

RIPARIAN AREA MANAGEMENT

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Grazing Management for Riparian-Wetland Areas



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Grazing Management for Riparian-Wetland Areas

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Dedication

This publication is dedicated to the memory of Jim Lewis, who for over 35 years devoted his life to the restoration and management of natural resources. Jim believed very strongly in working together to solve problems, maintaining the dignity of lifestyles, and restoring and ensuring proper use of natural resources. Until his untimely death, he continually worked on documentation for this publication because of his strong land use ethic and commitment to helping people find solutions to land use issues.

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Preface

This material was originally issued in 1989 as BLM Technical Reference 1737-4, *Grazing Management in Riparian Areas*, by Gene Kinch. Most of the information in the original reference is as valid today as it was in 1989, and therefore, is included in this document. Since 1989, numerous management actions have been implemented and evaluated, literature has been produced, and policies have emerged, and this information has been added to the original material. We hope the additional information will enhance the reader's ability to develop and implement successful riparian grazing management strategies over the full spectrum of land ownership and land types.

The original title has been changed to reflect the inclusion of wetlands as a component of riparian areas. Although the term riparian is used alone throughout the document, riparian-wetland is implied. Most of the examples feature running water (lotic) types of riparian-wetlands, but the principles apply to standing water or saturated (lentic) types of riparian-wetlands as well.

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Grazing Management for Riparian-Wetland Areas

I. Introduction

Generally, riparian areas are among the most resilient ecosystems. Depending on condition and potential, they usually respond more quickly than drier upland ranges to changes in management. This document presents information from various land managers and researchers to guide livestock management in riparian areas using their unique responsiveness to accomplish management objectives. However, management of riparian areas cannot be extricated from management of the larger landscape. Riparian areas, as interfaces between the aquatic and upland components of the ecosystem, comprise mosaics of landforms, communities, and environments within the larger landscape. The structure and processes of riparian areas, more than any other ecosystem, are influenced by their connectivity to adjacent ecosystems. Riverine ecosystems, in particular, connect headwaters with lowlands to provide for the transfer of water, nutrients, sediment, particulate matter, and organisms both laterally and downstream (Gregory et al. 1991). An ecosystem perspective provides an ecological basis for evaluating current grazing practices and other land uses, identifying riparian management objectives, and developing future management alternatives.

Livestock grazing management in riparian areas is one of the most pervasive issues facing rangeland managers. Most public and private rangeland is grazed, and even though riparian areas constitute only about 8 percent of the total public land acreage, and less than 1 percent of the public land in many of the more arid Western States (USDI 1995), most grazing allotments, including some desert allotments, contain some riparian acreage. Riparian area management is also one of the most complex issues for rangeland managers because:

- Most riparian acreage is privately controlled or intermingled with other ownerships
- Riparian areas are often the primary, and sometimes the only, watering place for livestock that graze on arid rangelands
- Public use of riparian areas is increasing
- Other resource values are concentrated in and dependent on those areas
- Grazing affects a number of resources and uses, both on-site and off-site
- The value of properly functioning riparian systems is not widely understood
- Traditional management practices are often inadequate and difficult to change

Because of these complexities, the involvement and cooperation of private landowners, ranchers, recreationists, other watershed users, and many different disciplines is critical to the success of riparian area management programs.

No single grazing management system has resulted in consistent recovery of degraded riparian areas. Many combinations of sites, resource conditions, and impacts, as well as human perspectives, are involved. The grazing management system for an

area should be tailored to the conditions, problems, potential, objectives, and livestock management considerations on a site-specific basis. From the standpoint of achieving livestock management objectives and minimizing soil, vegetation, and water quality impacts, grazing management plans will vary. There is no set formula for identifying the type of grazing system or management plan that will be best for any livestock operation or allotment. Water quality impacts are closely related to soil erosion and sedimentation, which are often associated with vegetation cover and concentration of livestock. The grazing system must be designed on the basis of soil and vegetation capabilities, water quality considerations, and livestock and wildlife requirements (Moore et al. 1979).

Ehrhart (in press) concluded that the common denominator among riparian areas that were functioning properly, or at least improving, in eastern and central Montana was continual involvement by the operator or manager. As long as there is control of livestock distribution and grazing intensity, the specific grazing system employed may not be important (Clary and Webster 1989). There are, however, grazing strategies and practices that, under given circumstances, make control of livestock distribution and grazing intensity easier or at least achievable.

II. Compatibility of Grazing in Riparian Areas

Livestock grazing can be a compatible use in riparian areas when managed in harmony with land management objectives, and when the function, capability, and potential of the site and the needs of the riparian vegetation guide the development of the grazing management prescription. Regardless of other differences in management objectives, grazing must be compatible with achieving or maintaining “proper functioning condition” to be considered sustainable. Proper functioning condition of riparian areas, as defined by Prichard et al. (1993 and 1994), is 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 water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses
- Support greater biodiversity

Livestock grazing in riparian areas, however, may not always be entirely compatible with other resource uses or values. Where soils in riparian areas are unstable, the vegetation complex is fragile, threatened and endangered plants and/or animals are affected, aquatic or recreation values are high, municipal watersheds are involved, etc., special livestock management prescriptions must be applied. In some cases, excluding livestock grazing may be the most logical and responsible course of action (at least for a time sufficient to achieve a level of recovery and stability that can support grazing in the context of the management objectives).

The compatibility of grazing in riparian areas depends on the extent to which grazing management considers and adapts to certain basic ecological relationships. Prior to developing grazing management prescriptions for riparian areas, the manager should have some understanding of grazing effects on:

- Natural functions of riparian ecosystems
- Growth and reproduction of woody and herbaceous plants on the site
- Dependency of other animals (mammals, fish, birds, and amphibians) on riparian areas
- Hydrologic and geomorphic conditions and processes
- Soils
- Water quality

III. Management Objectives, Key Areas, and Key Species

A. Management Objectives

Grazing management based only on objectives for nonriparian areas (uplands) does not often maintain or improve riparian areas in the same pasture. Therefore, where maintenance or improvement of riparian areas is desired, land use plan and activity plan objectives (or ranch plan objectives for private lands) and management prescriptions must be attuned specifically to riparian area features while considering the needs of the entire watershed. As mentioned previously, proper functioning condition, as defined by Prichard et al. (1993 and 1994), is the minimum acceptable condition; objectives related to achieving or maintaining proper functioning condition are paramount. Additional objectives related to desired future conditions for land uses and other values are important; however, they should be differentiated from functionality objectives because perceptions of land use and people's values are subject to change over time.

Establishing specific objectives, describing the desired plant community, and selecting key species should be an interdisciplinary effort carried out in close cooperation with range users and other interested parties. Objectives should be dictated by the present condition and trend of the riparian habitat in relation to management goals, the resource potential for change, and the importance of other resource values. Good management objectives should be achievable, measurable, and worthy of the costs incurred to accomplish and monitor them. Major considerations in establishing management objectives include:

1. Vegetation

- a. Historical conditions and disturbance regimes.
- b. Present plant community.
- c. Ecological site potential and capability.
- d. Proper functioning condition.
 - 1) Development and/or maintenance of different age classes of plant species for maintenance or recovery.
 - 2) The complex of vegetation cover necessary to minimize trampling damage and reduce the erosive effects of runoff events.
 - 3) Stabilization of streambanks and elimination of bank hoof shearing.
 - 4) Amount and kind of vegetation required to trap and hold sediment deposits during runoff events to rebuild streambanks and restore aquifers.

e. Desired plant community.

