from water toward steeper concave slopes and greater soil depth ($P < 0.05$).

Discussion and Management Implications

Beef cattle distributions in forested rangelands are influenced strongly by season of use, forage availability, habitat characteristics, and the environment. Results of this study suggest that early season distribution is much more uniform, with cattle selecting habitats with greater slope and greater distances from water. In contrast, late season grazing distribution is more concentrated in areas close to water and with higher tree canopies and more northerly aspects. Additionally, as length of grazing increased and forage availability became limited, cattle shifted resource selection toward areas of greatest forage availability.

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Smith-Bally area of the Starkey Experimental Forest.

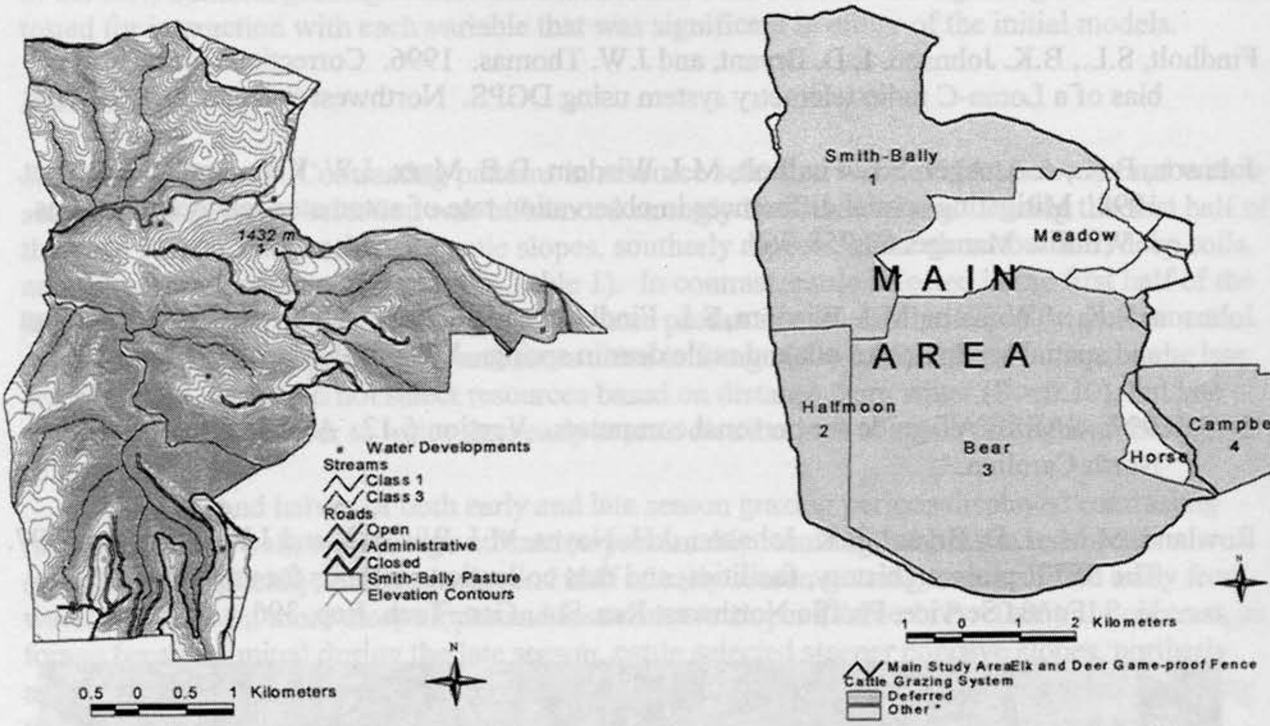

Figure 1. Beef cattle distributions were determined using an automated telemetry system and applying to GIS images for the Starkey Experimental Forest and Range. The cattle were managed in a deferred rotation system corresponding to the four shaded pastures, which comprised the main study area (right image). Cattle locations then were evaluated in terms of distance from water and habitat characteristics for the Smith-Bally and Campbell Pastures. The physical layout of the Smith-Bally Pasture is shown on the left.

