# Successful Strategies for Grazing Cattle in Riparian Zones



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# Contents

*Figure 1. Little Powder River south of Broadus, Montana.*

# Introduction

Despite their small proportion of the total landscape, riparian areas are ecologically and economically important from any perspective. These include water quality, biological diversity, wildlife and fisheries habitat, agricultural and ranching productivity, timber production, recreation, and simple aesthetics.

One of the most extensive human-caused influences on riparian zones in the western United States has been livestock grazing. It is well-known that improper grazing practices can adversely affect riparian areas. What is less obvious is which grazing management techniques are compatible with maintaining or improving these areas and under what conditions. This bulletin discusses both general principles for grazing cattle in riparian areas and specific techniques ranchers in Montana have employed to graze their riparian areas without sacrificing either the ecological or financial condition of their land. It is based on a review of the growing body of literature on this subject as well as on field observations and evaluations of operations on more than 70 ranches and numerous federal grazing allotments throughout Montana.

## Characteristics and Functions of Riparian Zones

### Characteristics of Riparian Areas

Riparian areas are the "green zones" which lie between channels of flowing water and uplands. They are the link between aquatic environments and upland, terrestrial ecosystems. Even with the recent emphasis on "The Riparian Zone," it is essential to keep in mind the fundamental interrelationships among aquatic, riparian, and upland ecosystems. An excellent reminder of these relationships is the observation that "management of salmonid habitats does not begin at the streambank but at the ridgeline [watershed boundary]" (Kauffman 1995).

Riparian areas are intimately related to their adjacent waterways since the presence of water for all or part of the growing season is their distinguishing characteristic. Moreover, the nature and condition of the riparian area abutting a stream channel fundamentally affects the aquatic ecosystem.

In addition to water, three other components of the riparian area essential for management consideration are soil, vegetation, and land form. In a healthy riparian ecosystem, the four are in balance and mutually supporting one another. While all four components are important, one might suggest that water and soil are the fundamental elements which define a riparian area and that vegetation reflects the nature and condition of the geomorphological and hydrological situations. Nevertheless, from a management perspective, vegetation is critical since often this is the element over which the manager has the most control, which is the easiest to manipulate, and which responds the quickest to human influences.

Riparian areas are usually much more dynamic than uplands (a term used in this report to refer to any part of the landscape beyond the non-streamside boundary of the riparian area). While plant communities may be especially susceptible to rapid change, it is not uncommon for physical conditions to change dramatically, often in relatively short periods. These changes might include: flooding (either temporary or more long term, as when caused by beavers); deposition of sediment on banks and across floodplains; accumulation of organic materials in areas such as wet meadows and bogs; dewatering of a site by a variety of means (for example, irrigation diversions); and changes in actual channel location. Each of these physical modifications can change the associated vegetation negatively or positively. Conversely, vegetation, or the lack of it, may contribute to each of the above phenomena.

The natural variation of riparian areas is an important consideration in seeking to understand and subsequently to manage these areas because it is often difficult to distinguish between natural and human-caused impacts. In addition, the inherently dynamic nature of riparian areas and their associated stream channels is such that natural events may override human-caused impacts, including efforts at in-stream and riparian rehabilitation.

## Functions of Riparian Areas

Healthy riparian areas provide several important ecological functions. These functions include water storage and aquifer recharge, filtering of chemical and organic wastes, sediment trapping, bank building and maintenance, flow energy dissipation, and primary biotic production.

***Riparian areas provide for water storage and aquifer recharge.***

The soil in the banks and floodplains and the substrate under the channel act as a sponge to retain water. In doing so, they reduce peak flows during floods. This stored water is released as subsurface or groundwater over time, extending the availability of water in the watershed for longer period in the summer and/or recharging the under-ground aquifer.

***Riparian vegetation dissipates the energy of flowing water and stabilizes streambanks.***

It thus reduces erosion and the introduction of excessive sediment into the channel. Vegetation can also limit the movement of upland soil into the stream. Floodplains also serve to reduce water velocity by allowing it to spread across a wider area and providing more obstacles to create friction These functions are particularly important during spring runoff periods and after major summer or fall rains.

***Riparian vegetation traps sediments carried by the stream and by overland flow from the adjacent uplands.***

Trapping of sediment may lead to the development of new banks and bars, which become the location for new vegetation communities, further enhancing stability. Sediment retention is also important because excessive sediment loads reduce habitat quality for aquatic life (including fish) and destabilize the natural hydrologic regime of the system. Healthy riparian systems enhance water quality by filtering out organic and chemical pollutants before they reach the channel and as they move downstream.

***Riparian vegetation shields soil and water from wind, sunlight, and rain drop impact.***

This reduces erosion due to wind and the disruptive impact of rainfall as well as reducing evaporation. Vegetative canopy cover also provides shade which reduces water temperatures and improves aquatic habitat. Dense vegetation may limit soil compaction through the presence of healthy root systems and by limiting accessibility of both domestic livestock and wild ungulates. Although an increase in vegetation may increase evapotranspiration, in natural riparian systems the overall benefits offset this loss.

***Finally, riparian areas are rich in biotic production.***

The presence of water and essential nutrients make them among the most productive parts of a landscape, especially in such regions as the arid and semiarid western United States. This productivity enhances livestock use as well. Biomass on mountain meadows, for example, may be "10 to 20 times higher than that of surrounding uplands" (Skovlin 1984). Roath and Krueger (1982) found that the riparian area in a Blue Mountain pasture in eastern Oregon provided more than 80 percent of the total herbaceous vegetation grazed by cattle, even though it comprised less than two percent of the total area of the pasture.

The ecological importance of riparian zones far exceeds the proportion of the landscape they comprise. Riparian areas provide innumerable wildlife species with water, food, cover, and travel routes. While riparian areas make up only about two percent of the land area of the western United States, "It is believed that, on land, the riparian/stream ecosystem is the single most productive type of wildlife habitat, benefiting the greatest number of species" (Kauffman and Krueger 1982). More than 75 percent of all wildlife species in southeastern Wyoming are dependent upon riparian habitats (Chaney and others 1990). In the western United States, more bird species rely on riparian habitats than all other western rangeland vegetation types combined (Chaney and others 1990).

Obviously, healthy riparian areas are ecologically vital. In addition, the ability of riparian areas to perform their ecological functions provides numerous direct benefits to people. They are among the most productive vegetative communities on the landscape. Their moisture storage capabilities provide water for human consumption, crop production, livestock and wildlife needs, and recreational enjoyment, while reducing the damage that might be caused by flooding. If riparian areas are to provide these multiple benefits, however, they must be properly managed. Because of the wide-spread use of riparian areas for livestock grazing, an important element of riparian management is to consider ways in which such grazing can occur without harming the riparian area. The next section of this report addresses this issue.

# Principles and Techniques for Riparian Grazing

## General Principles for Riparian Grazing

While each ranching operation and grazing allotment is unique, there are general guidelines which should be considered when determining an appropriate riparian grazing strategy. How they should be applied to specific situations will depend on the conditions, objectives, and resources which characterize an individual operation or situation. Nevertheless, the livestock operator or land manager who seeks to maintain or establish healthy riparian areas would do well to have these principles firmly in mind before undertaking any specific activities.

### Tailor the approach to the specific situation.

The dominant theme of virtually all the literature, experimental and anecdotal, on approaches to grazing riparian zones and their companion streams is that ***"no two stream systems are alike—each has its own level of ability to withstand natural and/or human-induced stress"*** (Buckhouse and Elmore 1993; italics in original). Accordingly, "no treatment or system of treatments will work everywhere" (Swanson 1986). This situation imposes a burden on land managers, private and public, for it requires that they understand the nature of the particular riparian system with which they are dealing, including: hydrologic and geomorphologic characteristics, current and potential plant species and communities and their responses to grazing and browsing, animal behavior, forage preferences, and the management feasibility of possible treatments (Krueger 1996). According to Green and Kauffman (1995), "Our results indicate that . . . basing management recommendation[s] on [only] 1 component ignores the inherent complexity of riparian ecosystems."

Tailoring one's approach to a particular area also involves determining ***specific riparian objectives.*** It is possible to maintain or even to improve riparian zones without identifying specific objectives beforehand. Several of the ranchers with whom we talked admitted they had undertaken actions to achieve a "non-riparian" goal and discovered one result was an improvement in their riparian area. Such situations, however, are definitely the exception. Knowing where you want to go is specially important to rehabilitate a riparian area in a degraded condition. Only rarely will this happen without definite, positive steps on the part of the manager.

Ranchers and range conservationists traditionally have focused on herbaceous plant growth and utilization. Development of riparian vegetation objectives may be viewed as a logical extension of this approach. On the other hand, given the importance of residual vegetation (see below), it is necessary to invert the emphasis from "what to take" to "what to leave" (Burkhardt 1979). In addition, objectives in riparian areas must include less familiar aspects such as woody species utilization and regeneration, streambank condition, and channel morphology. (Kinch [1989] and Krueger [1996] are especially good on what factors need to be considered and how to look at them.)

An important step toward the attainment of identified objectives is ***developing a monitoring program*** designed specifically to track those aspects of the system which will provide information on whether conditions are moving in the right direction. For example, if a management objective is to increase willow canopy cover along a stream, the regeneration and development of willow plants must be monitored. It is not enough simply to monitor the growth and utilization of herbaceous vegetation as traditionally done in upland pastures (Hansen 1993). In the words of Wyoming rancher Jack Turnell, first recipient of the National Cattlemen Association's Environmental Stewardship Award, *If you're not monitoring, you're not managing* (1993).

## Incorporate management of riparian areas into the overall management plan.

Because riparian areas comprise only a small portion of the area on any ranch or grazing allotment, they must be addressed within the context of an overall management plan. This does not contradict the previous guidance. Rather it recognizes the need to adopt approaches that are managerially feasible as well as ecologically sound. It also recognizes the essential links among the stream channel, the riparian zone, and the uplands: "Proper upland management is essential for obtaining a healthy riparian area, the two go hand in hand" (Tohill and Dollerschell 1990).

This principle serves as a reminder that any actions or decisions taken with regard to riparian zones will have an effect on other parts of the operation. Planning when and how long to use pastures with riparian areas, for example, will involve decisions on where the animals will be the rest of the year. An aspect of riparian management often overlooked is that the less time livestock spend in the riparian zone, the greater proportion of time they will be in the uplands. In situations in which wild ungulates also depend on upland forage, the impact of this redistribution must be carefully considered.

Focusing too narrowly just on actions within the riparian area ignores the full complement of possible steps which might contribute to maintaining or improving this zone. Some of the most significant steps Montana ranchers have taken to improve their riparian systems have occurred well out of the riparian area.

## Select season of use so grazing occurs, as often as possible, during periods compatible with animal behavior, conditions in the riparian zone, and riparian objectives.

Livestock will affect riparian vegetation and physical conditions differently depending on many factors, including the site's physical characteristics and conditions, the stage of plant development, the nature of the plant communities in both the riparian area and the uplands, and current weather. To attain management objectives that mesh economic ends with ecological needs requires that "soil physics, watershed (especially infiltration), plant growth and development factors/ responses, and animal behavioral responses all must be factored in" (Buckhouse 1995).

While our study results suggested there is no universally applicable "best time" in which to graze riparian zones, there is increasing evidence that different seasons have identifiable characteristics that tend to result in fairly predictable impacts— predictable enough, at any rate, to provide the basis for initial planning. (See below for a discussion on seasons of use.) One key reason for having clearly defined riparian objectives is to provide assistance in determining which seasons of use will best move a particular riparian zone toward specific objectives.

There are often tradeoffs in potential impacts with regard to time of use, and managers must keep in mind their objectives as well as the condition of the riparian area. For example, while late summer use will reduce trampling impacts on streambanks, it may also result in heavy use of young woody plants. Varying the season of use annually will change the nature and extent of the possible impacts which can result from livestock grazing.

## Limit the time livestock spend in pastures with riparian areas.

While there are different opinions regarding the best season of use, there is consensus that the length of time animals spend in a riparian area can be a significant factor in the condition of that area. According to Marlow and his colleagues (1991), "The most critical aspect in any grazing plan for the protection of riparian areas is the length of time cattle have access to a particular stream reach." Myers (1989), reviewing 34 allotments in southwestern Montana, concluded, "Duration in grazing treatments becomes a key factor in determining the severity of damage" because of the tendency of cattle to hang out in the riparian area even when not actively feeding. Marlow (1985) made the point that "the length of the grazing period should be based on the areas cattle are actually using, not the entire pasture."

With the exception of winter grazing periods, less than 20 percent of the operations we evaluated as having healthy riparian zones exceeded 45 days in the target pasture and most were considerably shorter. Those ranchers who did graze a pasture more than 45 days had taken other steps to reduce the time livestock actually spent in the riparian area.

## Influence the distribution of livestock within the targeted pasture.

Left on their own, cattle tend to spend a disproportionate amount of time in the riparian area and to overutilize the forage which grows there. According to Clary and Webster (1989), domestic livestock will spend from "five to 30 times longer" in a riparian area than might be expected based on the relative size of the riparian area to the entire pasture. Bryant (1979) noted that, given the choice, both yearlings and cows with calves preferred riparian areas over uplands for much of the summer grazing season.