- 1) Health and reproduction of both woody plants and herbaceous vegetation (depending on the riparian objectives and site potential).
- 2) Vegetation structure necessary for wildlife cover diversity.
- 3) Value of the site for forage production.
- 4) Aesthetic effect of a riparian area in good to excellent condition.
- 5) Period of time that is acceptable or necessary for restoration.

2. *Wildlife*

- a. Restoration or maintenance of aquatic and/or waterfowl habitat.
- b. Importance of the riparian community to riparian-dependent wildlife and to wildlife species that occur primarily on upland sites, but that are attracted periodically to riparian areas. In the Great Basin, 79 percent of terrestrial wildlife species are dependent on riparian areas (Thomas et al. 1986); in Arizona and New Mexico, 80 percent of all vertebrates depend on riparian areas for at least half of their life cycle (Cheney et al. 1990).

3. *Water*

- a. Raise in or maintenance of the present water table elevation.
- b. Restoration or maintenance of water quality and quantity.
- c. Restoration or maintenance of natural hydrologic regimes. In degraded systems, this often means reducing peak flow discharge and increasing minimum flows.

4. *Geomorphic*

- a. Establishment of proper stream channel, bank, and floodplain conditions and their related functions.
- b. Maintenance of long-term adjustment processes that may affect channel/riparian zone conditions. Processes may include gully widening and aggradation, bank and floodplain development, meandering, etc. (Van Haveren and Jackson 1986).
- c. Reduction of upland erosion and stream sediment load and restoration or maintenance of soil productivity.

See Appendix A for additional information that can be used to formulate objectives.

B. Key Areas and Critical Areas

In many allotments, riparian areas are “key areas” for management, and their condition may indicate whether grazing management is proper for the entire allotment. In other cases, riparian areas may be “critical areas” for management of site-specific concerns and objectives. In critical areas, proper management may severely limit upland use from what would otherwise be acceptable. Key areas and critical areas must be differentiated for analysis and subsequent management recommendations if needed.

As riparian objectives are developed, key areas for monitoring and judging the propriety of management must be located in representative portions of both the riparian area and the uplands. Key areas must possess (or have the potential to produce) all the specific elements contained in the objective(s) because these will provide data for evaluating management efforts. In many cases, it is appropriate to select the key areas first to represent important and/or common resource values and situations, and then develop objectives specific to each.

When an area is functioning properly, stream reaches that are functioning at-risk, with an unapparent or downward trend attributable to livestock use, are prime candidates for key areas. The limiting factors to proper functioning condition can guide the selection of attributes to monitor, as well as management changes needed. For instance, if adequate vegetative cover is the primary limiting factor, monitoring may focus more on annual physical bank damage and residual vegetation relative to duration of pasture use. On the other hand, if type of plant community and recruitment of key species are the primary limiting factors, short-term monitoring may focus more on utilization, incidence of use, or stubble height relative to season of use and/or recovery periods. Community composition would also be monitored in the long-term.

C. Key Plant Species

Key plant species are: 1) forage species that indicate the degree of use of associated species, and 2) those species that must, because of their importance, be considered in the management program (Interagency Technical Team 1996a). Key species should be necessary to natural stream functions, directly related to vegetation management objectives, and monitored as an indicator of grazing management performance relative to those objectives.

Key plant species will vary with the potential of each individual site. A mix of vegetation increases channel roughness and dissipates stream energy. Willows and other large woody vegetation filter larger water-borne organic material, and their root systems provide bank stabilization. Sedges, rushes, grasses, and forbs capture and filter out finer materials, while their root masses help stabilize banks and colonize filtered sediments. On sites with potential for both woody and herbaceous vegetation, the combined plant diversity greatly enhances stream function.

Understanding the physiological and ecological requirements of key woody species (in addition to key herbaceous species) is essential to designing a proper management

program (Thomas et al. 1979). This includes determining the effects of grazing on the particular growth characteristics of the species involved and the probable outcomes in community change.

IV. Grazing Management Principles and Concepts

Once objectives have been formulated, the resource manager, in consultation with the range user and other involved parties, must tailor grazing management strategies to meet those objectives. As potential grazing strategies are discussed, the objectives should be reviewed. Objectives and management must come together before either one is “established.” Where management is detrimental, the focus should first be on reducing negative impacts, then on using prescribed grazing management as a tool to achieve objectives (Mosley 1996). Because “it is easier to keep a riparian area degraded than it was to get it that way” (Elmore pers. comm.), changes in season, intensity, and frequency of use, or even temporary exclusion, might have to be implemented to initiate recovery. Then other prescriptive grazing strategies might be used to achieve objectives in plant composition, structure, etc.

Grazing management strategies must also consider the sensitivity of different riparian areas to disturbance, and their resiliency, or ability to recover, once degraded. Sensitive riparian areas experience a high degree of natural stress (or any natural attribute that makes them more sensitive to disturbance, such as noncohesive granitic soils), and therefore can tolerate little management-induced stress without degradation. Conversely, less sensitive systems have low natural stress, and therefore can tolerate more management-induced stress (Elmore and Kauffman 1994). Recovery potential is not always directly related to sensitivity to disturbance. Rosgen (1996) provides a guide to stream sensitivity and recovery potential.

Even though classifications such as Rosgen’s can help extrapolate responses of streams to grazing, structures, and other types of management, no two riparian systems are exactly alike. A grazing prescription must: 1) meet the needs of each specific riparian system, as well as other watershed components, 2) be compatible with the entire ranch operation, and 3) have the commitment of the operator/manager to achieve riparian objectives. These criteria have a higher probability of being met if the grazing strategy consciously incorporates (Krueger 1996):

- Animal (livestock) behavior
- Forage selectivity
- Plant responses
- Plant community change
- Hydrology
- Practicality

Plant responses, plant community change, and hydrology usually form the basis for achievable objectives, and thus become the focus of many grazing strategies. However, animal behavior and forage selectivity are the driving grazing management forces affecting those resource interactions.

A. Livestock Behavior

Cattle predominate rangeland, and especially riparian, grazing management concerns. Sheep are generally less of a problem because they tend to avoid low areas where they feel vulnerable to predation (Glimp and Swanson 1994). The switch from sheep or sheep and cattle that has been occurring throughout this century has often increased riparian management problems. Thus, most of this publication focuses on cattle management considerations. However, because any large herbivore (including wild horses, elk, deer, etc.) could cause similar problems or react similarly in specific situations, the term “livestock” will be used throughout this document.

Grazing managers must develop an understanding of the grazing patterns employed by the animals they manage (Stuth 1991). This involves understanding the predisposition of a given species to forage. Foraging behavior involves three distinct levels of selection—spatial (landscape), species, and plant part choice.