Table 1. Variables of resource selection functions of cattle grazing mixed forested rangelands in early summer (1991, 1993 and 1995,) and late summer (1994, and 1996) within Smith-Bally pasture, using locations obtained with a LORAN-C automated telemetry system, Starkey Experimental Forest and Range, northeastern Oregon.

Variable	Cattle resource selection during early season of use				Cattle resource selection during late season of use			
	β	Standardized β	SE[a]	P	β	Standardized β	SE	P
First half of pastures use:								
Intercept	-1.657	-1.980	0.071	0.001	1.156	-2.414	0.079	0.001
Percent slope	-0.027	-0.348	0.059	0.001				
Convexity					-0.007	-0.045	0.024	0.054
Cosine of aspect	0.168	0.118	0.035	0.001	0.304	0.212	0.043	0.001
Distance to water	0.002	0.286	0.033	0.001				
Soil depth	0.007	0.089	0.022	0.001	0.009	0.119	0.040	0.003
Distance to forage	-0.005	-0.176	0.042	0.001	-0.002	-0.061	0.030	0.046
Second half of pastures use:								
Intercept	2.600	-3.495	0.059	0.001	6.435	-2.932	0.061	0.001
Percent slope	-0.023	-0.301	0.301	0.083	-0.010	-0.139	0.062	0.024
Convexity	-0.011	-0.067	0.029	0.020	-0.091	-0.115	0.029	0.001
Sine of aspect					-0.180	-0.129	0.035	0.001
Cosine of aspect	0.125	0.087	0.044	0.050				
Distance to water					0.001	0.119	0.048	0.013
Soil depth					0.012	0.152	0.041	0.001
Distance to forage	-0.003	-0.111	0.037	0.003	-0.004	-0.150	0.036	0.001

[a] Standard error (SE) is of standardized β

Table 2. Variables of resource selection functions of cattle grazing mixed forested rangelands in early summer (1994 and 1996,) and late summer (1991, 1993, and 1995) within Campbell pasture, using locations obtained with a LORAN-C automated telemetry system, Starkey Experimental Forest and Range, northeastern Oregon.

Variable	Cattle resource selection during early season of use				Cattle resource selection during late season of use			
	β	Standardized β	SE[a]	P	β	Standardized β	SE	P
First half of pastures use:								
Intercept	19.906	-0.387	0.054	0.001	47.970	-0.562	0.070	0.001
Percent slope	0.026	0.117	0.026	0.001	0.019	0.094	0.031	0.003
Convexity	-0.042	-0.099	0.023	0.001	-0.097	-0.266	0.030	0.001
Distance to water	0.001	0.165	0.056	0.003	-0.001	-0.371	0.074	0.001
Soil depth	0.012	0.101	0.031	0.001				
Distance to forage	0.004	0.067	0.021	0.001	-0.007	-0.121	0.039	0.002
Grazing canopy					0.010	0.165	0.037	0.001
Second half of pastures use:								
Intercept	16.413	-0.792	0.057	0.001	73.541	-0.591	0.072	0.001
Percent slope	0.018	0.079	0.027	0.003	0.041	0.184	0.027	0.001
Convexity	-0.036	-0.081	0.025	0.001	-0.150	-0.368	0.041	0.001
Sine of aspect					0.206	0.104	0.055	0.059
Cosine of aspect					-0.243	-0.158	0.058	0.007
Distance to water	0.001	0.221	0.057	0.001	0.001	0.320	0.055	0.001
Soil depth	0.011	0.097	0.032	0.002				