Riparian areas are often only two to three percent of the area of a pasture, but they may produce 20 percent of the forage and receive up to 80 percent of the use if measures are not taken to redistribute animals (Krueger 1984, cited in Vavra 1984). In 23 of 25 cases in Idaho, Utah, and Nevada, cattle used streamside vegetation twice as heavily as overall pasture use (Platts and Nelson 1985b). Nor is the impact on vegetation the only concern. The presence of livestock has physical impacts as well, including soil compaction, bank trampling, and degraded water quality due to waste materials entering the stream channel.

Determining the most appropriate season for grazing a particular pasture with riparian areas is one method to control distribution because it allows the manager to use natural conditions and animal behavior to advantage. There are also numerous techniques to encourage livestock to venture away from the riparian area. Both season of use and other techniques are discussed below.

### Ensure adequate residual vegetation cover.

Vegetation cover is essential for maintaining almost all types of healthy riparian ecosystems. Myers (1989) concluded that, through a combination of rest and removing livestock in sufficient time to provide for regrowth, successful riparian grazing systems provided residual vegetative cover 75 percent of the years, whereas unsuccessful systems provided for this only 38 percent of the time. Although closely tied to utilization levels, an emphasis on residual vegetation cover offers a different perspective. Rather than emphasizing what the animals get, the focus is on the plants and their role in the ecosystem: "More important than knowing how much herbage can be removed . . . is knowing how much should be left for ecosystem maintenance. Approaching utilization from this standpoint provides for the physiological needs of the plant species" as well as for their capacity to perform riparian functions (Thilenius 1979).

How much and what type of vegetation exists on a site determines how well the riparian system performs its functions of reduction of flow velocity, sediment trapping, bank building, and erosion protection. What constitutes "adequate" cover depends on the location of the riparian pasture and the specific situation. In a simulation study of riparian stubble height, Clary and others (1996) concluded different stubble heights are needed to fulfill the two processes of sediment deposition (trapping) and sediment retention (bank building), with shorter heights (0.5-6.0 inches) better for the former and taller (8-12 inches) for the latter. It is, at any rate, important to remember that the vegetation which exists on site at the end of the growing season or at the end of a grazing period, *whichever comes last*, is what matters since this is essentially what will be available during the next runoff period. In many situations projections of residual vegetation must also include consideration of probable wildlife use prior to spring runoff.

### Provide adequate regrowth time and rest for plants.

For plants to remain vigorous and productive, they must have time for growth, seed development, and storage of carbohydrates. Continual grazing during the plant's growth period eventually causes roots to die back, the plant to lose vigor, and seed development to cease. The result can be a change in plant community, usually from more productive, palatable species to a less productive and less palatable group of plants. All of the studies which have identified steps toward proper riparian grazing management stress the crucial need for adequate rest or at least the cessation of grazing in time to allow plant regrowth to occur.

### Be prepared to play an active role in managing riparian areas.

At first glance, this statement seems trite and blatantly obvious. However, it gets to the heart of the matter. In their extensive review of riparian grazing literature, Clary and Webster (1989) concluded, "Most riparian grazing results suggest that the specific grazing system used is not of dominant importance, but good management is—with control of use of the riparian area a key item . . . ." They also observed that, while specific "results" are often attributed to the implementation of a particular grazing system, these effects may well have stemmed from "the whole range management program" that accompanied the introduction of that grazing system. In other words, success in maintaining or enhancing riparian health is dependent more on the degree of operator involvement than on what grazing system is employed.

There are a variety of specific techniques operators can use—and are using—to translate the general principles outlined above to on-the-ground operations. Which ones, or what combination of them, might be effective will depend on the riparian area in question and the willingness of the manager to be actively involved in their implementation. For ease of presentation, we have divided these activities into two broad categories: (1) determination of an appropriate season for grazing the riparian zone and (2) methods for reducing intensity of use in the riparian area through control and distribution of livestock within a pasture.

## Determining Season of Use*

Determination of an appropriate time of year for grazing a specific riparian area is one of the first steps in developing a riparian grazing management approach. Which season (or seasons) this might entail will depend on a broad range of factors. Perhaps the three most significant are: (1) the predicted response of different plant species, (2) the impact on the overall plant communities which can result from grazing, and (3) the degree of soil moisture on the site. Not surprisingly, there are potential advantages and drawbacks to grazing during each season. However, neither the potential advantages nor the possible disadvantages are certain to occur in every instance. Those listed below for each season should be considered potential, or even likely, outcomes, but none of them is guaranteed. Moreover, because of the fluctuation in natural systems (for

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** See Appendix A for time frames of seasons; see Appendix B for a summary of the material in this section.*

example, variations in temperature, timing and amount of precipitation, and vegetation growth), the appropriateness of using a particular pasture may vary somewhat from year to year. It is also possible that the nature of a given riparian area makes no grazing the most ecologically viable solution.

### Early Season (Spring) Use.

Evidence suggests early season use may be best for those situations in which: (1) livestock can be attracted to the uplands by succulent, herbaceous forage; (2) cool temperatures may discourage cows from loitering in the bottoms or weather in the uplands is not such as to drive them into riparian areas; (3) soil in the riparian area may be so wet as to discourage cows from entering; or (4) well-drained soils reduce the possibility of compaction (Gillen and others 1985; Platts and Nelson 1985a; Clary and Webster 1989; Kinch 1989; Clary and Booth 1993).

***Potential advantages.***

The availability of succulent upland vegetation may induce livestock to spend time out of the riparian area and thus reduce use of riparian plants as well as reduce the amount of soil compaction and bank trampling. In addition, early use allows time for subsequent regrowth of plant species in the riparian area as well as the uplands if animals are removed while sufficient soil moisture and appropriate temperatures remain (Elmore and Kauffman 1994). The presence of palatable herbaceous plants reduces pressure on woody plant species and allows them opportunity for maximum growth during this critical period (Kovalchik and Elmore 1992).

Platts and Nelson (1985a and 1985b) observed that livestock distributed themselves better throughout pastures and concentrated less in riparian areas during the spring. In a semi-arid portion of northcentral Wyoming, "relatively intense short-term grazing" in early summer apparently had little affect on the morphology of an ephemeral stream channel because cattle spent less time there during that period than later in the summer or fall (Siekert and others 1985). Both Crouse (1987) and Elmore (1988) reported improvements in riparian areas as a result of grazing them only in the spring (cited in Clary and Webster 1989). Krueger (1983) reported that forested riparian areas grazed in the spring had less than half the cattle occupancy compared to fall use (cited in Kovalchik and Elmore 1992).

Because of the essential role of woody species in maintaining riparian functions, reduced browsing pressure on trees and shrubs may be one of the most significant benefits of early season use (Swanson 1987). In eastern Oregon, cottonwood and willow seedling density was "somewhat greater" with moderate spring use than in moderate fall-grazed, season-long, or no grazing treatments (Shaw 1988, cited in Clary and Webster 1989). According to Kovalchik and Elmore (1992), early grazing "can be very beneficial to riparian areas, especially in establishing woody plants." They caution, however, that the impact of browsing during flowering and early seedling stages of willows, should this occur, needs more study. Clary and Webster (1989) concluded, "While no one management approach is best for all situations, spring grazing has shown promise in many areas of the Western United States."

Scheduling of early season grazing must allow time for vegetation regrowth (Bryant 1985; Clary and Webster 1989; Kinch 1989; Kovalchik and Elmore 1992; Buckhouse and Elmore 1993; Buckhouse 1995). In reviewing 34 grazing allotments in southwest Montana, Myers (1989) observed that the nine operations which had healthy riparian zones allowed for an average of 35 days of vegetation regrowth versus 21 days for unsuccessful operations. Failure to allow for regrowth after grazing ceases will, over time, not only impact vegetation in the riparian area, but will also reduce the vigor of upland plants and may result in changes in plant communities (Marlow and Poganick 1986).

***Possible disadvantages.***

There are possible drawbacks to early season grazing in riparian areas, however. First, because of high soil moisture levels, the potential impacts in terms of soil compaction, bank trampling, and subsequent erosion are greatest during this period. Second, grazing occurs during the critical period of plant growth and development, and repeated grazing of desirable herbaceous species at this time may affect plant vigor and may lead to changes in plant communities. Third, from a livestock production standpoint, the nutritive value of upland forage may be low and may require supplemental feeding. Finally, early season grazing may adversely affect wildlife in the area.

While wet soil conditions may discourage livestock from entering the riparian area, these same conditions make the system susceptible to serious damage if they do so. In a study at Red Bluffs Experimental Station west of Bozeman, Montana, Marlow (1985) discovered the greatest bank damage occurred in late June and early July when cattle use of the riparian zone was lowest, but soil moisture content was 18-25 percent. By August soil moisture had declined to 8-10 percent, and damage in the grazed riparian reach was no greater than that in the ungrazed reach. In some well-saturated soils, grazing animals are more likely to uproot plants in the spring than during other seasons (Kinch 1989). Underscoring the site-specific nature of this factor, Buckhouse (1995) cautioned that while early spring grazing seemed to work on well-drained soils, it tended to result in compaction on poorly drained soils. Livestock use of these zones in spring is more likely in areas where steep topography inhibits livestock movements into other parts of the pasture. Such situations will probably require additional management actions such as installation of drift fences to reduce the tendency of cattle to congregate and remain in the accessible bottoms. (See section on "Reducing Intensity of Grazing" below.)

Although the exact impacts of early season use on wildlife will depend on the species involved and the site itself, they may include disruption of birthing and nursing grounds and reduction in forage available to wild ungulates (Holecheck and others 1982). With appropriate timing, however, early season livestock grazing can "prepare" a pasture for later wild ungulate use by removing vegetation that would otherwise become rank and unpalatable (Anderson and Scherzinger 1975; Frisina and Morin 1991; Buckhouse 1995). Conflicts with ground-nesting birds, particularly those which nest and raise their young on the ground, are likely during this season (Bock and others 1993). Grazing during this or any other period does not impact all bird species the same, however, since the effects depend on the particular habitat involved, the bird species most likely to use that habitat, and the time of year (Dale 1984; Kantrud and Higgins 1992). Possible impacts of early season grazing on small mammals include loss of hiding cover and reduced food materials.

***Study reaches.***

Forty-three of the stream reaches reviewed in our study were grazed at least some years during the early part of the grazing year. Three of these alternated years between early use and late use (with the length of use ranging from 20 to 45 days). Six operators used the same pasture both early and late; the length of the grazing period ranged among the different operators from 0.5 days to 30 days during the early period. Five streams were grazed only during the early season and in a variety of ways. Three of them were used for 22-35 days, but livestock were removed by late May. One was a short duration operation used for less than eight days in the spring. A pasture on the Little Powder River in southeast Montana was grazed annually from the middle of May until mid-July (about 60 days). Its healthy condition may be attributed to the quality of offstream water (in contrast to that in the stream channel) and to the presence of older cottonwood groves away from the river which provide shade as temperatures rise.

Twelve stream reaches were part of short duration strategies which included early season use for no more than eight days during the course of any one year. Of the 19 stream reaches which were part of strategies that included more than eight days of early use during a grazing season, only one operator went into his pasture about the same time annually, but not earlier than June 20. The others varied season of use either within a definite rotation pattern or based on their assessment of their pastures. Significantly, all provided for early season rest at least one out of three years (if not more frequently) or moved livestock out of the pasture before the end of the growing season.

## Late Season (Fall) Grazing.

Deferring grazing use until fall may offer distinct benefits to maintaining the health of a riparian area under the following conditions: (1) when riparian plant communities consist of herbaceous rather than tree or shrub ("woody") species; (2) when cool season grasses stimulated by timely precipitation provide palatable forage in the uplands; (3) where offstream water near accessible forage sources is available, or other inducements (for example, cold air pockets streamside or the absence of hot temperatures in the uplands) draw cattle out of the riparian area.

***Potential advantages.***

The primary advantages of late season grazing are that soils are drier, which reduces the probability of compaction and bank trampling; most plants have completed their growth cycle, and grazing will not adversely affect plant development; and, generally, there is less impact on wildlife habitat.

Compared with spring use, fall grazing occurs when soil moisture is greatly reduced (Marlow 1985). This difference can be particularly significant where fine-textured soils are highly susceptible to compaction when wet. In Oregon, Buckhouse and Bunch (1985) determined there were no significant differences between streambank erosion in pastures moderately grazed in the fall and ungrazed control pastures. However, on a similar stream in the same area other researchers concluded, "The late season grazing was found to significantly increase streambank erosion," although it did not appreciably affect soil compaction (Kauffman and others 1983).

One of the most important advantages of late season grazing is that for many herbaceous species seed set has already occurred, and defoliation will have less impact than during earlier development stages (Kauffman and Krueger 1984; Gillen and others 1985). In addition, with adequate precipitation, regrowth of upland forage may draw cattle out of the riparian bottoms. Swanson (1987) suggested grasses, sedges, and rushes in Nevada can do well under late season use, and researchers in Oregon agreed late season grazing may be appropriate for herbaceous-dominated streams without natural woody components (Buckhouse 1995). Green (1991) found productivity and density of riparian meadows were maintained with late season grazing at moderate use levels (cited in Elmore and Kauffman 1994).