An animal with experience in a given landscape will know its boundaries, routes of access and escape, plant communities and their spatial distribution, and the seasonality of desirable species (Table 1). Free-standing water is the principal focus around which most large grazers orient their foraging strategies. Large herbivores are “central place foragers,” with the central or home place centered on water (Stuth 1991). The nature of the terrain, concentrations of shrubs, changes in forage availability due to drought, and mobility of an animal all influence spatial use patterns around water sources.

Table 1. Landscape characteristics that influence animal movement patterns (Stuth 1991).

Attribute	Components
Boundaries	Fences, home range, migration routes
Distribution of plant communities	Range sites, soils, aspect, elevation, structure, species composition
Accessibility	Slope, gullies, water courses, shrub density, rockiness, roads, trails, fence lines, cut openings, pipeline/utility rights-of-way
Distribution of foci	Location of water, shade, loafing and bedding sites and other convergent and divergent points in a landscape

An animal's selection of a given plant community is largely related to those attributes of a site that influence its ability to harvest nutrients (Table 2).

Table 2. Attributes at the plant community and patch level that influence the animal's selection of forage sites (Stuth 1991).

Attribute	Function
Moisture-holding capacity of soil	Affects forage supply and stability
Species composition	Affects suitability/stability of the site for general dietary and nutritional needs
Plant frequency	Affects the probability of encounter of plant species by the animal and number of dietary decisions
Abundance	Affects the supply of nutrients
Structure	Affects accessibility and harvestability of plant species and nature of thermal niches provided
Continuity	Affects movement velocity
Size	Affects amount of search area available
Aspect	Affects the thermal characteristics of the site
Orientation in landscape	Position relative to needs foci affects frequency of exposure to grazing

It is difficult to force an animal to perform in a manner that is contrary to natural preferences and instincts. Based on what is known about livestock behavior, grazing programs can be designed to attract animals to specific areas at specific times, encouraging grazing patterns that yield a desirable response to the vegetation. For example, livestock use of riparian zones is known to vary by season. During spring, livestock tend to disperse because of better forage on uplands, better water distribution in shallow reservoirs and natural water pockets, and acceptable or preferable thermal conditions on uplands. During summer, livestock tend to be attracted to riparian zones due to water availability; generally higher concentrations of nutritious, palatable forage; and, if trees or shrubs are part of the system, preferable thermal conditions. During fall, livestock still tend to be attracted to riparian zones primarily due to water availability, and possibly to availability of browse with higher nutrient content and palatability than mature upland forage; however, fall greenup can be a mitigating factor. During winter, livestock might avoid riparian zones if they function as cold air pockets or drainages. The specifics of each riparian zone and its associated upland areas, such as upland water distribution, determine appropriate management options.

Variable weather conditions also affect animal behavior by impacting vegetation production, water distribution, etc. For example, a drought can cause the growing

season to be earlier and shorter. As a result, animals may prefer riparian zones much earlier, and dates of grazing may need to be adjusted. Conversely, a prolonged wet, cool spring and summer may result in longer-than-normal use of a given pasture, which would allow deferment or rest of some other pasture as a possible beneficial treatment. Riparian zones would also be relatively less attractive under such conditions.

The kind (cattle, sheep, etc.), class (yearling, cows with calves, etc.), and previous experience of livestock influence behavior as well. Cows with calves are usually less mobile than yearlings or dry, mature cows. Cows experienced in a pasture prefer certain locations, much like home ranges of big game, and can be expected to head for and stay in a given area. Inexperienced animals initially search for the boundaries of their environment and then for preferred locations, with water being a primary factor. These behavior attributes may provide a means to select animals that use areas beneficial to management objectives, cull those that don't, and train replacement animals appropriately.

B. Forage Selectivity

Selectivity varies by animal species, forage palatability, and preference. Palatability refers to characteristics of a plant that elicit a selective response by a herbivore. It changes throughout the annual plant growth cycle and can vary spatially as a result of soil characteristics. Preference is a behavioral function that involves proportional choice of one plant species from among two or more species. Preference for a particular plant species depends largely upon its abundance, morphological/phenological characteristics, the array of other species available, and the species of animal in question. Preference changes with season, weather, soil moisture (and palatability), and forage availability. Thus, forage selectivity is a dynamic, situation-specific phenomenon. However, some generalizations can be applied. For example, in riparian areas, livestock generally don't browse woody plants if they have a sufficient supply of palatable grass, but, where only a few woody plants are available, animals may seek them out to obtain dietary diversity. Most generalizations have exceptions though, so management must be refined to fit the specific situation.

V. Grazing Management Strategies

A. Key Management Considerations

To properly manage livestock grazing in riparian areas, it is important to recognize that:

- Grazing management practices that improve or maintain an upland site may neither improve nor maintain a riparian area. While riparian areas respond uniquely, they should not be considered independently of uplands. Problematic upland watershed conditions, such as excess runoff and erosion, often reduce the effectiveness of management in the riparian zone. To be managed effectively, the whole pasture containing the riparian zone and the whole watershed containing the pasture should be considered.
- Passive, continuous grazing rarely improves a deteriorated riparian area or maintains a riparian area in good condition without reducing stocking levels to extremely low and uneconomic levels.
- Grazing management must provide an adequate cover and height of vegetation on the banks and overflow zones to promote natural stream functions (sediment filtering, bank building, flood energy dissipation, aquifer recharge, and water storage).

It is also important to recognize that there is a lot of public concern about management of riparian areas. Gaining the understanding and cooperation of everyone involved in riparian area management, including land managers, landowners, users, and the public, improves the chances for success. Through consultation and cooperation with livestock managers, changes can be implemented that benefit other users of riparian areas. Workshops and demonstration areas can promote an understanding and appreciation for the value of properly functioning riparian systems and build support for a sound program. Recognizing operators who have implemented management practices that improved riparian area conditions can demonstrate the benefits of good stewardship and help expand good management into other areas. Ranchers who have experienced the benefits of proper grazing management in riparian areas are some of the best salespeople for changing traditional riparian area management practices.

Finally, it is important to recognize that there are a number of other factors to consider in selecting management strategies to meet riparian objectives, including timing, duration, and frequency of grazing; distribution of livestock; stocking rates; utilization levels and patterns; and pasture design, including topography and seasonal implications of topography. These factors influence the economic feasibility and practicality of the management strategy, which are both essential if commitment to the strategy is to be achieved.

1. Timing, Duration, and Frequency of Grazing

Successful grazing management strategies for riparian areas can usually be achieved using a combination of options, including grazing “prescriptions” that:

- Limit grazing intensity, frequency, and/or season of use, thereby providing sufficient rest to encourage plant vigor, regrowth, and energy storage and minimize compaction of soils.
- Control the timing of grazing to prevent damage to streambanks when they are most vulnerable to trampling.
- Ensure sufficient vegetation during periods of high flow to protect streambanks, dissipate energy, and trap sediments.

In a study of 34 grazing systems in operation for 10-20 years in southwestern Montana, Myers (1989a) found timing of grazing, duration of use, and frequency of fall grazing were important factors in successful management (Table 3). The effectiveness of livestock grazing management was judged based on the vigor, regeneration, and utilization of woody species, as well as on bank stability.

Table 3. Criteria for successful grazing management (Myers 1989a).