[a] Standard error (SE) is of standardized

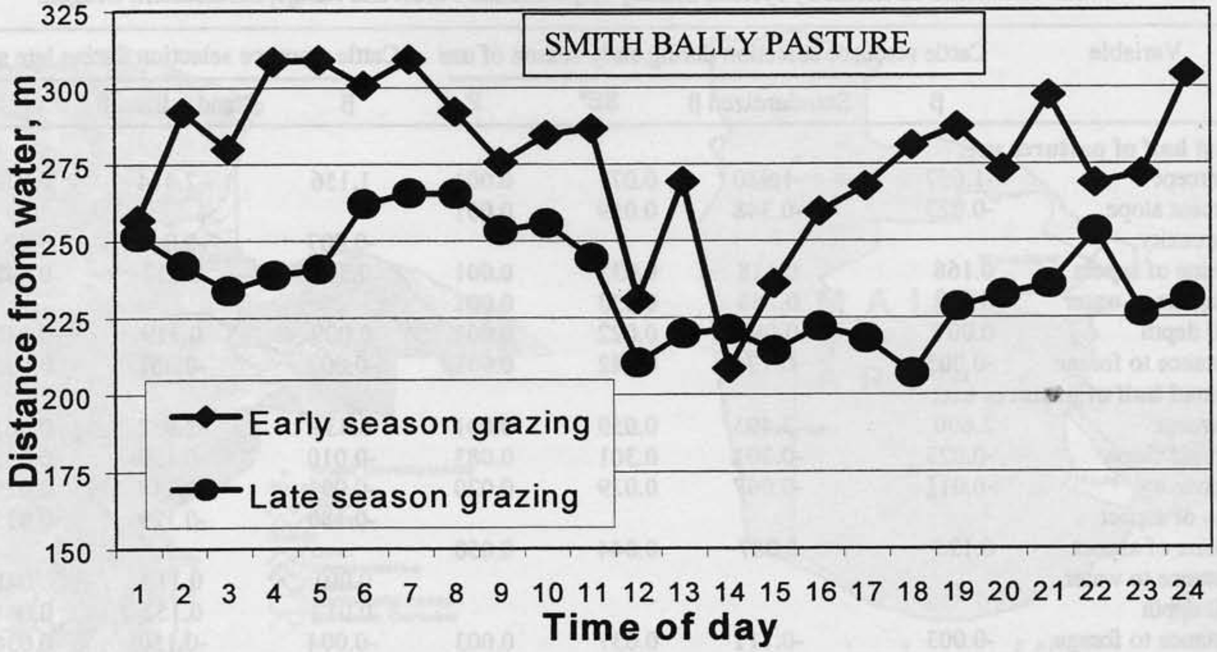

Figure 2. Mean distance of cattle to perennial streams during early and late summer grazing on an hourly basis in Smith-Bally Pasture, Starkey Experimental Forest and Range, northeast Oregon, 1991-1996. Diurnal patterns of beef cattle distribution relative to class 1 and 3 streams were influenced by season of use. Early season use reflects observations obtained in 1991, 1993, and 1995, whereas late season distribution was derived from 1994 and 1996 grazing seasons.

USING 35-MM PHOTOGRAPHS TO MONITOR HERBACEOUS AND WOODY PLANT ABUNDANCE IN RIPARIAN SYSTEMS

Chad Boyd and Tony Svejcar

Summary

Observer-based methodologies are used widely in vegetation monitoring programs. These methods often suffer accuracy problems within and between observer variations. We currently are exploring ground-based photography and computer image analysis as tools for monitoring herbaceous standing crop in riparian plant communities, and production and stand development of riparian willow communities. This technology has the potential to minimize observer bias and creates a permanent record of vegetation status. Preliminary data were collected in the growing season of 1999, and technique evaluation will take place during the growing seasons of 2000-2001. Our method for estimating herbaceous standing crop and woody plant production involves using computer image analysis to determine visual obstruction of a photoboard. The resulting numbers are regressed against the actual (harvested) weight of vegetation influencing the photoboard to determine the utility of computer generated visual obstruction values as predictors of herbaceous and woody plant abundance. Preliminary data between visual obstruction and plant abundance yielded an R^2 of 0.88 for herbaceous standing crop and 0.91 for current annual willow growth. We also are evaluating the use of community scale photographs and image analysis for tracking changes in the properties of willow communities over time. Photographs are taken from permanent photo-points and scanned, and willow clumps are hand-digitized. The processed image then can be used to generate diameter, height, and area measurements for willow clumps.