Late season grazing avoids conflict with ground-nesting birds (Kauffman and others 1982; Vavra 1984; Bock and others 1993). It may, however, reduce the forage available for winter ungulate use and limit cover density for small mammals prior to the following year's green up (Kauffman and others 1982). Kauffman (1982) suggested late season grazing in eastern Oregon resulted in minimal short-term disturbance to wildlife as well as limited soil disturbance, improved livestock performance, and allowed for good plant vigor and productivity (cited in Kauffman and Krueger 1984).

***Possible disadvantages.***

Late season use may be detrimental to the health of riparian areas. Where reduced soil moisture and declining temperatures are the norm, regrowth after the cattle are removed will not occur. This may limit the capability of plant communities to fulfill their riparian functions during the succeeding spring runoff. In addition, livestock are much more likely to browse woody species during this period. Finally, unless provided with incentives, cattle are less likely to range away from the riparian areas; moreover, the natural incentive of palatable upland forage often is not present.

While regrowth of cool season grasses and cooler weather may draw cattle out of the riparian area in the fall, should weather in the uplands remain unpleasant or should palatable forage not be available there, they are likely to congregate in the riparian area (Platts and Raleigh 1984; Green and Kauffman 1995). Even when positive conditions prevail, cattle are still less likely to distribute themselves as broadly as in the spring. Under these conditions, cattle have a tendency to remain in the riparian area and to continue to graze vegetation there even when the nutritive value of that forage has declined (Gillen and others 1985). Thus, it is particularly important to monitor the extent of residual vegetation to ensure enough remains to perform sediment trapping and streambank protection functions as well as to provide for continued plant vigor (Marlow 1985; Clary and Webster 1989).

Where woody species (trees and shrubs) are part of the potential natural community of a riparian site, perhaps the most detrimental aspect of late season grazing is its possible impact on shrubs and trees (Cheney and others 1990; Buckhouse and Elmore 1993; Krueger 1996). Cattle preference for woody species often increases significantly in late summer and fall. This seems to be due in the first instance to greater palatability and higher protein content when compared with most surrounding herbaceous species (Kovalchik and Elmore 1992). Higher browse use may also reflect the fact that cows are spending more time in the riparian area and have already consumed significant portions of the available herbaceous forage. While observing that riparian meadows remained healthy under moderate fall use, Green and Kauffman (1995) noted woody growth and succession on gravel bars were adversely affected.

Based on extensive experience in Nevada, Swanson (1987) recommended shrub-lined streams should be grazed in the spring and early summer since they are adversely affected by heavy late summer, fall, or winter grazing. Myers (1989), who considered the condition of woody plant communities as a paramount criterion for a "successful" riparian grazing program, noted successful systems involved "significantly less" late season grazing than unsuccessful systems (an average of 21 days versus 36.5 days) and less frequent grazing late in the year (31 percent of the years as opposed to 51 percent). One of the criticisms of many three pasture rest rotation systems is that the fall grazing period, even though only occurring every three years, may remove two to three years of willow growth, thus setting back succession or maintenance of willow communities (Buckhouse and Elmore 1993).

Kovalchik and Elmore (1992) suggested willow use generally will remain low as long as palatable herbaceous forage is available, and they tentatively identified herbage utilization levels which trigger greater browse use. For initial planning, they recommended ending mid- and late season grazing before herbaceous forage use in the riparian area exceeds 45 percent. There is some evidence, however, that in certain circumstances livestock may prefer woody browse over herbaceous material even before some threshold of herbage utilization is reached (Personal observations). In one of the short duration operations we observed, for example, cattle made frequent use of *Acer negundo* (box elder) saplings and seedlings the first day they went into the pasture and when palatable herbaceous forage was present.

Green suggested herbaceous utilization levels on riparian meadows "were an inadequate indication of willow recovery" (cited in Elmore and Kauffman 1994). For this reason, managers must monitor woody browse use rather than relying on traditional herbaceous utilization when healthy woody communities are a management objective (Hansen 1993).

In many cases, the reduction of shrubs in riparian zones results primarily from browsing of new, young plants rather than mechanical damage to older plants (Clary and Webster 1989). Kovalchik and Elmore (1992) observed first year seedlings are "very sensitive to grazing" and may easily be destroyed by browsing, trampling, or being uprooted. If woody regeneration is an objective, several years of non-use may be necessary to allow new plants to become established (Munther 1982; Skovlin 1984; Personal observations).

As with each of the other possible seasons of use, however, with proper management late season grazing need not be detrimental to the health of riparian zones. Manoukian (1994), evaluating 28 years of cattle grazing in the Centennial Valley of southwest Montana, determined that a four-pasture rest rotation strategy which included late season use had not reduced tall willow growth or development. Riparian areas in a BLM three-pasture rest rotation system on Blucher Creek in southern Wyoming was grazed late every third year and had all age classes of willows, good plant vigor, and predominantly stable streambanks (Kinch 1989).

***Study reaches.***

Many of the ranchers we worked with grazed their riparian areas at least sometimes during the late season. Ten stream reaches were used only in the fall. Interestingly, all ten of these riparian areas were primarily woody habitat or community types, and in all but one cattle remained in the pasture more than 30 days. Nevertheless, each of the reaches rated in healthy condition. Seven of the ten (including those with the longest grazing times) contained alternate water; one operator deliberately grazed his pastures very hard and then provided two full years of rest; and two operators herded livestock regularly. Five operators grazed the target pasture both early and late in the same year. Only one of these did so for up to 45 days in the fall; the other four remained no more than 14 days. Again, ten reaches were part of short duration strategies which included late season use for no more than eight days in any year.

Of the 19 ranch operations that included late use from between 9 and 21 days during a grazing season, none grazed the target pasture in the fall two years in a row; many provided more rest than that. Although rotation systems by themselves (particularly conventional three-pasture rest rotation) generally appear not to be "the solution" to riparian grazing requirements, alternating or at least not using a pasture the same time each year may alleviate the potential drawbacks to both late and early season grazing strategies.

## Hot Season (Mid-summer) Grazing.

Next to season-long grazing, which is universally recognized as detrimental to riparian areas, repeated or extended grazing during the hot summer season is generally considered most injurious to riparian zones. However, under certain conditions, pastures with riparian areas can be grazed during the summer without harming the riparian area. The following situations are most likely to prevent deterioration of riparian zones during this period: (1) when the operator closely monitors conditions in the riparian area specifically and the period of grazing is limited in duration and frequency (Clary and Webster 1989); (2) when effective management actions have been taken to encourage livestock to move out of the riparian zone; (3) when time of removal and climatic conditions provide opportunity for regrowth or cattle are not put into the pasture on an annual basis (Swanson 1987).

***Possible disadvantages.***

Although there are some advantages to grazing during the hot period of the summer (see below), the possibilities of adversely affecting riparian areas is very high. These result from disadvantages of grazing during this period, including: (1) the greater tendency of livestock to remain in the riparian area and accompanying stream channel; (2) reduced plant vigor and possible changes in vegetation communities from the more intense use that results; (3) possible damage to tree and shrub species that play vital roles in maintaining riparian zone health.

Drying out of upland herbaceous vegetation and high temperatures in the uplands combine to push livestock into the riparian area during the summer. Along an ephemeral stream in northcentral Wyoming, cattle were found in the channel during the summer grazing period at a rate more than twice that at which they were sighted there during the spring (Siekert and others 1985). Once there, they tend to overgraze herbaceous plants even when the nutritional value they receive declines (Gillen and others 1985). Compounding the effect of this tendency is the increased vulnerability of the plant communities.

The hot season is the "period of greatest stress in the plant community" because there is less time for vegetative regrowth and for the replenishment of carbohydrate reserves necessary to maintain the plants during their dormant cycle (Kinch 1989). If grazing extends beyond the growing season, there will be no regrowth. Repeated grazing during this period (that is, every year) reduces the vigor of individual plants and, over time, will result in a shift in the plant communities from desirable to less desirable species. Often the latter are less capable of performing the functions required for a healthy riparian ecosystem as well as being less economically productive (Hansen and others 1995). Palatable shrubs such as willows are also particularly vulnerable before they complete carbohydrate storage processes (Kindschy, cited in Kinch 1989).

As palatability of herbaceous forage declines through the summer, livestock are increasingly likely to shift to browse species, often with detrimental effects. According to Kovalchik and Elmore (1992), "Unless grazing systems allow for sufficient [herbaceous] forage height growth during the mid- to late-summer period, they will fail to maintain willow-dominated plant communities."

In a four-year study in northeast Montana, *Populus deltoides* (Great Plains cottonwood) seedlings sprouted readily, but were all eaten or trampled within two weeks of the introduction of cattle during both summer and fall grazing periods (Gjersing 1981). Following a ten year study in Oregon, Green and Kauffman (1995) concluded, "Livestock browsing had significant [negative] affects on the density and height of woody species on gravel bar communities." Their study sites contained several tree and shrub species common to Montana, including *Populus trichocarpa* (black cottonwood), *Salix bebbiana* (Bebb willow), *Salix exigua* (sandbar willow), and *Alnus incana* (mountain alder).

In the course of our study, we observed summer use pastures with poor condition woody communities as a result of livestock use. Even in the sites we inventoried there was evidence that cattle were browsing young willow and cottonwood plants during this period, sometimes in wet meadows which still had herbaceous forage. Knopf and Cannon (1982) noted that, in addition to degradation due to browsing, livestock also damage woody plants during this period by rubbing against them and by breaking them as they seek other forage (cited in Kovalchik and Elmore 1992).

Myers (1989) concluded that one significant difference between unsuccessful and successful grazing programs in southwest Montana was that the former had almost three times the amount of hot season use as the latter. This relationship was seconded by the experience of the Snowline Grazing Association, also in southwest Montana, where the difference in functioning condition between two adjacent, similar reaches was determined to be twice as much hot season use in the degraded reach as in that evaluated as properly functioning (Landgraf, pers. com. 1995).

***Potential advantages.***

Despite these problems, there are some advantages to allowing cattle to graze in riparian areas during this season, *provided managers maintain close control and monitoring* (Clary and Webster 1989). Swanson (1987) noted that while streambanks are more stable in summer than earlier in the year, there frequently is sufficient soil moisture to allow for regrowth. From a livestock production standpoint, herbaceous forage in the riparian area may be considerably more palatable and nutritious than desiccated upland plant material. To avoid impacting plant vigor, Swanson recommended short grazing periods rotated between years. Bohn and Buckhouse (1985) showed that, over a five year period, grazing in September demonstrated "a positive hydrologic response, whereas late-season grazing in October was negative— probably due to the onset of fall rains and a change in soil moisture conditions."

***Study reaches.***

Five ranchers grazed the inventoried pasture only during the hot season. One did so only 10 to 20 days at different times each year; another grazed heavily each August and followed this with two years of complete rest; and a third grazed a mountain riparian zone every other summer with alternate water and shade available. The other two operators grazed their pasture every summer. One had taken other steps to induce cattle not to camp in the riparian area. Of the ten ranchers (operating in 19 reaches) who grazed at various times between April and December, including the hot period from mid-July to mid-September, none grazed the study pasture every summer. In addition, 15 of the 19 pastures contained alternate water, and most had shade available away from the riparian area.

Hot season use can be less detrimental when there is both alternate water and upland shade. Along Greyson Creek south of Townsend cattle were in the study pasture the third week of August, but had done little browsing on riparian willows and had not appreciably impacted either herbaceous vegetation or streambanks. This pasture contained wooded uplands and alternate water, and the operator distributed salt along ridgetops well away from the bottoms. Conversely, several pastures we inventoried but rated as not functioning at potential were summer use pastures in drier, eastern Montana with only limited woody shade and that generally confined to riparian zones with intermittent streams. In several of these operations, recent introduction of additional water tanks, and in one case a change in pasture arrangement, may result in improved conditions. When they were inventoried, however, insufficient time had elapsed to determine this.

The need to monitor conditions especially closely during this period was illustrated by two operations in this study. Both had been in excellent functioning condition when inventoried (one in 1994, the other in 1995). When we had the opportunity to look at them again in 1996, both clearly showed heavy use in the riparian area due to circumstances to which the operator did not respond quickly enough or which were the result of climatic conditions affecting other portions of the ranch. Fortunately, livestock were removed in 1996 while an opportunity for regrowth remained. Because the reaches had been in high functioning condition, they should recover. Still, the visual differences between years were great, and several consecutive years of such treatment would result in detrimental long-term impacts.

### Winter Use.

Winter use may be the least detrimental to riparian area health and may, in fact, "benefit both range and riparian conditions by improving livestock distribution and plant response" (Masters and others 1996). It can be an especially useful management approach: (1) where soil type makes compaction and susceptibility to streambank trampling and deterioration during other seasons a high probability; (2) when the pasture is large enough to supplemental feed cattle well away from the stream; and (3) when drainages are colder than surrounding uplands or open south-facing slopes reduce use of the riparian area.

***Potential advantages.***

The advantages of winter use are obvious. Soil compaction should be minimal, and bank trampling should be limited because of frozen ground (Severson and Bolt 1978; Buckhouse and Skovlin 1979). Utilization of herbaceous species is not detrimental to plants because no growing parts are exposed at this time of year. In addition, this period may be the easiest in which to control livestock distribution through location of watering facilities and feeding stations. Eleven operators in this study limited their use of the inventoried polygons to winter only, ranging from 30-45 days up to 120-200 days.