Criteria Used	Successful Management	Unsuccessful Management
1. Time provided for postgrazing herbaceous regrowth (average number of days).	35	21
2. Duration of use - total days per season (average number of days).	28	59
3. Fall use duration (average number of days).	21	37
4. Percent of years fall use occurred (average).	31	51
5. Percent of grazing treatments providing residual cover* through rest or regrowth (average).	75	38

*Residual cover was defined as at least 30 days of regrowth.

Successful systems were defined as those demonstrating good or excellent riparian condition or an upward trend if in fair condition. The results highlight the importance of adequate vegetation vigor and regeneration at the end of the growing season and the apparent critical nature of the frequency and duration of fall grazing treatments. Myers suggests that the duration of grazing treatments often prescribed for upland management (60-75 days) be shortened to 25-30 days. Shortening the duration and providing growing season rest in all pastures lessens animal impacts, provides regrowth, and allows stock to be more selective in grazing.

2. Distribution of Livestock

Utilization patterns relative to total forage distribution reveal that livestock distribution, coupled with timing, duration, and frequency of grazing, are often the main problems. Most successful grazing strategies or “prescriptions” also include additional practices or techniques that promote distribution of livestock, such as:

- Techniques that attract livestock away from riparian areas, including stock water development, developing alternative or improved forage, prescribed fire in uplands, careful salt and supplement placement, and fertilization in uplands.
- Techniques that restrict livestock from riparian areas, including fencing or fence relocation, barriers such as thickets or brush wind rows, water gaps in erosion-resistant stream reaches, hardened crossings or water access, and relocation of bed grounds and management facilities.
- Herd management and animal husbandry practices that promote mobility, including herding and culling practices, and managing the kind (sheep versus cattle, etc.), class (steers versus cows with calves, etc.), and breed of livestock.

Research in Idaho, Utah, and Nevada illustrates the importance of livestock distribution throughout the pasture and away from the riparian area. Platts and Nelson (1985) found that livestock took an average of 29 percent, and as much as 40 percent, more vegetation from riparian sites (wildlife use was trivial) than from adjacent upland sites. Although use on the allotments was moderate, use on riparian sites was heavy to severe. Managing and controlling the attractant features of riparian areas usually increases the use of, and improves distribution in, uplands.

Proper distribution of livestock can be an effective and economical tool in managing riparian areas. In some areas that are degraded, some rest may be required, especially where woody species are part of the management objective.

3. Stocking Rates

Total stocking rate problems at the pasture, ranch, or allotment level are the exception rather than the rule in today’s operations. The apparent overstocking of some areas while others are only moderately grazed or even ungrazed will not be solved by simply reducing numbers if other factors are not also changed. Reducing stocking rates may reduce the percentage of area in unsatisfactory condition, but the impacts around the foci of highly utilized areas (e.g., riparian areas, other waters, etc.) will remain the same until few, if any animals remain. Many pastures, ranches, or allotments are appropriately stocked for the majority of the area, but a temporary reduction in the stocking rate is necessary to allow recovery of localized problem areas. This is especially true in rest-rotation strategies where part of the area is removed from grazing for an entire season. The rest may not compensate for the increased use during grazing until sufficient recovery is achieved. There are also some operations that are still simply overstocked. No strategy will work until



stocking rates are at an appropriate level for the existing conditions and prescribed management.

4. Utilization Levels and Patterns



If utilization, timing, and residual vegetation are factors in developing a grazing prescription, the primary focus is usually the physiology of key plant species that must stay healthy and reproduce. The primary focus of associated management techniques is often to achieve better livestock distribution and avoid grazing intensity problems. However, the effects are often intertwined and problems can be addressed in many ways. Utilization mapping is an excellent tool for checking the distribution of livestock use and for identifying management opportunities. However, measurement of stubble height (residual vegetation) is often more straightforward and easier to interpret. Relative use or seasonal use may impact the physiology of key species and guide development of a grazing strategy, but annual measurements vary among years and individual observers. Therefore a range of utilization or stubble heights should accommodate favorable and unfavorable production years.

Due to the variation in riparian sites and management objectives, one standard utilization and/or residual vegetation target is not appropriate. However, utilization and/or residual vegetation should be considered (together with regrowth potential) to ensure that vegetation stubble necessary for natural stream functions is present or other land use objectives (e.g., residual nesting cover for waterfowl) are accomplished. Management plans should recognize that an average stubble height or utilization level generally represents rather complete use of certain plants and partial or no use of others. The first bite may reduce all eaten stems to close to ground level. Other stems on that plant and adjacent plants remain uneaten at first.

In most situations where both upland and riparian sites exist in the same pasture(s), portions of each pasture can be seasonally unusable or unused for grazing because of wet soils, lack of green forage, length or steepness of slope, distance to or lack of water, and absence of shade, etc., as shown in Figure 1 (Elmore pers. comm.).

In pasture A, the corridor along the stream is unsuitable due to saturated soils,  and some of the uplands are not used due to lack of green forage .

In pasture C, portions of the uplands are unusable due to lack of water and unused due to length and steepness of slope.

In pasture D, portions of the uplands are unused due to length and steepness of slope and lack of water . Also the stream corridor is of concern due to utilization of willow and bank trampling in excess of allowable limits  that may occur during this period.

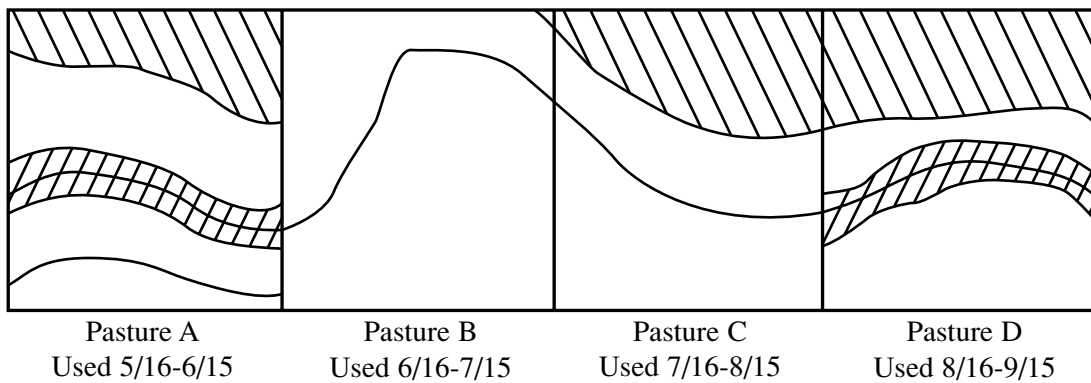


Figure 1. Examples of seasonally unused areas within a pasture.

In pastures C and D, frequent riding and herding of the livestock may increase utilization of the upland and relieve grazing pressure in the riparian areas. This would reduce the need to adjust season of use or numbers of livestock to compensate for heavy riparian area use.

5. Pasture Design

In pasture planning, the pasture should include as much of a stream as possible and not use streams as fenced pasture boundaries (Myers 1981). Small stream sections and other small riparian areas such as springs and seeps within large pastures usually cannot be effectively managed. Exclusion fencing is often the most practical approach for small areas. When pasture boundary fences zig-zag across streams, livestock impacts tend to be concentrated near the stream. Livestock tend to concentrate near and trail along fences, accentuating trampling damage. Also, wire fences across streams tend to catch trash and frequently wash out. Myers recommends trying to center streams within a pasture where possible.