Introduction

Observer-based methods for quantifying vegetation abundance (e.g., canopy cover estimation) are used widely in monitoring protocols because they are time efficient, financially feasible, and, when sound protocols are followed, can provide a meaningful estimation of vegetation attributes. However, observer-based methods may suffer from several credible problems, namely observer bias and variability between observers. Additionally, observer-based monitoring programs lack a permanent record of vegetation status (e.g., photograph, classified image) that may be re-analyzed as new technologies become available. Variability between observers can be reduced by using quantitative monitoring techniques such as clipping and weighing plant material; however, quantitative methods are time intensive, often to the point of being prohibitive.

Analysis of remotely sensed imagery (e.g., aerial photos) as a monitoring tool provides a permanent record of vegetation status while minimizing observer bias. However, use of this technology may be limited by image availability, cost, and the scale of interest. Ground-based photography combined with image analysis may serve as a viable alternative for meeting small-scale monitoring objectives. To date, this technology has been used to measure a variety of plant autecological and community attributes, including canopy cover of individual (Birdsall et al., 1997; Ewing and Horton, 1999) and multiple (Dietz and Steinlein, 1996) plant species, and leaf area of woody species (Ansley et al., 1988). We currently are evaluating the use of ground-based photography and image analysis for the following applications: (1) quantifying standing crop of herbaceous vegetation in riparian plant communities, and (2) quantifying production of individuals and stand development of riparian willow communities. Preliminary fieldwork was conducted in the growing season of 1999 and experimental evaluation of techniques is scheduled for the growing seasons of 2000 and 2001.

Materials and Methods

Our study site is located in the Logan Valley, 80 km northeast of Burns, OR. This site is predominantly wet meadow vegetation dominated by *Poa* sp., *Carex* sp., and *Deschampsia caespitosa* and is bisected by several riparian drainages. Historically, the study site has been grazed in the early growing season and later hayed. Both livestock grazing and haying activities recently have been curtailed.

Our field methodology is based in part on the relationship between visual obstruction and plant production. The underlying theory is that changes in visual obstruction of an object will correspond to changes in the weight of plant material. For herbaceous vegetation, we relate visual obstruction to standing crop (current and preceding year's production), and for willow plants, to current annual growth. Visual obstruction has been shown to be a reliable predictor of herbaceous standing crop (Robel et al., 1970); however, the relationship between woody plant biomass and visual obstruction is less well defined.

Herbaceous vegetation. Approximately 150 sampling points will be subjectively chosen to represent a broad range of biomass values. Sampling will take place during the growing seasons of 2000 and 2001. At each point, a 1 m^2 white photoboard will be placed perpendicular to the ground, and a 35-mm photograph will be taken of the photoboard, using a 50-mm lens, at a distance of 2 m. The height of the camera will be equal to the center-point of the photoboard. A 40- x 100-cm quadrat then will be placed immediately in front of the photoboard, and all herbaceous vegetation will be clipped, dried, and weighed. Photographs will be scanned and cropped to encompass the dimensions of the photoboard. Visual obstruction will be estimated using Sigma Scan 5.0 computer software by determining the amount of the photoboard visible in the image and comparing that to its actual area. The relationship between percent visual obstruction and standing crop will be evaluated using regression analysis. Preliminary analysis of pilot data from the 1999 growing season indicates a strong relationship between herbaceous standing crop and percent visual obstruction of the photoboard (Figure 1).