***Possible disadvantages.***

There are potential drawbacks to winter grazing operations. In the first place, grazing of dead standing material can reduce streambank protection capabilities and reduce sediment entrapment in the spring (Kinch 1989; Kovalchik and Elmore 1992). Depending on the species and their locations, browsing of shrubs and small trees remains a problem. For example, while sedge communities in flat, broad valleys in Montana increased under a winter grazing regime, shrubs continued to be overused (Myers, pers. com. cited in Elmore and

Kauffman 1994). Even if there is little browsing, livestock can do significant physical damage to trees and shrubs by trampling and rubbing. Discussions with several ranchers and personal observations suggest bulls are especially likely to cause such damage.

Woody draws and other woody riparian communities provide valuable protection to livestock during extreme weather conditions, but repeated concentration of animals in these areas can result in deterioration of the woody community. This condition will be evidenced by a lack of regeneration and a predominance of dead and decadent mature plants. Moreover, if livestock are still present when spring thaw occurs, there is likely to be serious soil compaction, bank trampling, and erosion as well as physical damage to emerging herbaceous plants.

Significant damage, or at least changes, may occur during the winter as a result of natural causes, such as ice flows and jams, anchor ice, and high water. Buckhouse and Skovlin (1979) noted that overwintering periods (during which no grazing occurred) along a streamside meadow in the Blue Mountains tended to be more erosive than any of their summer grazing treatments (rest rotation, deferred rotation, season-long) for both grazed and ungrazed areas. In his extensive review article, Skovlin (1984) referred to several researchers in various states as agreeing that, frequently, whatever trends might be apparent after summer grazing in different systems at moderate stocking levels "are erased by natural events such as peak flows and river ice conditions over winter." Additionally, the effects of soil compaction and the amount of pugging (trampling) which occurs during the spring and summer may be ameliorated over winter by the alternation of freeze-thaw and wet-dry periods (Federer and others 1961, cited in Skovlin 1984).

Season of use, then, is an important element to successfully grazing pastures with riparian areas. Selecting a feasible season, however, does not constitute a complete approach since the time livestock spend in the riparian area itself must also be considered. Clary and Webster (1989) concluded, "**The level of utilization occurring on a site—including riparian areas—is the most important consideration**" (bold in original). After reviewing 18 studies, Van Poollen and Lacey (1979) stressed riparian vegetation is more affected by grazing intensity than by grazing system. On the other hand, Krueger (1996) argued, "Intensity of use or stocking intensity is far less important than season of use, within reasonable limits of intensity."

Regardless of the relative importance of season and intensity per se, the more time cattle spend in the riparian area itself, the greater the potential for damage. Therefore, managers must look for ways to manage the amount of time cattle spend in the riparian area.

*Figure 2. Water tank above Elk Creek in the foothills of the Adel Mountains, Cascade County, Montana.*

## Reducing Intensity of Use by Influencing Distribution

Finding ways to influence the amount of time livestock spend in the riparian area is an essential component of proper riparian management. Selecting the appropriate season of use is one basic, and often relatively easy, strategy which can contribute to this objective. There are other techniques to encourage livestock to move out of the riparian area "by making the uplands more attractive to the grazing animal" (Krueger 1996). Of these, the single most important may be the development of off-stream (alternate) water.

### Off-stream water.

Clawson (1993) found that installation of a water trough in an Oregon mountain meadow pasture reduced use of the stream from 4.7 to 0.9 minutes per cow per day, while use of a spring in the same pasture dropped from 8.3 to 3.9 minutes per cow per day. Cattle watered out of the trough 73.5 percent of the time, compared to only 3 percent from the stream and 23.5 percent from the spring. During a winter feeding operation in Oregon, the presence of a water trough 100 yards from the riparian area reduced the time cattle spent at the stream by 90 percent (Miner and others 1992).

Wyoming rancher Jack Turnell, often cited for his outstanding stewardship, declared that water developments are "the key" to successful grazing management (1993). Demonstrating that no one approach works everywhere, however,

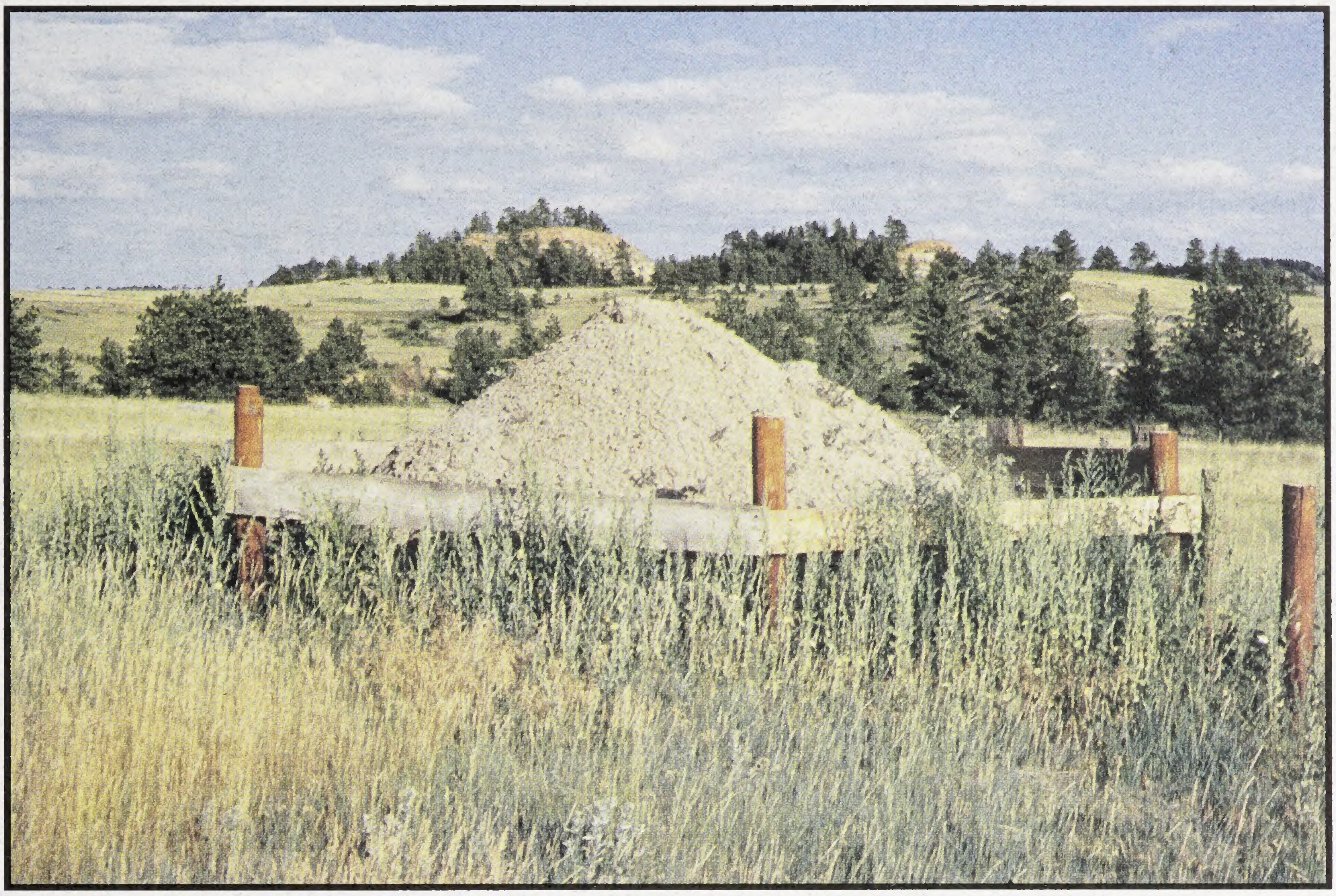

*Figure 3. Insulated water tank, Custer County, Montana.*

Bryant (1979) determined that neither alternate water nor mineral placement influenced distribution significantly in another Oregon mountain meadow. The appeal of alternate water sources includes water quality, temperature, and better footing (when excess water is piped away from the trough).

Developing water away from the riparian area may include running pipelines from the stream, fencing out and developing seeps and springs with pipes leading to troughs, and installing windmills. Technological improvements have significantly reduced the cost of such developments. For example, a hard, synthetic pipe is now available which can be laid on top of the ground rather than having to be entrenched and covered (Burleson, pers. com. 1995). This reduces the expense of installation and provides some flexibility in moving tanks to meet management objectives and local conditions.

The Snowline Grazing Association in Beaverhead County (southwest Montana) has placed several troughs fed by over-ground pipes with good success (Robinson, pers. com. 1996). Harding Land and Livestock Company east of Miles City has dug water tanks (fed by pipelines) into hillsides and covered each with a mound of dirt for insulation (Figure 3). These remain unfrozen and available to livestock at temperatures down to -40 degrees F (Currie, pers. com. 1994).

Hydraulic ram pumps, portable solar-powered pumps, and animal-activated (by nose) pumps are currently being used not only in Montana but in other states and Canada (Robinson pers. com. 1996; Ducks Unlimited n.d.).

*Figure 4. Gravel approachway on Ben Hart Creek, Gallatin County, Montana.*

Except for those using short grazing periods or engaged in winter only operations, 70 percent of the ranchers with whom we worked have developed one or more off-site water sources in the inventoried pastures. The significance of this action was especially noticeable in those areas where hilly topography or upland conditions would tend naturally to push and keep livestock in the riparian area. While the majority of winter operations did not include off-site water, one-third of them did. In addition, most winter use operators took care to feed away from the riparian area. One rancher succinctly stated, "We never feed anywhere near a shrub that we want to live."

### Stable access points.

A variation of off-stream water development is to encourage livestock use of only a small part of the stream. Providing stable access points to water can significantly reduce streambank trampling. There is evidence livestock prefer stable footing and clean water and will travel a considerable distance to reach them (Kellogg, pers. com. 1995). Large-gravel approachways laid down perpendicular to Ben Hart Creek north of Belgrade in a sedge-dominated meadow resulted in a marked improvement in stability of streambanks which previously had suffered considerable bank deterioration (Figure 4).

The installation of concrete walkways, with incised troughs to maintain water flow, on Big Warm Creek in Phillips County south of Malta provided livestock with easy access to water and a means to cross the stream without trampling the

*Figure 5. Protected stream crossing, Beaverhead County, Montana.*

banks. It had the additional benefit of reducing what had been the loss of about a cow each year to mud and ice breakthroughs to none since their installation about eight years ago. Rock dams along Larb Creek in Valley County have contributed to streambank stability and revegetation by concentrating livestock access. Such in-stream structures, however, can affect a stream's hydrology and must be carefully planned and installed.

Streams with a large percentage of bank rock greater than gravel-size have an inherent stability which makes such devices less necessary. Since the majority of operations in central and eastern Montana lack this characteristic, stable access points merit serious consideration. Proven designs are now available which reduce the impact of concentrating livestock at a few locations; these include "side bars" of logs or rock and web matting as well as gravel approachways (Figure 5).

## Salt and mineral block placement.

Although unlikely by itself to affect animal distribution significantly, placement of salt and mineral blocks can contribute to better distribution as well as improved forage utilization. Kinch (1989) recommended salt and supplements be placed a minimum of a quarter-mile from a stream and preferably at least a half-mile. In conjunction with other steps such as alternate water, this can be effective. None of the ranchers with whom we worked salted in the immediate vicinity of the stream. Twelve of them specifically commented on salt and mineral placement as a deliberate part of their management strategy.

*Figure 6. Improving riparian vegetation resulting from chiseling of upland western wheatgrass pastures, Prairie County, Montana.*

## Improved upland forage.

Another approach to luring livestock out of the riparian area is to improve upland forage (Storch 1979; Kinch 1989; Krueger 1996). Again, "It is important to recognize that uplands must not be excluded from consideration of riparian areas, because they are an integral part of the system" (Elmore 1990). Several activities we observed in the field underscored the value of considering riparian zones within the context of an overall management plan. By disking and planting introduced species, including *Medicago sativa* (alfalfa) and *Agropyron cristatum* (crested wheatgrass) in his uplands, a rancher along the North Fork of Snow Creek north of Brusett not only increased forage production almost 100 percent, but also enticed stock out of the vulnerable streamside areas. The palatability of this succulent early season vegetation also allowed native species several additional weeks of unimpeded growth.

In Prairie (Figure 6), Custer, Phillips, and McCone counties, chiselling of upland areas resulted in significant increases in *Agropyron smithii* (western wheatgrass) production. This, in turn, pulled livestock out of the adjacent bottoms in the early spring when streambanks and adjacent meadows are most vulnerable to trampling and compaction.

The vigorous upland vegetation communities which have resulted from a system which includes extended rest between grazing uses contribute to the exceptionally healthy woody draws found on a ranch in Wibaux County. Sagebrush reduction has also been used successfully to increase forage production on both private and public grazing lands.