Where a stream must serve as the division line, fencing one or both sides of the stream with water gaps to the stream, if needed, can effectively avert most riparian concentration. Suspending panels of corrugated metal roofing over the stream, between ends of a fence, has proven effective in controlling livestock movement in Oregon. The panels swing with the flow of water, do not catch trash, and are avoided by livestock (Elmore pers. comm.). Other forms of swing panels constructed of hanging pipe or heavy chain have also proven effective.

B. Grazing Treatments

Following are descriptions and examples of grazing treatments for riparian areas. Generalized responses to grazing treatments are provided in Table 4 (Platts and Nelson 1989), Table 5 (Buckhouse and Elmore 1991), and Table 6 (Kovalchik and Elmore 1991). Elmore and Kauffman (1994) caution that the ratings presented in these tables are based on observations in different riparian/stream systems. However they do express similarities for assessing the potential for management success in the northern Rocky Mountain and Pacific Northwest regions.

Table 4. Evaluation and rating of grazing strategies for stream riparian habitats (Platts and Nelson 1989).

Strategy	Level to which riparian vegetation is commonly used	Control of animal distribution (allotment)	Streambank stability condition	Brushy species regrowth potential	Seasonal plant rehabilitative	Stream-riparian	Rating
Continuous season-long (cattle)	heavy	poor	poor	poor	poor	poor	1 ^a
Holding (sheep or cattle)	heavy	excellent	poor	poor	fair	poor	1
Short duration-high intensity (cattle)	heavy	excellent	poor	poor	poor	poor	1
Three herd-four pasture (cattle)	heavy to moderate	good	poor	poor	poor	poor	2
Holistic (cattle or sheep)	heavy to light	good	poor to good	poor	good	poor to excellent	2-9
Deferred (cattle)	moderate to heavy	fair	poor	poor	fair	fair	3
Seasonal suitability (cattle)	heavy	good	poor	poor	fair	fair	3
Deferred-rotation (cattle)	heavy to moderate	good	fair	fair	fair	fair	4
Stuttered deferred-rotation (cattle)	heavy to moderate	good	fair	fair	fair	fair	4
Winter (sheep or cattle)	moderate to heavy	fair	good	fair	fair to good	good	5
Rest-rotation (cattle)	heavy to moderate	good	fair to good	fair	fair to good	fair	5
Double rest-rotation (cattle)	moderate	good	good	fair	good	good	6
Seasonal riparian preference (cattle or sheep)	moderate to light	good	good	good	Fair	fair	6
Riparian pasture (cattle or sheep)	as prescribed	good	good	good	good	good	8
Corridor fencing (cattle or sheep)	none	excellent	good to excellent	excellent	good to excellent	excellent	9
Rest rotation with seasonal preference (sheep)	light	good	good to excellent	good to excellent	good	excellent	9
Rest or closure (cattle or sheep)	none	excellent	excellent	excellent	excellent	excellent	10

^a Rating scale based on 1 (poorly compatible) to 10 (highly compatible with fishery needs).

Table 5. Generalized relationships between grazing system, stream system characteristics, and riparian vegetation response (adapted from Buckhouse and Elmore 1991).

Grazing system	Steep low sediment load		Steep high sediment load		Moderate low sediment load		Moderate high sediment load		Flat low sediment load		Flat high sediment load	
	shrubs	+	shrubs	+	shrubs	+	shrubs	+	shrubs	+	shrubs	+
No Grazing	shrubs herbs banks	+ + 0	shrubs herbs banks	+ + 0 to +	shrubs herbs banks	+ + 0	shrubs herbs banks	+ + +	shrubs herbs banks	+ + +	shrubs herbs banks	+ + +
Winter or Dormant Season	shrubs herbs banks	+ + 0	shrubs herbs banks	+ + 0 to +	shrubs herbs banks	+ + +	shrubs herbs banks	+ + +	shrubs herbs banks	+ + +	shrubs herbs banks	+ + +
Early Growing Season	shrubs herbs banks	+ + 0	shrubs herbs banks	+ + 0 to +	shrubs herbs banks	+ + +	shrubs herbs banks	+ + +	shrubs herbs banks	+ + +	shrubs herbs banks	+ + +
Deferred or Late Season	shrubs herbs banks	- + 0 to -	shrubs herbs banks	- + 0 to -	shrubs herbs banks	- + 0 to +	shrubs herbs banks	- + +	shrubs herbs banks	- + +	shrubs herbs banks	- + +
Three-Pasture Rest-Rotation	shrubs herbs banks	- + 0 to -	shrubs herbs banks	- + 0 to -	shrubs herbs banks	- + 0 to +	shrubs herbs banks	- + +	shrubs herbs banks	- + +	shrubs herbs banks	- + +
Deferred Rotation	shrubs herbs banks	- + 0 to -	shrubs herbs banks	- + 0 to -	shrubs herbs banks	- + + to 0	shrubs herbs banks	- + +	shrubs herbs banks	- + +	shrubs herbs banks	+ + +
Early Rotation	shrubs herbs banks	+ + 0 to -	shrubs herbs banks	+ + 0 to +	shrubs herbs banks	+ + + to 0	shrubs herbs banks	+ + +	shrubs herbs banks	+ + +	shrubs herbs banks	+ + +
Rotation	shrubs herbs banks	- + 0 to -	shrubs herbs banks	- + 0 to -	shrubs herbs banks	- + 0 to +	shrubs herbs banks	- + +	shrubs herbs banks	- + +	shrubs herbs banks	- + +
Season-Long	shrubs herbs banks	- - 0 to -	shrubs herbs banks	- - 0 to -	shrubs herbs banks	- - -	shrubs herbs banks	- - -	shrubs herbs banks	- - -	shrubs herbs banks	- - -
Spring and Fall	shrubs herbs banks	- - 0 to -	shrubs herbs banks	- - 0 to -	shrubs herbs banks	- - -	shrubs herbs banks	- - -	shrubs herbs banks	- - - to 0	shrubs herbs banks	- - 0 to +
Spring and Summer	shrubs herbs banks	- - 0 to -	shrubs herbs banks	- - 0 to -	shrubs herbs banks	- - -	shrubs herbs banks	- - - to 0	shrubs herbs banks	- - - to 0	shrubs herbs banks	- - 0 to +

Note: - = decrease; + = increase; 0 = no change. Stream gradient: 0 to 2% = flat; 2 to 4% = moderate; >4% = steep.

Table 6. Generalized relationships between grazing system and willow and sedge response on willow-dominated plant associations (Kovalchik and Elmore 1991).