Willow. The relationship between visual obstruction and the weight of current annual willow growth (CAWG) will be determined using a sequential removal technique and image analysis. Harvested willow branches will be placed in a holding device such that they are oriented perpendicular to the ground and located in front of a 1-m^2 photoboard. The CAWG obstructing view of the photoboard then will be incrementally removed, with each successive removal representing about a 25 percent decrease in visual obstruction of the photoboard. A photo will be taken before and after each removal, and harvested CAWG will be dried and weighed. Camera placement will be at 3.5 meters from the photoboard with a lens focal length of 80 mm. Slides will be scanned and cropped to encompass the dimensions of the photoboard. Visual obstruction will be estimated for all scanned images, using Sigma Scan 5.0 software, by determining the amount of the photoboard visible in the image and comparing that to its actual area. The relationship between percent visual obstruction and the weight of CAWG will be evaluated by regressing the weight of CAWG covering the photoboard against percent visual obstruction.

Preliminary results using this technique indicate a strong relationship between CAWG and percent visual obstruction of the photoboard (Figure 2).

We also will explore the use of permanent visual obstruction monitoring stations for ascertaining changes in willow abundance over time. Each monitoring station will consist of two 30-cm-wide visual obstruction boards placed behind a willow clump (Figure 3). The boards will be placed at approximately 1/2 and 2/3 the height of the willow clump. If the clump is immature, an average willow height of nearby mature willows will be used to determine height placement of boards. Annual photographs will be taken from a permanent photo point located perpendicular to the visual obstruction boards. Photos will be scanned and visual obstruction of each board will be determined as described above. This setup will facilitate determination of visual obstruction at two levels in the tree canopy. Changes in these readings from year to year can be used to imply changes in the amount of CAWG in the clump. The boards will be of known length and can be used as scale references for determining the height and width of the clump. We will put in place six visual obstruction monitoring stations at the Logan Valley site.

We will use a combination of community scale photographs and image analysis to evaluate changes in the size of the willow community surrounding the visual obstruction station. Permanent end posts will be put in place to mark the outer boundaries of the community photograph and will be located equal distance from the edge of the visual obstruction monitoring station (Figure 4). A 35-mm photograph of the community scene will be taken at a permanent photo-point at the end of each growing season. Images will be scanned and willow clumps in the image then will be hand digitized with a mouse and measured using Sigma Scan 5.0 software. Measurements will include maximum clump diameter, maximum height, and area. This approach to monitoring changes in willow community properties is similar to that presented by Hall (1999).

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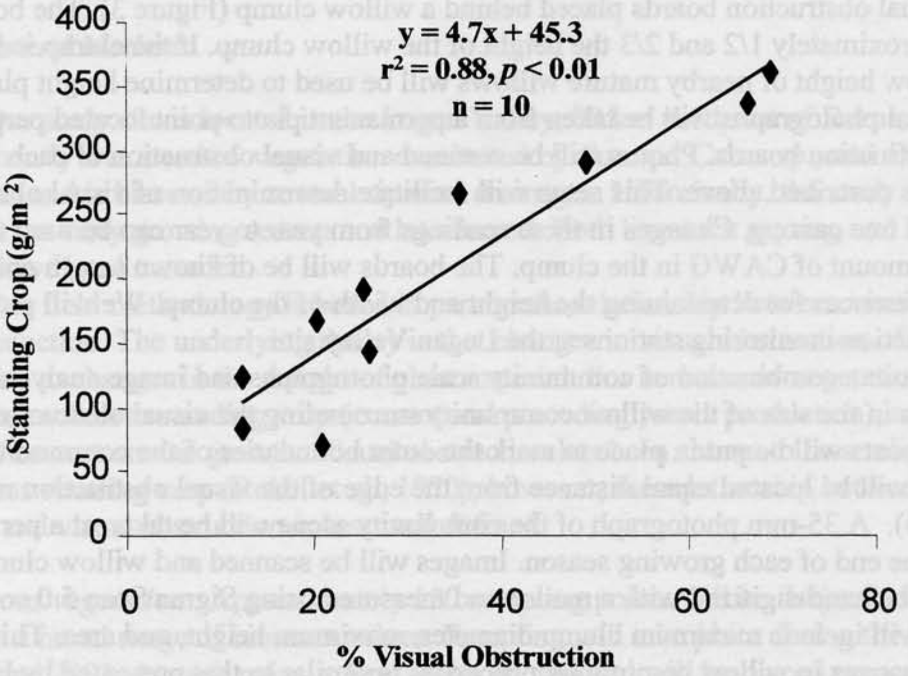

Figure 1. The relationship of herbaceous standing crop and percent visual obstruction for a wet meadow plant community.