## Riding.

Riding is increasingly being used as a method to move stock out of riparian areas, especially by large operations (Storch 1979). Many ranches and grazing associations routinely ride their herds to check on their animals. Thus, applied to riparian management, riding represents an expansion of a traditional activity rather than implementation of a new technique. The purpose of the riders in this case is to move the cows away from the streamside area. Such activity has been used with some success by the Upper Ruby Grazing Association along the Ruby River south of Sheridan, by the Snowline Grazing Association south of Lima, and by the Lane Ranch in the foothills of the Adele Mountains south of Cascade. The efficiency of this technique is enhanced by the presence of alternate water to reduce the incentive to return to streamside immediately.

The experience of these operations indicates that ensuring the riders know what is expected and the reasons behind such actions is critical to success. Poorly conducted riding can cause more harm to the riparian system and to livestock performance than having the cows remain in the riparian area. Obviously, using riparian areas as gathering areas and collection points is exactly the opposite of riding to disperse cattle. Not unexpectedly, the results inevitably demonstrate this.

*Figure 7. Dead woody material placed across streamside trails to deflect cattle uphill, Beaverhead County, Montana.*

Related to the idea of providing incentives to encourage cows to distribute more widely throughout the pasture is the issue of **home ranges**. According to Roath and Krueger (1982), cattle have home ranges much like wild ungulates, and animals which remain near the riparian area pass this behavior pattern to their offspring. Several authors have suggested this could be one basis for culling decisions (May and Davis 1982; Kinch 1989). To our knowledge, the economic feasibility of such an approach has not been investigated, and it may not be feasible on a large scale. However, it may be worth considering for animals that are especially prone to such behavior or in situations where a riparian ecosystem is particularly important for its ecological role or because of human values.

### Drift fences.

In hilly topography or incised channels, livestock are likely to use the riparian area and the streambed itself as a corridor and routinely meander up and down. Drift fences or other obstacles which deflect movement out of and away from this corridor can greatly reduce pressure on the riparian area and streambanks (Figure 7).

### Turn-in location

A common sight in pastures on private and public land alike is the location of gates near, if not immediately adjacent to, a riparian area. Often, particularly in the case of hilly terrain, this reflects the fact that the riparian and stream corridor is the easiest point of access since the lay of the land makes it a funnel for movement uphill and down. In a study in the Blue Mountains of Oregon, Gillen and others (1985) observed that the turn-in location can delay up to two weeks the arrival of cattle to the riparian area. In an allotment in the Sula Ranger District south of Darby, moving the cattle directly to grassy, open hilltops above the narrow riparian bottoms combined with the development of water in these uplands significantly improved distribution (McClure, pers. com. 1994). Similarly, the Snowline Grazing Association has relocated a gate into one of their pastures. Although it is too early to determine the long-term effect of this step, it appears to be improving distribution and easing the pressure on the riparian area (Robinson, pers. com. 1996).

Along several study reaches in central and eastern Montana we observed that *Bromus inermis* (smooth brome) not only provided excellent soil stability, but also acted as a barrier to livestock when these pastures were grazed in late fall and winter. The coarseness of the plant reduces its palatability and enhances its capacity as a physical barrier. This is particularly the case when there are "designated" access points to the stream or, better, alternate water sources are available.

### Riparian pastures.

A major tool to control the time livestock spend in riparian areas (and thus reduce the intensity of use) is the establishment of riparian pastures (Kauffman and others 1983; Swanson 1987; Elmore 1990). These can be defined as "a small pasture within an allotment that is set aside to be managed independently to achieve a specific vegetative response." (Platts and Nelson 1985b). In three tributaries on USDA Forest Service allotments in Idaho, utilization of forage was ***less*** in the riparian area than in the upland portion of specifically designed riparian pastures. Researchers

*Figure 8. Riparian pasture along Smith Creek has resulted in increased vegetation and improved streambanks, Gallatin County, Montana.*

attributed this to the ratio of upland to riparian forage, the fact that the entire pasture was in the livestock's home range, and the placement of salt away from the stream (Platts and Nelson 1985b).

The purpose of riparian pastures is not to fence out the riparian areas, but to provide for closer management and control of their use (Figure 8). Such pastures should include not just narrow riparian strips but upland areas with sufficient forage so that cattle will not be forced into the riparian area for feed (Kinch 1989). Skovlin (1984) suggested a minimum size of 30-40 acres for mountain riparian pastures. Use patterns may have to be different from upland pastures because the riparian pastures may have to be grazed at different times of the year or for different lengths of time. Given the productive nature of many riparian areas, it may be possible to graze these pastures more frequently although not for so long a period of time at any one use (Myers 1989). Our experiences in this study with short duration grazing operations, however, suggest this must be evaluated on a case-by-case basis.

### Smaller pastures.

Another variation of this approach is to establish smaller pastures with some riparian area in each rather than having only a few large pastures with a limited amount of riparian area (Elmore 1990). Smaller pastures can result in better distribution and forage utilization throughout each pasture due to the resulting higher stocking density (Marlow and others 1991). Along Birch Creek northwest

*Figure 9. Use of temporary electric fences to create smaller pastures has resulted in significant increase in vegetation along Birch Creek, Pondera County, Montana.*

of Valier (Figure 9), the creation of smaller pastures using easily portable electric fence and short duration grazing has contributed to a significant increase in young age classes (seedling and sapling) of *Populus angustifolia* (narrowleaf cottonwood), *Salix lutea* (yellow willow), and *Salix exigua* (sandbar willow). More pastures allow for greater control over the amount of time spent in any one riparian zone since livestock can be moved more frequently when use in each has reached the desired limit. Because of the higher stocking density, it is imperative to monitor herbaceous utilization, browse levels, and streambank conditions closely.

## Fencing.

Exclusion of livestock through fencing is a riparian management technique that works. In some instances, permanent—or at least long-term—exclusion may be the easiest, most convenient, and most economical option to restore riparian areas. In a few situations, it may be the only ecologically feasible method. It is not, however, the optimum approach in most cases. None of the operations we studied in this project involved total exclusion, yet the riparian areas in each were either functioning properly or recovering from a previously degraded condition.

There seems little doubt that "livestock exclusion [from riparian zones] has consistently resulted in the most dramatic and rapid rates of recovery" (Elmore and Kauffman 1994). Fencing out reservoirs and running pipes to outside troughs provided clean, cool water for livestock while simultaneously providing excellent habitat for waterfowl and other wildlife on the Diamond Willow Ranch south of Malta. Use of water gaps can provide access to water along reaches which are temporarily or permanently fenced (Figure 10).

On the other hand, total exclusion may not be required to maintain riparian zones, including their stream channels, in properly functioning condition or to restore those that are not functioning as they should. Wayne Elmore and J. Boone Kauffman (1994), two of the most experienced practitioners and researchers in the field, recently concluded, "Livestock grazing can be present in some areas while streams are improving." Implementation of one or more of the other techniques discussed above—***accompanied by clear objectives and an adequate monitoring program***— may be sufficient for rehabilitation. While most of the sites we evaluated were being maintained in proper functioning condition, at least six were clearly improving due to management changes (four with shortening of the grazing period, one by adding an alternate water source, and one by converting to winter use instead of season long).

Temporary fencing to allow for the restoration of riparian systems which are not functioning properly may be necessary or at least may be the quickest method for reestablishing healthy and productive riparian areas (Platts and Wagstaff 1984). In four operations in this study in which at least two full years of rest had been provided within the five or six years prior to being inventoried, this rest was reflected in the amount of young shrubs and trees. Restoration of degraded woody plant communities is especially likely to require either com-

*Figure 10. Water gap beside the Little Blackfoot River, Powell County, Montana.*

plete rest for several years or, at the least, limited early season use only (Platts and Raleigh 1984; Clary and Webster 1989; Personal observations).

How much time is required to rehabilitate a degraded riparian ecosystem to functioning condition is a matter of some debate (See Skovlin [1984] and Platts and Raleigh [1984] for excellent summaries of this dialogue). Not unexpectedly, the answer must be site-specific and consider such factors as current physical and hydrologic conditions, existing plant communities, potential and desired plant communities, topography, hydrology, and climate. At any rate, technical improvements in electric fencing and solar-powered batteries make temporary fencing more feasible than in the past.

Whether by total rest or by improved management techniques, restoration of degraded riparian ecosystems is rarely immediate. Vegetation will often respond within a few years. If the soil and hydrologic characteristics are severely degraded, however, restoration to properly functioning condition may take an extended period (Platts and Raleigh 1984; Hubert and others 1986).

Canadian Lorne Fitch, co-author of a recent riparian grazing publication (Adams and Fitch 1996), has suggested exclosure fencing is an admission that we can't out-think a cow (pers. com. 1995). This homily, humorous on the surface, bears a fundamental truth: to out-think a cow requires that we *do* think, as well as implement, monitor, and respond to developments (Figure 11). The days when streamside zones could be written off as "sacrifice areas" are past. Successful management of cattle in riparian areas requires active management both in planning and in on-the-ground activities. As the operations in this study demonstrate, however, the rewards for this effort include both ecologically healthier ecosystems and economically more productive livestock operations.

## Conclusions

For people who seek simple answers to complex issues or problems, the conclusions of this report will be disappointing. There is no single—let alone simple—solution on how to graze livestock in riparian areas in ecologically and economically feasible ways. Nor are there boiler-plate solutions that can be easily hammered into a shape to meet any situation (Myers 1989). What is required is not a catch-all remedy, but a carefully considered prescription drawn up to address the conditions at a specific site with its unique circumstances and desired objectives (Anderson 1993; Buckhouse and Elmore 1993). This approach, referred to as **prescription grazing**, is well-summarized by Dr. William Krueger (1996, emphasis in original): *"By understanding the nuances of specific watersheds, in specific settings, during specific weather patterns, with specific livestock or big game herds, and involving specific people, a program with a high degree of potential for success can be developed."*

There are numerous techniques available for developing and implementing an appropriate prescription for any given riparian ecosystem. The only *required* ingredients are a serious commitment and personal involvement on the part of operators and managers. The one theme which pervades both the riparian grazing literature and the operations studied in our project is that ***the manager is more important than a particular approach.***

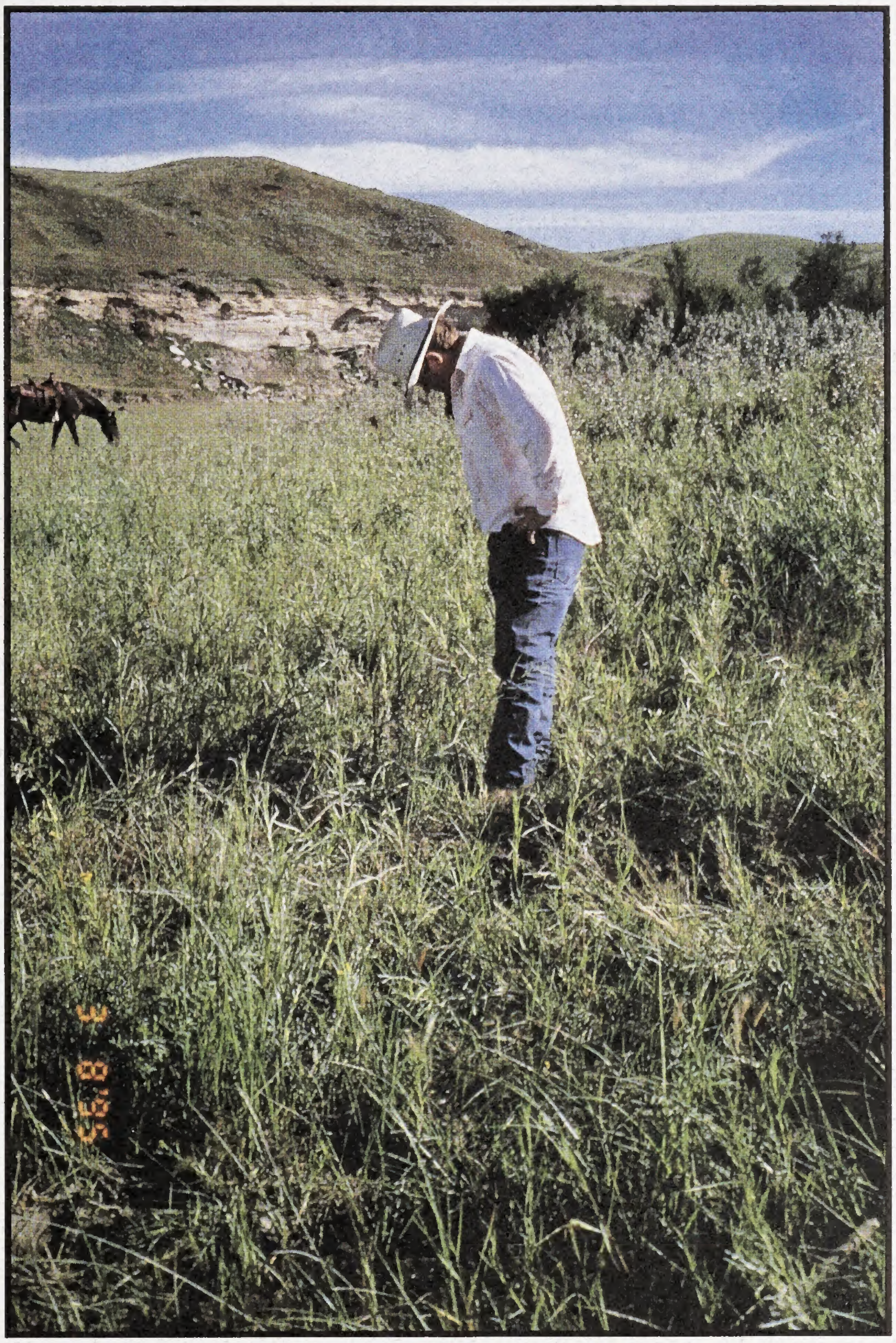

*Figure 11. Successful riparian grazing requires on-the-ground monitoring and timely response to developing situations.*

# Suggested Reading

In the past fifteen years, a considerable body of literature has evolved dealing with various aspects of livestock grazing in riparian areas throughout the western United States. To assist in finding these materials, several useful bibliographies are now available. Particularly extensive, although somewhat dated (which is an indication of how rapidly the field is developing), is *A Bibliography of Riparian Research and Management* (1992) by John Van Deventer and the Idaho Riparian Cooperative. Oregon State University Extension Service has recently published a more current compilation available on computer disk: *Livestock Influences on Riparian Zones and Fish Habitat: A Bibliography* (Larsen and others 1997).