Systems highly compatible with willow management		
Corridor fencing	Willows	↑
	Sedges	↑
Spring grazing	Willows	↑
	Sedges	↑
Riparian pasture	Willows	↑
	Sedges	↑
Winter grazing	Willows	↔ to ↑
	Sedges	↑
Systems moderately compatible with willow management		
Two-pasture rotation	Willows	↔ to ↑
	Sedges	↑
Three-pasture deferred rotation	Willows	↔ to ↓
	Sedges	↔ to ↑
Three-pasture rotation	Willows	↔ to ↓
	Sedges	↑
Systems incompatible with willow management		
Spring-fall grazing	Willows	↓
	Sedges	↔ to ↓
Late-season grazing	Willows	↓
	Sedges	↓
Deferred grazing	Willows	↔ to ↓
	Sedges	↔ to ↓
Season-long grazing	Willows	↓
	Sedges	↓
↑ = highly compatible, ↓ = incompatible, ↔ = no change		

1. Passive, Continuous Grazing; Spring-Summer, Summer-Fall, or “Season-Long” Grazing

In this document, the term “passive, continuous grazing” means grazing throughout the growing period, with little or no effort to control the amount or distribution of livestock use in particular areas. Riparian areas will usually be overgrazed under passive, continuous grazing (Figures 2 and 3). During portions of the grazing period when air temperatures are hot, riparian sites are usually preferred by livestock over upland sites on arid and semiarid ranges due to the presence of water, lush forage, more consistent regrowth, cooler air, shade, and relatively flat terrain. Until utilization becomes excessive, livestock do not need to spend as much time and effort in riparian areas as they do on uplands to satisfy their daily nutritional requirements (Skovlin 1984). In Montana, during August and September, approximately 80 percent of the forage used by livestock may come from riparian sites, even though they often comprise less than 4 percent of the total pasture (Marlow 1985).

Similarly to passive, continuous grazing, riparian areas may also be overgrazed under a program of deferred rotation or rest-rotation grazing with an extended season of use. Use on adjacent uplands in such pastures may be moderate or light. This concentrated use of areas next to water in effect results in the creation of “upland exclosures,” and often reduces the effectiveness of the grazing prescription for the uplands (Elmore pers. comm.).



Figures 2 & 3. Typical impacts from passive, continuous grazing. Note bank hoof shear, lack of vegetation on point bars, encroachment of dry land vegetation, willows well above the channel elevation, heavily hedged willows, presence of only one age class of willow, lack of adequate vegetation for silt filtering and bank protection, and the wide, shallow stream profile.

2. Spring and Fall Grazing

Spring and fall grazing in the same year may work in some cases, but it usually fails to meet riparian vegetation needs because it doubles the potential limitations of either spring grazing or fall grazing alone. If temperatures are still warm when fall grazing begins, livestock concentrate in the riparian zone while palatability of both herbaceous plants and willows is high. Appropriate use on willows can easily be exceeded and residual vegetation for protection of banks during high flows is removed before uplands are grazed (Figure 4). Livestock preference for the riparian area is compounded the following spring because the removal of standing dry matter increases the palatability of riparian forage over ungrazed upland plants.

Successful spring and fall grazing was observed by BLM's National Riparian Service Team on a private, irrigated riparian pasture in south-central Idaho. Factors contributing to success in this case included plentiful herbaceous forage, water availability throughout the pasture, and a short duration of use (approximately 2 weeks) in the fall. Above all, the owner/operator observed use daily.



Figure 4. An example of typical spring and fall use on the right compared to winter use on the left.

3. Riparian Pasture

Riparian pastures may be smaller areas of rangeland containing both upland and riparian vegetation that is managed together as a unit to reach riparian objectives. They may also be streamside pastures containing only riparian vegetation. They differ from other pastures that are managed primarily to achieve results in upland

areas. A riparian pasture is particularly applicable where the riparian zone encompasses an area large enough to be managed separately from the uplands. Because it is separate from the rest of the ranch or allotment, it can be grazed or rested depending on current conditions and stream riparian needs (Elmore and Kauffman 1994), providing the ultimate in control and flexibility. Riparian pastures can be used seasonally, in conjunction with rotation strategies, or as special use pastures (i.e., gathering pasture, bull pasture, etc.).

In the design of riparian pastures containing both upland and riparian vegetation, the balance of forage between upland and riparian areas is important. Forage in the upland sites should not limit proper distribution or utilization; for example, there should be enough forage in the upland areas so that livestock are not forced to the riparian areas to find sufficient forage. Forage balance may change with changes in season of use and kind or class of livestock.

Platts and Nelson (1985) found that on six 10-acre pastures in Idaho, Nevada, and Utah, the timing and location of grazing in specially managed riparian pastures could be controlled much more effectively than in large allotment pastures, providing an easier way to make grazing compatible with other resource uses. Using riparian pastures offers alternatives to eliminating livestock grazing and fencing riparian boundaries, which can be costly. By experimenting with different types of riparian and upland range, different sizes and shapes of pastures, and different ratios of riparian forage to upland forage, it may be possible to efficiently graze riparian vegetation without damaging this sensitive zone.¹ In mountain meadow ranges, special management pastures would need to be larger to better match benefits derived from improved riparian and fish habitat with the costs of fencing. The influence of a livestock herd's home range on grazing use requires careful analysis; pastures may have to be larger than a herd's home range in less productive range types. When fencing narrow streamside corridors or eliminating livestock from the allotment are the only alternatives for maintaining productive riparian and aquatic habitats, the cost of special management pastures may not seem exorbitant.

¹ This may not be practical in many cases due to cost.

Figures 5 and 6 depict change from season-long use on the North Fork of the Humboldt River in Nevada to a riparian pasture for use by yearling bulls several weeks prior to mid-June.



Figure 5. North Fork of the Humboldt, 1989.



Figure 6. North Fork of the Humboldt, 1994.

The Goosey Lake Flat (Nevada) riparian pasture (Figures 7 and 8) has generally been used as a gather or turnout pasture since it was changed from continuous season-long use. The grazing plan calls for use in early June for 1 year out of 3, and for 2 weeks in September for gathering during the remaining 2 years (Masters et al. 1996b).



Figure 7. Goosey Lake Flat Creek, 1965.



Figure 8. Goosey Lake Flat Creek, 1991.

4. Winter (Dormant-Season) Grazing

Normally, there is little or no vegetation growth during winter. Winter use is usually the least detrimental to soils (where they are frozen) and to dormant herbaceous vegetation. However, it may be the period of greatest use of browse species by both livestock and wildlife depending on temperatures, snow depth and duration, availability of other feed, animal concentration, forage/browse preference, and the extent of the woody plant community. Many riparian areas are unavailable for grazing during a major part of the winter due to snow depth. In areas that can be grazed, winter can be a season of use with minimal impact when grazing is closely monitored and controlled (especially use of woody plant growth).

Winter use can reduce a user's winter feed costs in some areas. In Oregon, this has amounted to as much as \$30 per head per season (Elmore 1987). However, winter use also has the potential to remove excessive amounts of vegetation cover just prior to spring runoff. Most streambanks need carryover vegetation for bank protection and sediment trapping during spring runoff.

Wickiup Creek in northern Nevada has been grazed in the winter by cattle since 1910 (Masters et al. 1996a). Winter grazing has maintained stable riparian conditions for decades (Figures 9 and 10). Additional management practices include placing salt well away from riparian areas, culling riparian loafers, and varying turnout locations from year to year.