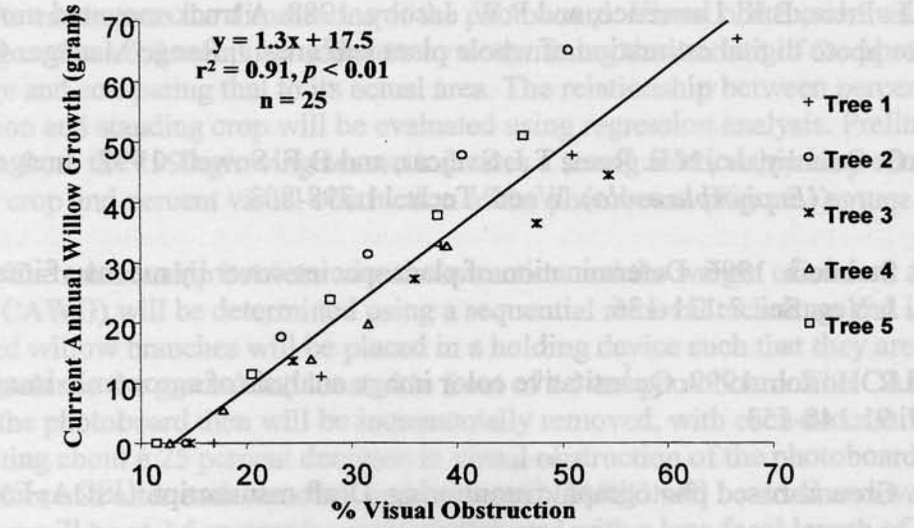

Figure 2. The relationship of the weight of current annual growth and percent visual obstruction for simulated willow trees.

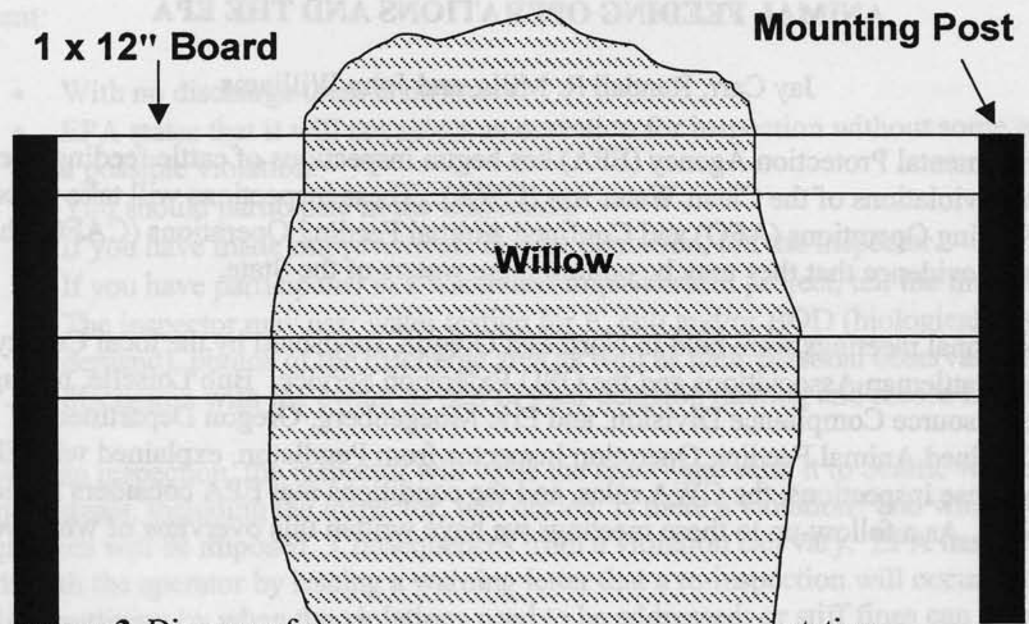

Figure 3. Diagram of willow visual obstruction monitoring station.