This section makes no attempt to duplicate the works mentioned above. Its purpose is to identify for interested readers, both agency people and livestock operators, some of the most useful and available publications and to provide some insight into the strengths of each. The focus is on management considerations important to those who deal with riparian grazing on a regular basis in the field. Emphasis is on overview materials rather than specific studies or individual grazing strategies. Publication details are contained in the literature cited portion of this report.

The most recent, and the best, "How To" publication intended primarily for private ranch operators is *Caring for the Green Zone: Riparian Areas and Grazing Management* (1996) by Canadians Barry Adams and Lorne Fitch. Public land managers will also find it extremely helpful. Effectively using photographs and diagrams, the authors present information on riparian structure and function, the ingredients of a successful grazing management program, and techniques by which these might be applied to a piece of ground. This glossy 36-page pamphlet is "must reading" for those who wish to prepare and implement a riparian grazing strategy.

Jon Skovlin's 1984 article, "Impacts of Grazing on Wetlands and Riparian Habitat: A Review of Our Knowledge," contains a wealth of information on the impact of livestock grazing on riparian and wetland ecosystems. Scholarly in tone and presentation, it is an excellent starting point for understanding the impact of livestock on all aspects of riparian and wetland ecosystems, including vegetation, soil erosion and stability, water quality, and fish and wildlife habitat and populations. Skovlin also briefly summarizes cattle behavior as it affects their activities in riparian areas and the reasons for high use of these areas by domestic grazing animals. Although information on management practices is limited, it does have an exceptional bibliography for those interested in more detailed articles on the many issues the author addresses.

Contained in the same book (*Developing Rangeland Strategies*) is a commentary by William Platts and Robert Raleigh (1984) which expands on Skovlin's points. They particularly stress the importance of understanding the geomorphologic and hydrologic aspects of individual sites and emphasize the extended time periods which might be needed for full restoration of degraded reaches.

Platts and Raleigh refer to their own extensive field experiences as well as to the literature.

Although shorter than Skovlin's, another essential overview of grazing effects is "Livestock Impacts on Riparian Ecosystems and Streamside Management Implications . . . A Review," by J. Boone Kauffman and William Krueger (1984). In a concise yet illuminating manner, the authors cover the importance of riparian areas to in-stream ecosystems, wildlife, and livestock. Having laid this background, they present tersely but comprehensively the available knowledge on the demonstrated effects of livestock on aquatic ecology, terrestrial wildlife, riparian vegetation, and soil and streambank stability. Again, given the date of publication, references to successful grazing strategies are limited. The literature cited section, however, is extensive. The ready availability of this article (*Journal of Range Management*, September 1984) enhances its value as a source for understanding the nature of riparian zones and their associated in-stream systems and the impact that domestic grazing can have.

The two major land management agencies have also produced publications with guidance for managing domestic grazing in riparian areas. The USDA Forest Service's technical report, *Managing Grazing of Riparian Areas in the Intermountain Region* (1989) by Warren Clary and Bert Webster, focuses on that region, but is applicable to many parts of the West. The authors pay particular attention to the stubble heights required to maintain riparian functions, with recommendations on appropriate stubble height to retain when grazing in different seasons. Densely packed appendices address the relative merits of focusing on grazing system, stocking rate, intensity of use, and season of use as guidelines for developing proper grazing strategies. An additional appendix includes A. H. Winward's guide to calculating ecological status and resource value ratings in riparian areas.

The USDI Bureau of Land Management's contribution, *Grazing Management in Riparian Areas* by Gene Kinch (1989), is a somewhat longer document. After stressing the importance of management objectives, Kinch reviews the major considerations in grazing management, including season of use, distribution of use, appropriate utilization levels, and timing, duration, and frequency of grazing based on both a review of the literature and examples from BLM experiences. He notes briefly specific management activities which can influence distribution of livestock within a pasture. A large portion of the document presents examples of successful grazing treatments on BLM allotments broken out by season of use or specific grazing system.

For a review of the negative impacts of livestock grazing on western rangelands, including riparian areas, written from the perspective of conservation biology, a solidly written article is Thomas Fleischner's "Ecological Costs of Livestock Grazing in Western North America" (1994).

One of the most recent comprehensive reviews of livestock grazing management for maintaining and restoring riparian functions is Wayne Elmore's and J. Boone Kauffman's "Riparian Watershed Systems: Degradation and Restoration" (1994), in the Society of Range Management's excellent *Ecological Implications* *of Herbivory in the West.* After touching on the historical situations which led to present conditions, the authors' emphasis is on management strategies and their probable impacts. An extra bonus is the inclusion of tables which summarize key articles by Platts (1989), Myers (1989), Kovalchik and Elmore (1992), and Buckhouse and Elmore (1991, reprint in 1993). Although not comprehensive, the literature cited section does contain the more current materials.

Bernard Kovalchik's and Wayne Elmore's "Effects of Cattle Grazing Systems on Willow-Dominated Plant Associations in Central Oregon" (1992) is one of the few studies which looks specifically at a variety of grazing strategies and willow species. The authors evaluate eleven common grazing systems and their impact on willow-dominated communities. While the study sites were in central Oregon, most of the plant communities are found in other locations as well.

One of the best short articles on the relationship between riparian vegetation and livestock grazing is "Managing Ungulates to Allow Recovery of Riparian Vegetation" (Krueger 1996). Stressing the need to develop grazing approaches based on site-specific vegetation responses, Krueger addresses briefly but effectively basic principles of animal behavior, forage palatability, plant responses to grazing, plant community responses, hydrology, and economic and social feasibility.

Lew Myers' 1989 paper on "Managing Livestock to Minimize Impacts on Riparian Areas" analyzes 34 grazing systems in operation in southwest Montana. Assessing riparian communities largely on the basis of their woody species components, Myers compared "successful" (properly functioning) and "unsuccessful" (not functioning properly) systems in terms of season of use, length of use, residual herbaceous material, stocking rates, duration of grazing in different seasons, and percentage of treatments with fall use.

The often negative impacts of livestock grazing on fisheries was one of the major reasons generating interest in grazing of riparian areas. William Platts, a leader in this effort, has authored or co-authored numerous articles on aspects of the topic. Perhaps the most comprehensive of these is his chapter entitled "Livestock Grazing" in *Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats* (1991). After a brief history of grazing in the western United States and the current condition of riparian areas, Platts reviews the importance of riparian vegetation in terms of fish habitat, streambank stability, stream temperature, and production of fish prey. The meat of the chapter focuses on the effects which must be considered on streambanks, water column, stream channel, and riparian vegetation when developing a grazing strategy. He then evaluates the compatibility of 17 livestock grazing strategies (including different kinds of animals) with fishery needs.

Given the current emphasis on "stability" of stream and riparian ecosystems, the study by Thomas Myers and Sherman Swanson, "Variation of Stream Stability with Stream Type and Livestock Bank Damage in Northern Nevada" (1992), is useful in pointing out the significance of different stream types when making decisions in such areas as setting local use standards, writing management objectives, or determining grazing strategies. Specifically, the authors relate the

Pfankuch (1975) stream stability rating procedure to Rosgen's stream type classification system (1996).

Although not dealing specifically with grazing of riparian areas, an excellent short discussion of the physical features of small streams useful to land managers and operators seeking to understand riparian and stream systems is "Morphological Features of Small Streams: Significance and Function" (1986) by Robert Beschta and William Platts. While focusing on physical characteristics, they are also good on stressing "the important role of riparian vegetation" in stream stabilization efforts.

The Environmental Protection Agency (EPA) has produced two eye-catching publications intended for the general public and private land managers and prepared by three key figures in research and management of riparian grazing: Ed Chaney, Wayne Elmore, and William Platts. The first, *Livestock Grazing on Western Riparian Areas* (1990), touches on the functions and values of western riparian zones, the causes and effects of degradation, and possible approaches to successful riparian grazing. The bulk of the pamphlet consists of case studies of riparian areas throughout the West which have been enhanced by management actions. A particular strength of the book is the photographs (especially the series of "before and after" comparisons) and diagrams which help to explain the points being made.

*Managing Change: Livestock Grazing in Western Riparian Areas* (1993) is a companion pamphlet aimed specifically toward "the men and women who move the stock." Its purpose is to get people to consider riparian areas from a variety of perspectives and to stimulate thinking about possible management improvements. Again, the use of "before and after" photographs as well as computer enhancements of site potential overlaid on photos of existing conditions are particularly useful in understanding the key points. Although brief, the discussion of considerations for developing a riparian grazing strategy will be helpful to many operators.

## Literature Cited


Adams, B., and L. Fitch. 1995. Caring for the green zone: riparian areas and grazing management. Alberta Riparian Habitat Management Project, Lethbridge, Alberta.

Anderson, E. William. 1993. Prescription grazing to enhance rangeland watersheds. Rangelands 15(1):31-34.

Anderson, E. William, and Richard J. Scherzinger. 1975. Improving quality of winter forage for elk by cattle grazing. Journal of Range Management 28(2):120-125.

Beschta, Robert L., and William S. Platts. 1986. Morphological features of small streams: Significance and function. Water Resources Bulletin 22(3):369-379.

Bock, Carl E., Victoria A. Saab, D. Rich Terrell, and David S. Dobkin. 1993. Effects of livestock grazing on neotropical migratory landbirds in western North America. *In:* Status and management of neotropical migratory birds. Edited by D.M. Finch and P.W. Stangel. USDA Forest Service General Technical Report RM-229. Rocky Mountain Forest and Range Experimental Station, Fort Collins, CO. pp. 296-309.

Bohn, C. C., and John C. Buckhouse. 1985. Some responses of riparian soils to grazing management in northeastern Oregon. Journal of Range Management 38(4):378-381.

Bryant, Larry D. 1979. Livestock response to riparian zone exclusion. M.S. Thesis, University of Idaho, Moscow, ID.

Bryant, Larry D. 1985. Livestock management in the riparian ecosystem. *In:* Riparian ecosystems and their management: Reconciling conflicting uses. R. Roy Johnson, Charles D. Ziebell, David R. Patton, Peter F. Ffolliott, and R. H. Hamre, Technical Coordinators. First North American Riparian Conference, April 16-18, Tucson, AZ. USDA Forest Service General Technical Report RM-120. Rocky Mountain Forest and Range Experimental Station, Fort Collins, CO. pp. 285-289.

Buckhouse, John C. 1995. Lessons learned concerning livestock in riparian zones and the associated uplands of rangeland watersheds. *In:* Eastern Oregon Agriculture Research Center Field Day annual report. Oregon Agricultural Experiment Station Special Report 951. Oregon State University, Corvallis, OR. pp. 34-39.

Buckhouse, John C., and Thomas Bunch. 1985. Riparian erosion inside and outside of exclosures on Mill and McKay Creeks: A validation of management. *In:* Eastern Oregon Agriculture Research Center Field Day annual report. Oregon Agricultural Experiment Station Special Report 951. Oregon State University, Corvallis, OR. pp. 29-30.

Buckhouse, John C., and Wayne Elmore. 1991 [reprint 1993]. Grazing practice relationships: Predicting riparian vegetation response from stream systems. *In:* Watershed management guide for the Interior Northwest. Edited by Thomas Bedell. Oregon State University Extension Service, Corvallis, OR. pp. 47-52.

Buckhouse, John C., and Jon M. Skovlin. 1979. Streambank erosion in a Blue Mountain stringer meadow in response to livestock and big game grazing management. *In:* Eastern Oregon Agriculture Research Center Field Day annual report. Oregon Agricultural Experiment Station, Special Report 549. Oregon State University, Corvallis, OR. pp. 2-4.

Burkhardt, Wayne. 1986. Unpublished notes from BLM monitoring committee meeting held in Washington, DC. Cited in Hayes, Art. 1992. An annotated bibliography on the utilization of grasses with emphasis on riparian areas. N.p.

Burleson, Wayne. 1995. Certified Range Consultant. Absarokee, MT. Personal conversation with authors.