Winter grazing has also improved riparian conditions on Meadow Valley Wash in southern Nevada (Masters et al. 1996a), Comes Ranch in Montana (Massman ed. 1995), and Texas Creek in Colorado (Prichard et al. 1993).



Figure 9. Wickiup Creek, 1939.



Figure 10. Wickiup Creek, 1991.

5. Spring Grazing

Cool-season vegetation growth begins and peaks in spring. Warm-season plants begin growing during mid- to late spring. Spring use normally results in better live-stock distribution between riparian and upland areas due to flooding of riparian areas and presence of highly palatable forage (including many annuals) on the uplands.

In the spring, seed and litter can be trampled into wet soil by hoof action. However, on some moist or saturated soils, grazing animals more easily uproot plants and compact soils or shear streambanks. Subsequent rest is often required to encourage root growth and other biological activity, which offsets the effects of soil compaction prevalent during the spring season. In a southwestern Montana study, most bank damage resulted when soil moisture was in excess of 10 percent, which normally occurs prior to late July/early August in arid/semiarid areas of the West (Marlow and Pogacnik 1985). The soil moisture content that minimizes bank damage may vary with differences in soil texture.

Spring use provides more opportunity for regrowth and plant recovery than summer or fall use. Regrowth is important for sustaining the important physical functions of a riparian system (e.g., shading, insulation, sediment filtering), as well as for buffering the effects of peak runoffs on streambanks. For example, in the BLM's Prineville District, which is in Oregon's sagebrush- and juniper-dominated high desert, spring grazing has been used to improve riparian conditions on Bear Creek. Prior to 1976, the area was a single pasture licensed for 72 animal unit months (AUMs) from April to September. This strategy depleted streamside vegetation (low diversity and productivity) and deeply incised the stream channel, causing it to be unstable and actively eroding. Summer streamflow was often intermittent and low in quality.

In 1976, the BLM decided to rest the area to restore the productivity of the riparian zone (Figure 11). After 3 years of attempted rest, the area was used for 1 week in September in 1979 and 1980. In 1983, juniper trees were removed from the uplands to improve range condition and watershed health. In 1985, a grazing treatment was designed authorizing use from the time of spring runoff (mid-February) until April 15 in a three-pasture system. In 1988, permitted AUMs were nearly five times the forage obtained from the area under season-long use. Furthermore, the permittee has reportedly cut his annual hay bill by \$10,000. The riparian zone continues to improve (Figure 12). The resulting improvement in quality and quantity of streamflow has allowed the reestablishment of rainbow trout. Though this early season riparian grazing treatment works well on this site's sandy loam soils, it might not work as well on soils with high moisture content.



Figure 11. Bear Creek, 1976.



Figure 12. Bear Creek, 1996, after continued spring use.

Additional examples where spring grazing has worked well include allotments on Bully Creek and the South Fork of the Crooked River in Oregon (Elmore pers. comm.) and T-Creek, Tabor Creek, and Pie Creek in Nevada (Evans pers. comm.).

6. Hot-Season Grazing

Summer is usually the period of greatest photosynthetic activity, especially for riparian and warm-season plants. Upland and cool-season plant growth diminishes due to reduced soil moisture content. Summer use is generally regarded as the most critical. During the hot season, livestock concentrate in or near the riparian area when upland forage becomes rank or dry, water distribution is more limited, and the desire for shade is more intense. Where free-choice grazing is allowed, summer use usually results in greater utilization of riparian vegetation. Summer is also when grazing causes the greatest stress in most plant communities. There is less time for regrowth and replenishment of carbohydrate reserves than with spring use, and more need for leaf area than later in the growing season.

Annually repeated grazing throughout the hot season is nearly always detrimental to riparian vegetation (essentially the same as season-long use), especially in large pastures with small riparian areas that are not managed as riparian pastures. Therefore, some form of deferred rotation, rest-rotation, short-duration rotation, utilization or bank trampling limits, or exclusion is needed to reduce frequency, intensity, and/or duration of riparian use. Deferring use in a riparian pasture until the hot season extends the green feed period of nutritious forage and may provide an economic incentive for better riparian management. However, duration of use needs to be restricted to avoid repeat defoliation, overuse, and streambank trampling.

Myers (1981) found that in the foothills of southwestern Montana, the frequency of hot-season use from July 10 to September 1 (period of heavy use) appeared to be a critical factor in developing and maintaining satisfactory riparian area conditions. Grazing systems with hot-season use in more than 1 year out of 3 or 4 met riparian habitat goals on only 24 percent of 21 streams. Grazing systems lacking hot-season use, or with no more than one hot-season treatment in 3 or 4 years, met riparian habitat management goals on 90 percent of 20 streams evaluated. Utilization data were not available in this study.

Myers (1989a) also analyzed duration of hot-season (7/1-9/15) grazing treatments and found that successful treatments averaged only 12.5 days, whereas unsuccessful treatments averaged 33.4 days. In this case, utilization of willows was important. However, duration was important from the standpoint of physical damage, regardless of utilization or regrowth potential, because of more frequent watering requirements and preference for shade while loafing. Duration of successful grazing treatments varied greatly depending on vegetation and stream type.

7. Deferment Until the Late Season (Fall Grazing)

Deferment is the postponement or delay of grazing to achieve a specific management objective (Forage and Grazing Terminology Committee 1991). Skovlin (1984) suggests that deferring use until the late season, until restoration of habitat is acceptable, offers a good measure of protection without great expense.

In fall, warm-season plants stop growing. Some cool-season species may grow where moisture and temperatures allow. Fall use is usually less critical than summer use because many perennial plants are completing their storage of carbohydrates and no longer need active leaf area. Upland cool-season species may again produce palatable forage, which, together with cooler temperatures, shifts livestock use to the uplands and relieves grazing pressure in riparian areas.

While livestock are often assumed to be leaving riparian areas to use upland range, that may not always be the case. On one study site in a long glaciated U-shaped valley in Idaho, Platts and Raleigh (1984) found that a late grazing system helped restore riparian quality because livestock moved to the uplands in late summer and fall when a cold air pocket formed over the bottomlands. However, at another study site in a flat, broad valley 15 miles away, livestock were drawn to the riparian areas during late season because those areas contained the only remaining succulent vegetation.

Heavy fall riparian use can leave streamside vegetation depleted and banks vulnerable to damage during spring runoff. Streambank damage relates to many factors, including soil moisture content, soil type, absence of woody plants and root systems, bank rock content, stock density, availability of off-stream water, and duration of grazing. Streambank damage due to livestock trampling of wet soils, and where other factors are not controlling, may be avoided by deferring grazing until bank soil moisture content is less than 10 percent. This usually occurs by late July or early August in most of the arid and semiarid western range (Marlow and Pogacnik 1985).

Deferring grazing until after seedripeness can benefit sedge/grass communities if sufficient regrowth (or residual vegetation) protects banks and retains sediment during the next high-flow event (Elmore and Kauffman 1994). Furthermore, woody species utilization must be carefully monitored because use often begins during the later part of the hot season when livestock tend to concentrate in riparian areas. Levels of utilization that maintain the diversity and productivity of meadow communities were found to retard woody plant succession on gravel bars (Green 1991). Kovalchik and Elmore (1991) noted that systems with late-season grazing are incompatible with willow management.