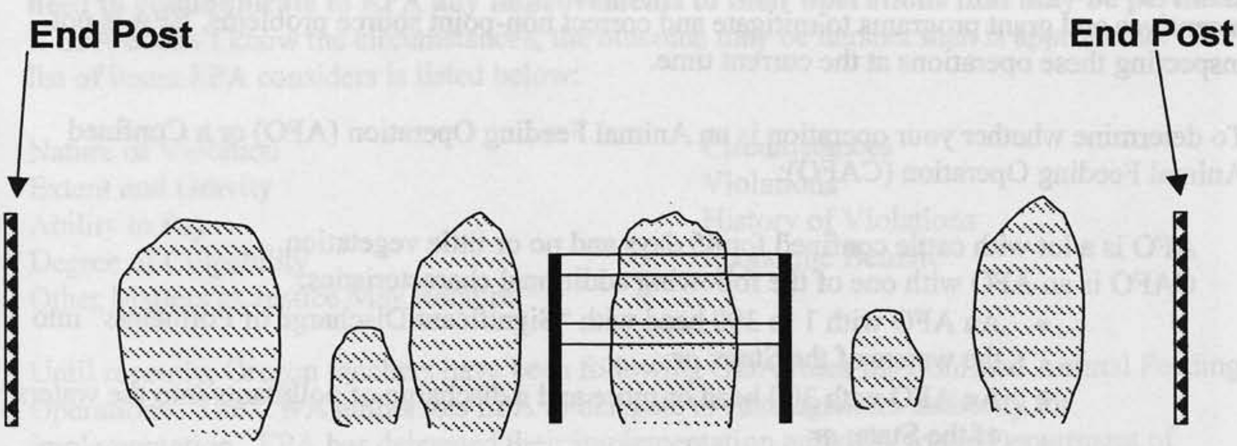

Figure 4. Diagram of willow visual obstruction and community monitoring stations.

COMPLIANCE WITH THE CLEAN WATER ACT: ANIMAL FEEDING OPERATIONS AND THE EPA

Jay Carr, Randall R. Mills, and John Williams

The Environmental Protection Agency (EPA) has begun inspections of cattle feeding operations for potential violations of the Clean Water Act (CWA). These inspections will take place on Animal Feeding Operations (AFO) and Confined Animal Feeding Operations (CAFO) that have shown some evidence that they may be polluting the waters of the State.

Four educational meetings were held in Northeast Oregon, sponsored by the local County Stock growers or Cattleman Associations and the OSU Extension Service. Bub Loiselle, manager of EPA's point source Compliance Division; and Eric Moegenberg, Oregon Department of Ag. (ODA) Confined Animal Feeding Operation Inspector from Pendleton, explained why EPA was beginning these inspections, the CWA rules, and the conditions that EPA considers in violation of the CWA. As a follow-up to these meetings we have written this overview of what we learned.

EPA is concentrating on "point source" pollution generated from either an AFO or CAFO operation, as defined below. Currently, EPA is concentrating its inspections on the AFO/CAFO operations with more than 300 head of cattle.

If you do *not* qualify as an AFO or CAFO operation, you are regulated under the "non-point" source pollution found in Section 208 and 319 of the Clean Water Act. These sections lay out incentives and grant programs to mitigate and correct non-point source problems. EPA is not inspecting these operations at the current time.