Chaney, Ed, Wayne Elmore, and William S. Platts. 1990. Livestock grazing on western riparian areas. Northwest Resource Information Center, Inc., for U.S. Environmental Protection Agency. Eagle, ID.

Chaney, Ed, Wayne Elmore, and William S. Platts. 1993. Managing change: Livestock grazing on western riparian areas. Northwest Resource Information Center, Inc., for U.S. Environmental Protection Agency. Eagle, ID.

Clary, Warren P., and Gordon D. Booth. 1993. Early season utilization of mountain meadow riparian pastures. Journal of Range Management 46:493-497.

Clary, Warren P., and Bert F. Webster. 1989. Managing grazing of riparian areas in the Intermountain Region. USDA Forest Service General Technical Report INT-263. Intermountain Research Station, Ogden, UT.

Clary, Warren P., Christopher I. Thorton, and Steven R. Abt. 1996. Riparian stubble height and recovery of degraded streambanks. Rangelands 18(4):137-140.

Clawson, Jeff E. 1993. The use of off-stream water developments and various water gap configurations to modify the watering behavior of grazing cattle. M.S. Thesis, Oregon State University, Corvallis, OR.

Crouse, Michael R. 1987. New approaches to riparian area management on public lands. *In:* Wetland and riparian ecosystems of the American West: Proceedings of the Society of Wetland Scientists' eighth annual meeting. May 26-29, Seattle, WA. N.p. pp. 32-35.

Currie, Dan. 1994. Manager, Harding Land and Livestock Company, Ismay, MT. Personal conversation with authors.

Dale, Brenda C. 1984. Birds of grazed and ungrazed grasslands in Saskatchewan. Blue Jay 42(2):102-105.

Ducks Unlimited. n.d. Quality water for livestock [video]. Available from Society for Range Management, Denver, CO.

Elmore, Wayne. 1988. Stream processes and grazing strategies. Presentation at Riparian Management Workshop: Challenges and Opportunities. May 3. Elko, NV. Cited in Clary, Warren P., and Bert F. Webster. 1989. Managing grazing of riparian areas in the Intermountain Region. USDA Forest Service General Technical Report INT-263. Intermountain Research Station, Ogden, UT.

Elmore, Wayne. 1990. Riparian responses to grazing practices. *In:* Watershed management: Balancing sustainability and environmental change. Edited by Robert J. Naiman. Springer-Verlag, New York, NY. pp. 442-457.

Elmore, Wayne, and J. Boone Kauffman. 1994. Riparian and watershed systems: Degradation and restoration. *In:* Ecological implications of livestock herbivory in the West. Edited by Martin Vavra, William A. Laycock, and Rex D. Piper. Society for Range Management, Denver, CO. pp. 212-231.

Fleischner, Thomas L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology 8(3):629-644.

Frisina, Michael R., and Forest G. Morin. 1991. Grazing private and public land to improve the Fleecer Elk Winter Range. Rangelands 13(6):291-294.

Gillen, R. L., W. C. Krueger, and R. F. Miller. 1985. Cattle use of riparian meadows in the Blue Mountains of northeastern Oregon. Journal of Range Management 38(3):205-209.

Gjersing, Frank M. 1981. Effects of grazing on riparian zones in northcentral Montana. *In:* Management of riparian ecosystems. Proceedings of the Montana Chapter, Wildlife Society, February 3-5, Great Falls, MT. N.p. pp. 75-81.

Green, Douglas M. 1991. Soil conditions along a hydrologic gradient and successional dynamics in a grazed and ungrazed montaine riparian ecosystem. Ph.D. Diss. Oregon State University, Corvallis, OR. Cited in Elmore, Wayne, and J. Boone Kauffman. 1994. Riparian and watershed systems: Degradation and restoration. *In:* Ecological implications of livestock herbivory in the West. Edited by Martin Vavra, William A. Laycock, and Rex D. Piper. Society for Range Management, Denver, CO. pp. 212-231.

Green, Douglas M., and J. Boone Kauffman. 1995. Succession and livestock grazing in a northeastern Oregon riparian ecosystem. Journal of Range Management 48(4):307-313.

Hansen, Paul L. 1993. Developing a successful riparian-wetland grazing management plan for the Upper Ruby River cattle and horse allotment in southwestern Montana. *In:* Riparian management: Common threads and shared interests. Western Regional Conference on River Management Strategies, February 4-6, Albuquerque, NM. USDA Forest Service General Technical Report RM-226. Rocky Mountain Forest and Range Experiment Station, Ft Collins, CO. pp. 328-335.

Hansen, Paul L., Robert D. Pfister, Keith Boggs, Bradley J. Cook, John Joy, and Dan K. Hinckley. 1995. Classification and management of Montana's riparian and wetland sites. Montana Forest and Conservation Station, School of Forestry, The University of Montana, Missoula, MT.

Hays, Art. 1992. An annotated bibliography on the utilization of grasses with emphasis on riparian areas. N.p.

Holecheck, Jerry L., Raul Valdez, Sanford D. Schemnitz, Rex D. Pieper, and Charles A. Davis. 1982. Manipulation of grazing to improve or maintain wildlife habitat. Wildlife Society Bulletin 10(3):204-210.

Hubert, Wayne A., Robert P. Lanka, Thomas A. Wesche, and Fred Stabler. 1985. Grazing management influences on two brook trout streams in Wyoming. *In:* Riparian ecosystems and their management: Reconciling conflicting uses. R. Roy Johnson, Charles D. Ziebell, David R. Patton, Peter F. Ffolliott, and R. H. Hamre, Technical Coordinators. First North American Riparian Conference, April 16-18, Tucson, AZ. USDA Forest Service General Technical Report RM-120. Rocky Mountain Forest and Range Experiment Station, Ft Collins, CO. pp. 290-294.

Kantrud, Harold A., and Kenneth F. Higgins. 1992. Nest and nest site characteristics of some ground-nesting, non-passerine birds of northern grasslands. Prairie Naturalist 24(2):67-84.

Kauffman, J. Boone. 1982. Synecological effects of cattle grazing riparian ecosystems. M.S. Thesis, Oregon State University, Corvallis, OR.

Kauffman, J. Boone. 1995. An ecological basis for the management and recovery of riparian zones. *In:* Eastern Oregon Agriculture Research Center Field Day annual report. Oregon Agricultural Experiment Station Special Report 951. Oregon State University, Corvallis, OR. pp. 27-33.

Kauffman, J. Boone, and William C. Krueger. 1984. Livestock impacts on riparian ecosystem and streamside management implications—A review. Journal of Range Management 37(5):430-438.

Kauffman, J. Boone, William C. Krueger, and Martin Vavra. 1982. Impacts of a late season grazing scheme on nongame wildlife in Wallowa Mountain riparian ecosystems. *In:* Wildlife-livestock relationships symposium: Proceedings 10. University of Idaho Forest, Wildlife, and Range Experiment Station, Moscow, ID. pp. 208-218.

Kauffman, J. Boone, William C. Krueger, Martin Vavra. 1983. Effects of late season cattle grazing on riparian plant communities. Journal of Range Management 36(6):685-691.

Keller, Charles, Loren Anderson, and Paul Tappel. 1979. Fish habitat changes in Summit Creek, ID, after fencing the riparian area. *In:* Proceedings: Forum-on grazing and riparian/stream ecosystems. Trout Unlimited, Inc., Vienna, VA. pp. 46-52.

Kellogg, Warren. 1995. Water quality specialist, Natural Resources Conservation Service, Montana Department of Water Quality. Helena, MT. Personal conversation with authors.

Kinch, Gene. 1989. Riparian area management: Grazing management in riparian areas. USDI Bureau of Land Management Technical Report 1737-4. Denver, CO.

Knopf, Fritz L., and Richard W. Cannon. 1982. Structural resilience of willow riparian community to changes in grazing practices. *In:* Wildlife-livestock relationships symposium: Proceedings 10. University of Idaho Forest, Wildlife, and Range Experiment Station, Moscow, ID. pp. 198-207.

Kovalchik, Bernard L., and Wayne Elmore. 1992. Effects of cattle grazing systems on willow-dominated plant associations in central Oregon. *In:* Proceedings—Symposium on ecology and management of riparian shrub communities. Compiled by Warren P. Clary, E. Durant McArthur, Don Bedunah, and Carl L. Wambolt. May 29-31 1991, Sun Valley, ID. USDA Forest Service General Technical Report INT-289, Intermountain Research Station, Ogden, UT. pp. 111-119.

Krueger, W. C. 1996. Managing ungulates to allow recovery of riparian vegetation. *In:* W. D. Edge and S. L. Olson-Edge, Editors. Sustaining Rangeland Ecosystems Symposium. Oregon State University Special Report 953, Corvallis, OR. pp. 160-165.

Landgraf, Barb. 1995. Range Conservationist, Natural Resources Conservation Service, Dillon, MT. Personal conversation with authors.

Manoukian, Mark Edward. 1994. Evaluation of tall willows (*Salix* spp.) within a livestock grazing allotment in southwest Montana. M.S. Thesis, Montana State University, Bozeman, MT.

Marlow, Clayton B. 1985. Controlling riparian zone damage with little forage loss. Montana AgResearch 2(3):1-7. Montana State University, Bozeman, MT.

Marlow, Clayton B., and Thomas M. Pogacnik. 1986. Cattle feeding and resting patterns in a foothills riparian zone. Journal of Range Management 39(3):212-217.

Marlow, Clayton B., Douglas Allen, and Kathyrn Olson-Rutz. 1991. Making riparian zone protection a workable part of grazing management. *In:* Proceedings of the international beef symposium. January 15-17, Great Falls, MT. Animal Range Sciences Department, Montana State University, Bozeman, MT. pp. 256-266.

Masters, Linda, Sherman Swanson, and Wayne Burkhardt. 1996. Riparian grazing management that worked: I. Introduction and winter grazing. Rangelands 18(5):192-195.

May, Bruce, and Barry Davis. 1982. Practices for livestock grazing and aquatic habitat protection on western rangelands. *In:* Wildlife-livestock relationships symposium: Proceedings 10. University of Idaho Forest, Wildlife, and Range Experiment Station, Moscow, ID. pp. 271-278.

McClure, Thomas. 1994. Range Conservationist, Sula Ranger District, Bitterroot National Forest, Sula, MT. Personal conversation with authors.

Miner, J. Ronald, John C. Buckhouse, and James A. Moore. 1992. Will a water trough reduce the amount of time hay-fed livestock spend in the stream (and therefore improve water quality)? Rangelands 14(1):35-38.

Munther, Greg L. 1982. Beaver management in grazed riparian ecosystems. *In:* Wildlife-livestock relationships symposium: Proceedings 10. University of Idaho Forest, Wildlife, and Range Experiment Station, Moscow, ID. pp. 234-241.

Myers, Lewis H. 1989. Grazing and riparian management in southwestern Montana. *In:* Practical approaches to riparian resource management: An educational workshop. Edited by Robert E. Gresswell, Bruce A. Barton, and Jeffrey L. Kershner. May 8-11, Billings, MT. BLM-MT-PT-89-001-4351. Bureau of Land Management, Washington, DC. pp. 117-120.

Myers, Thomas J., and Sherman Swanson. 1992. Variation of stream stability with stream type and livestock bank damage in northeastern Nevada. Water Resources Bulletin 28(4):743-754.

Platts, William S., and Rodger L. Nelson. 1985a. Impacts of rest-rotation grazing on stream banks in forested watersheds in Idaho. North American Journal of Fisheries Management 5:547-556.

Platts, William S., and Rodger L. Nelson. 1985b. Will the riparian pasture build good streams? Rangelands 7(4):7-11.

Platts, William S., and Robert F. Raleigh. 1984. Impacts of grazing on wetlands and riparian habitat. *In:* Developing strategies for rangeland management. National Research Council/National Academy of Sciences. Westview Press, Boulder, CO. pp. 1105-1118.

Rickard, W. H., and C. E. Cushing. 1982. Recovery of streamside woody vegetation after exclusion of livestock grazing. Journal of Range Management 35(3):360-361.

Roath, Leonard Roy, and William C. Krueger. 1982. Cattle grazing influence on a mountain riparian zone. Journal of Range Management 35(1):100-103.

Robinson, Art. 1996. Manager, Snowline Grazing Association, Snowline, MT. Personal conversation with authors.

Severson, K. E., and Charles E. Boldt. 1978. Cattle, wildlife, and riparian habitats in the western Dakotas. *In:* Management and use of northern plains rangeland. Regional Rangeland Symposium, February 27-28, Bismarck, N.D. N.p. pp. 90-103.

Siekert, Ronald E., Q. D. Skinner, M.A. Smith, J. L. Dodd, and J. D. Rodgers. 1985. Channel response of an ephemeral stream in Wyoming to selected grazing treatments. *In:* Riparian ecosystems and their management: Reconciling conflicting uses. R. Roy Johnson, Charles D. Ziebell, David R. Patton, Peter F. Ffolliott, and R. H. Hamre, Technical Coordinators. First North American Riparian Conference, 16-18 April, Tucson, AZ. USDA Forest Service General Technical Report RM-120. Rocky Mountain Forest and Range Experiment Station, Ft Collins, CO. pp. 276-278.

Skovlin, Jon M. 1984. Impacts of grazing on wetlands and riparian habitat: A review of our knowledge. *In:* Developing strategies for rangeland management. National Research Council/National Academy of Sciences. Westview Press, Boulder, CO. pp. 1001-1103.

Storch, Robert L. 1979. Livestock/streamside management programs in eastern Oregon. *In:* Proceedings: Forum-on grazing and riparian/ stream ecosystems.Trout Unlimited, Inc., Vienna,VA. pp. 56-59.

Swanson, Sherman. 1986. Options for riparian grazing management. Nevada Cooperative Extension Fact Sheet 86-77. University of Nevada, Reno, NV.

Swanson, Sherman. 1987. Riparian pastures. Nevada Cooperative Extension Fact Sheet 87-53. University of Nevada, Reno, NV.

Thilenius, John F. 1979. Range management in the alpine zone: Practices and problems. *In:* Special Management needs of alpine ecosystems: A symposium sponsored by the Society for Range Management. Edited by Douglas A. Johnson. February 14, Casper, Wyoming. N.p. n.p.

Tohill, Al, and James Dollerschell 1990. "Livestock" the key to resource improvement on public lands. Rangelands 12(6):329-336.

Turnell, Jack. 1993. Presentation to Deer Lodge Conservation District, July 10. Deer Lodge, MT.

Van Deventer, John S. 1992. A bibliography of riparian research and management: Fish, wildlife, vegetation, and hydrologic responses to livestock grazing and other land use activities. Idaho Riparian Cooperative, University of Idaho, Moscow, ID.

Van Po'ollen, H. Walt, and John R. Lacey. 1979. Herbage response to grazing systems and stocking intensities. Journal of Range Management 32(4):250-253.

Vavra, Martin. 1984. Livestock production possibilities on streamside meadows. *In:* Range management short course. Oregon State University, Corvallis, OR. pp. 35-44.

# Appendix A.

## Delineating seasons of use.

Delineating seasons of use by such terminology as"early," middle," and "late" is an artificial construct which provides only general time frames. For this report, the categories we selected were: *Early*, *Middle*, *Late*, and *Winter*.

In general, *Early* season, or spring, encompasses the period from the end of supplemental feeding to seed ripe and includes the time during which soil moisture levels are likely to be high due to snow melt and spring rain. The *Middle* period includes the hotter part of the summer during which upland forage has dried, seed ripening has occurred, and soil moisture content in the riparian area has declined. *Late* season covers the period after seed set and, except for cool-season grasses benefiting from fall precipitation, the cessation of herbaceous plant growth outside portions of the riparian area (i.e., the uplands). *Winter* covers the period during which supplemental feeding usually occurs and soils are usually frozen.

Obviously, the exact dates which each of these periods encompasses depend on geography, topography, weather conditions, and range condition. In a state as large and geographically varied as Montana, key indicators such as plant phenology and soil moisture may vary considerably. Readers should rely on their knowledge of plant growth and soil moisture to decide whether the broad time frames listed below apply to their situation. For purposes of this report, the following time frames apply:

| | |
|---|---|
| **Early:** | *late April/early May to early/mid July* |
| **Middle:** | *early/mid July to mid/late September* |
| **Late:** | *mid/late September to late December/early January* |
| **Winter:** | *late December/early January to late April.* |

# Appendix B.

## Determining season of use.

Which season or seasons of use will be most appropriate for grazing a given riparian area will vary from site to site. Although it is possible to provide general guidelines on the conditions within which each season is most likely to be successful, operators must weigh both the negative and positive potential impacts and then must monitor the actual effects during and after the grazing period.

The following material summarizes the more detailed discussion found in the text under "Principles and Techniques for Grazing in Riparian Zones." Operators must remember, however, that simply selecting an appropriate season does not constitute a complete approach to riparian grazing. Since the more time cattle spend in the riparian area, the greater the potential for damage, managers must also look for ways to influence the amount of time cattle spend in the riparian area.

### Early Season (Spring) Grazing

***Early season use may be best for those situations in which:***

- Livestock can be attracted to the uplands by succulent, herbaceous forage;
- Cool temperatures may discourage cows from loitering in the bottoms, or weather in the uplands does not drive them into riparian areas;
- Soil in the riparian area may be wet enough to discourage cows from entering;
- Well-drained soils reduce the possibility of compaction.

***The possible advantages of early season grazing include:***

- Less streambank trampling and soil compaction if livestock spend most of their time in the uplands;
- Time for regrowth of riparian and possibly upland vegetation;
- Less pressure on woody species in the riparian area.

***Possible drawbacks to early season grazing in riparian areas include:***

- High potential impact in terms of soil compaction, bank trampling, and subsequent erosion because of high soil moisture levels;
- Repeated grazing during this period may affect plant vigor and lead to changes in plant communities because utilization occurs during the critical period of plant development;
- Nutritional value of upland forage may be low and may require supplemental feeding;
- Early season grazing may adversely affect wildlife in the area.

### Late Season (Fall) Grazing

***Deferring grazing until fall may offer distinct benefits to maintaining the health of a riparian area under the following conditions:***

- When riparian plant communities consist of herbaceous rather than tree or shrub species;

- When cool season grasses stimulated by timely precipitation provide palatable forage in the uplands;
- Where offstream water near forage sources is available, or other conditions (for example, cold air pockets streamside or the absence of hot upland temperatures) draw cattle out of the riparian area.

***The possible benefits of late season grazing include:***

- Drier soil conditions reduce the probability of compaction and streambank shearing;
- Most plants have completed their growth cycle and will be less affected by grazing;
- Generally, there is less impact on wildlife.

***Late season use may be detrimental in the following situations:***

- When regrowth after the cattle are removed will not occur due to reduced soil moisture and declining temperatures;
- When there are no incentives to induce cattle to move out of the riparian area;
- When woody species maintenance or regeneration are objectives.

## Hot Season (Mid-summer) Grazing

***Repeated or extended grazing during the hot summer season can be injurious to riparian areas.The following situations are most likely to prevent deterioration of riparian area during this period:***

- When the operator closely monitors conditions in the riparian area specifically and the period of grazing is limited in duration and frequency;
- When effective management actions are taken to encourage livestock to move out of the riparian area;
- When time of removal and climatic conditions provide opportunity for regrowth or cattle are not put into the pasture on an annual basis.

***Disadvantages of grazing during this period include:***

- The greater tendency of livestock to remain in the riparian area;
- Reduced plant vigor and possible changes in vegetation communities due to the more intense use that results;
- Possible damage to tree and shrub species that play vital roles in the maintenance of riparian health.

***Possible advantages to hot-season (mid-summer) grazing may include:***

- Drier and hence more stable streambanks;
- The possibility of regrowth of riparian vegetation after grazing ceases;
- Higher palatability of riparian forage compared to upland vegetation.

## Winter Use

***Winter use can be an especially useful management approach in the following situations:***

- When the pasture is large enough to feed livestock well away from the stream;
- When drainages are colder than surrounding uplands or open south-facing slopes reduce use of the riparian area;

- Where soil type makes compaction and susceptibility to streambank damage likely during other seasons.

***Advantages of winter use may include:***

- Minimal soil compaction and limited streambank damage;
- Utilization of herbaceous plants will not affect plant development;
- Livestock distribution can be influenced relatively easily through location of watering facilities and feeding stations.

***Detrimental effects of winter grazing may include:***

- Grazing of dead standing material can reduce streambank protection capabilities and reduce sediment entrapment in the spring;
- Browsing and physical damage of shrubs and small trees can be a problem.

# Glossary

**Beaver Dams.** Dams built by beavers that span the stream channel. In general, water is still flowing through the riparian system.

**Browse.** Woody forage (from shrubs or trees) consumed by wildlife.

**Community (Plant Community).** An assembly of plants living together, reflecting no particular ecological status.

**Diversity.** The kind and amount of species in a community per unit area.

**Ecosystem**. All the land that has potential to produce similar structural life forms and has broad environmental characteristics (nonvegetated, conifer, juniper, shrub, wetland, grassland, etc.)

**Ground Water.** Water occupying the interconnected pore spaces in the soil or geologic material below the water table; this water has a positive pressure.

**Healthy.** A riparian system is considered "healthy" when it is capable of performing its normal functions. These may include, but are not limited to, water storage and aquifer recharge, filtering of chemical and organic wastes, sediment trapping, bank building and maintenance, flow energy dissipation, and primary biotic production. As used in this report, "healthy" is synonymous with the BLM's definition of ***Proper Functioning Condition.***

**Herbaceous.** Nonwoody vegetation, such as graminoids and forbs.

**Hydric Soil.** A soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part of the soil profile.

**Hydrology.** The science dealing with the properties, distribution, and circulation of water.

**Intermittent Stream.** A stream or reach of stream which flows only at certain times of the year when it receives water from springs or from some surface source (e.g., melting snow). Such streams are usually divided with respect to the source of their water into spring-fed or surface-fed intermittent streams. These streams generally flow continuously during periods of at least one month or more during the year.

**Irrigation Canal.** Includes all types of canals associated with irrigation systems.

**Nonfunctioning.** Riparian areas are considered nonfunctioning when they are clearly not providing adequate vegetation, landform, or large woody debris to perform the functions listed under **Proper Functioning Condition**. The absence of certain physical attributes such as a floodplain where one should be are indicators of nonfunctioning condition.

**Perennial Stream.** A stream or reach of a stream that flows continuously. Such streams are generally fed in part by springs. Surface water elevations are commonly lower than water table elevations in adjacent soils.

**Proper Functioning Condition.** As defined by the BLM (TR 1737-9 1993), riparian areas are functioning properly when adequate vegetation, landform, or large woody debris is present to: dissipate stream energy associated with high waterflows, thereby reducing erosion and improving water quality; filter sediment, capture bedload, and aid floodplain development; improve flood-water retention and ground-water recharge; develop root masses that stabilize streambanks against cutting action; develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses; and support greater biodiversity.

**Reservoir.** An artificial (dammed) water body with at least 8 ha (20 acres) covered by surface water.

**Rhizomatous.** Describes species with underground, inter-connected root systems (rhizomes).

**Riparian.** *adj.* Of, on, or relating to the banks of a natural course of water (Latin *riparius*, from *ripa*, bank).

**Riparian area.** A geographically delineable area with distinctive functions and characteristics. Includes both the riparian ecosystem and the adjacent aquatic ecosystem.

**Riparian Wetlands (Lotic Wetlands).** Riparian wetlands are wetlands associated with running water systems found along rivers, streams, and drainageways. Such wetlands contain a defined channel and floodplain. The channel is an open conduit which periodically or continuously carries flowing water, dissolved and suspended material. Beaver ponds, seeps, springs, and wet meadows on the floodplain of, or associated with, a river or stream are part of the riparian wetland.

**Riparian or Wetland Ecosystem.** The ecosystem located between aquatic and terrestrial environments. Identified by hydric soil characteristics and riparian or wetland plant species that require or tolerate free water conditions of varying duration.

**Riparian or Wetland Species.** Plant species occurring within the riparian or wetland area. *Obligate* riparian or wetland species require the environmental conditions associated with the riparian or wetland area. *Facultative* riparian or wetland species are tolerant of these environmental conditions, but also occur in uplands.

**Riparian Zone.** A geographically delineated portion of the riparian ecosystem based on management concerns.

**River.** Rivers are usually larger than streams. They flow year around in years of normal precipitation and when significant amounts of water are not being diverted out of them.

**Shrub.** A multi-stemmed woody plant generally shorter than 4.8 m (16 ft).

**Spring.** A groundwater discharge area. In general, springs are considered to have more flow than seeps.

**Stream.** A natural waterway that is defined as first to third order (see *Stream Order*).

**Streambank.** That portion of the channel bank cross-section that controls the lateral movement of water.

**Stream Order.** A classification of streams according to the number of tributaries. Order 1 streams have no tributaries; a stream of order 2 or higher has two or more tributariesof the next lower order.

**Stream reach.** A specified length of stream, the exact length depending on the objective.

**Tree.** A single-stemmed woody plant generally taller than 4.8 m (16 ft).

**Uplands.** Any area that does not qualify as a wetland because the associated hydrologic regime is not sufficiently wet to elicit development of vegetation, soils, and/or hydrologic characteristics associated with wetlands. Such areas occurring in floodplains are more appropriately termed "nonwetlands."

**Water Table.** The upper surface of the zone of saturation within the soil or geologic material.

**Wet Meadow.** A herbaceous wetland on mineral soil. Generally, wet meadows occur in seasonally flooded basins and flats. Soils are usually dry for part of the growing season.

**Wetlands.** Areas that under normal circumstances have hydrophytic vegetation, hydric soils, and wetland hydrology. They include landscape units such as bogs, fens, carrs, marshes, and lowlands covered with shallow and sometimes ephemeral or intermittent waters. Wetlands also include potholes, sloughs, wet meadows, riparian zones, overflow areas, and shallow lakes and ponds having submerged and emergent vegetation. Permanent waters of streams and water deeper than 3 m (approximately 10 ft) in lakes and reservoirs are not considered wetlands.

**Wetland Hydrology.** Permanent or periodic inundation or prolonged soil saturation sufficient to create anaerobic conditions in the soil.