To determine whether your operation is an Animal Feeding Operation (AFO) or a Confined Animal Feeding Operation (CAFO):

AFO is a lot with cattle confined for 45 days and no or little vegetation.
CAFO is an AFO with one of the following additional characteristics:

- An AFO with 1 to 300 head with "Significant Discharge of Pollutants" into the waters of the State; *or*
- An AFO with 300 head or more and a discharge of pollutants into the waters of the State; *or*
- An AFO with 1,000 head or more of livestock.

The most important question EPA is looking at is, **"Does a rancher have animal waste discharging into the waters of the State from his cattle feeding area?"** If the answer is yes, then pollution is occurring as defined by the Clean Water Act.

To determine which of the AFO/CAFO operations with more than 300 head of cattle the EPA will inspect, the Agency is utilizing a couple of methods. First, they are doing aerial observations of the areas; and, second, they look at the various agency complaint lists (ODA, DEQ, EPA, etc.)

If your operation is selected for inspection, we have heard a variety of things that might be important:

- With no discharge there is no worry.
- EPA states that it will not select an operation for inspection without some evidence of a possible violation.
- You should participate in the inspection.
- If you have made improvements in your operation, tell the inspector.
- If you have participated in a watershed improvement project, tell the inspector.
- The inspector may use: water testing for E. coli and/or BOD (biological oxygen demand), photos of the discharge area as well as their personal observations, and the discussion with the owner as part of their decision making and record keeping.

Following an inspection, the inspector will write the report and send it to Seattle where a team of EPA individuals, including the inspector, will decide: Is there a violation? and what consequences will be imposed. Consequences from a violation can vary. EPA has the discretion to work with the operator by issuing a warning letter that a re-inspection will occur and including a timeline outlining by when the violations need to be addressed; or stiff fines can be imposed; or anything in-between.

When the consequences are made known, an operator needs to decide if they are fair. If the operator feels they are not fair, the concerns need to be communicated to the EPA. **The EPA does look at mitigating circumstances when imposing consequences; therefore, operators need to communicate to EPA any improvements to their operations that may be pertinent.** If EPA doesn't know the circumstances, the outcome may be harsher than is appropriate. The list of items EPA considers is listed below:

Nature of Violation	Circumstances
Extent and Gravity	Violations
Ability to Pay	History of Violations
Degree of Culpability	Economic Benefit
Other Matters as Justice May Require	

Until recently, Oregon ranchers have been following ODA rules for Confined Animal Feeding Operations. The CWA authorizes EPA to delegate to state agencies authority for implementation. EPA has delegated their implementation authority to the Department of Environmental Quality in Oregon. DEQ has signed agreements with ODA for implementation of the Confined Animal Feeding Operations rules. EPA is stepping in where DEQ has not implemented any program for AFO operations and is spot-checking ODA on CAFO inspections. This will continue until EPA and DEQ come to agreement on the appropriate rules, and who will implement them.

In addition to the lack of AFO inspections, the EPA rules are more stringent than the current ODA rules. EPA will be using these more stringent rules when doing inspections. The differences are listed below:

Condition	**ODA**	**EPA**
Days of Confinement	4 months	45 Days
Hardened Surface	Yes	No
Lack of Vegetation	NA	Yes
Waste Handling	Yes	NA

These inspections are separate from the Senate Bill 1010 plans that are being developed around the state. The SB1010 plans cover "non-point source" pollution while the inspections are only for "point source" pollution.

For more information, you can contact Jay Carr, 2610 Grove St., Baker City, OR (541) 523-6418; Randy Mills, 721 SE Third St., Suite 3, Pendleton, OR (541) 278-5403; or John Williams, 668 NW 1, Enterprise, OR (541) 426-3143; or your local county Extension specialist.

Definitions:

AFO	Animal Feeding Operation
CAFO	Confined Animal Feeding Operation
EPA	Environmental Protection Agency
ODA	Oregon Department of Agriculture
DEQ	Department of Environmental Quality