On the Smiths Fork Allotment in the Kemmerer Resource Area of the Rock Springs District in Wyoming, deferred grazing, together with good herding and salting practices, resulted in improved riparian and fish habitat in the Huff Creek drainage. Prior to treatment, Huff Creek was in a deteriorated state. It had changed from a cold-water fishery in good condition to a warm waterway with severe streambank erosion and excessive siltation. Willows had been replaced by sagebrush (Smith pers. comm.). During 1976 to 1979, in order to protect and enhance habitat for the rare Bear river cutthroat trout population, two exclosures were built, instream habitat improvement structures were added to one exclosure, and deferred grazing was initiated outside the exclosures (Figures 13 and 14). Livestock use in Huff Creek was limited to August 15 to September 30 each year. The range rider salted the ridges away from water and kept the 500 livestock distributed over the entire watershed. Livestock were moved away from the stream every 2 to 3 days, thus reducing impacts in the riparian area (Netherly and Hendersen pers. comm.).

The Wyoming Game and Fish Department monitored Huff Creek during 1978 to 1984 (Binns and Remmick 1986). As a result of the treatments and management applied in Huff Creek, trout habitat improved at all study stations inside and outside the



Figure 13. Riparian conditions in grazed area on Huff Creek below lower enclosure, July 1986.



Figure 14. Looking upstream into lower Huff Creek enclosure from grazed area, July 1986.

exclosures by 57 percent. Trout cover increased 214 percent. Bank stability improved except inside the small exclosure. Trout 6 inches and larger increased 300 percent in one exclosure, 92 percent in the other exclosure, and 72 percent in the grazed area. Field personnel credited the local grazing association's and range rider's control of the livestock as the key to riparian area improvement outside the exclosures.

8. Deferred and Rotational Deferred Grazing

Deferred grazing is a nonsystematic rotation with other land units, and rotational deferred grazing is the systematic rotation among land areas within a grazing management unit (Forage and Grazing Terminology Committee 1991). Both strategies have been successful in restoring and improving riparian areas. Deferred and rotational deferred grazing strategies are often combined with rotational stocking (rest-rotation). The common thread of successful application, except for riparian pastures used in a deferred strategy, has been to use many pastures to shorten duration of use and provide greater flexibility. Many riparian grazing successes in Montana use seven pastures or more (up to 38) (Massman ed. 1995). Masters et al. (1996b) concluded, "Four-pasture, five-pasture (or more) rotation schemes with no rested pasture may be more suitable to areas that require increased streambank vegetation. The additional pastures or smaller riparian pastures allow for a shorter grazing season and greater flexibility in rotation schedules."

One common problem in multiple-pasture systems is allowing livestock to drift between pastures rather than moving them in a timely fashion. In his evaluation of 30 grazing systems on 44 stream reaches in Montana, Myers (1981) concluded that livestock should be moved between pastures rather than left to drift over a period of

several days. In this analysis, riparian vegetative response seemed to be better in allotments where the livestock were moved and the gates closed, as opposed to the use of livestock drift and simultaneous use of two pastures. Other field personnel also emphasize the need to move livestock and not expect drift to accomplish the desired movement. Some livestock will stay in a pasture eating regrowth even though there is adequate palatable forage in the next pasture. One recommended approach, which can minimize livestock stress and encourage better dispersal, is to open the gate in late afternoon of day one, allow drift on day two, and clean the pasture and close the gate on day three (Hagener pers. comm.).

Based on research at the Red Bluff Research Ranch near Norris, Montana, Marlow (1985) suggests a grazing system based on seasonal preference for riparian and upland forage. In this area, livestock spend most of their time during June and July in the uplands, moving to the riparian sites in late July where they graze until October. Bank trampling damage is reduced by deferring grazing until after late July when soil moisture content had decreased to 8 to 10 percent or less. This system requires a minimum of three pastures and uses a 3-year cycle. Stocking rates in the pasture used first are based on forage available on both the upland and riparian sites. Stocking rates on the two pastures used later are based on 20 to 30 percent utilization of forage on only the riparian sites. Although this may appear to drastically limit the length of time a pasture can be used, riparian zones usually produce three to four times the forage of upland areas. The regrowth potential of riparian species is great enough that, during most years, regrazing of the same pasture can occur at 30- to 40-day intervals until frost. Consequently, there is little, if any, change in the amount of forage a rancher has available to his livestock in the grazing season. Once the target level of use is reached, livestock are moved to the next pasture. Each pasture receives 2 years of deferment during periods when soil moisture exceeds 10 percent (June-July). The pasture used early the first year is grazed progressively later during the second and third years.

Using riparian habitat as a key management area in conjunction with a deferred rotation grazing system has improved riparian area conditions on the Little Sandy Allotment in the Green River Resource Area of the Rock Springs District. This success is the result of sufficient flexibility, use supervision, and cooperation by permittees and the Wyoming Game and Fish Department. The sagebrush and grassland allotment is grazed by 2,500 cattle from May 1 to November 15 using five pastures, with riparian areas in each pasture. Herding and drift fencing control livestock movement from lower to higher range. Pasture moves are made so as to prevent adverse impacts in the riparian areas, avoiding bank trampling damage and excessive utilization. Sixty percent utilization of key herbaceous vegetation in riparian areas is used as a general rule to prompt pasture moves. One of the two lower pastures is always used first each spring due to elevational effects on range readiness, and the other is used last in the fall. Livestock graze the middle pasture twice per season going to and coming from the upper part of the allotment. They alternately graze the upper two pastures after seedripeness each year.

This management system has been in effect since 1980. Prior to that, bank trampling damage was evident, much of the streambanks lacked protective cover, plant

vigor was poor, willow reproduction was very limited, and wildlife habitat was nonproductive (Smith pers. comm.). After 16 years, conditions are much improved (Figures 15 and 16). Willow reproduction is apparent, banks are stabilized, plant vigor is improved, and the fish, beaver, moose, and duck habitat is productive again (Krosting and Christensen pers. comm.).



Figure 15. Riparian conditions on Little Sandy River in Little Sandy Allotment following July grazing treatment, 1986.



Figure 16. Riparian conditions on Lander Creek in Little Sandy Allotment, July 1986.

9. Rest-Rotation Grazing (Rotational Stocking)

Though the term “rotational stocking” is recommended over the term “rest-rotation grazing” (Forage and Grazing Terminology Committee 1991), rest-rotation is still commonly used in both application and literature, and thus, it is retained throughout this document. Rest-rotation is a grazing method that uses recurring periods of grazing and rest among two or more paddocks in a grazing management unit throughout the period when grazing is allowed. It differs from rotational deferred grazing in that it includes a year (or full growing season) with no grazing in the rotation for each pasture at least once in each cycle. There are great differences of opinion on the value of rest-rotation grazing, as generally applied, in the proper management of riparian areas.

Hormay (1976) emphasized that each rest-rotation system should be designed to meet the resource needs of the area. The amount of rest, stocking rate, and season of use should be determined by the manager based on the growth requirements of the vegetation present, all species considered. Rest-rotation does not dictate heavy grazing under any treatment (emphasis added).

As with deferred and deferred rotation strategies, a system that uses more pastures is usually better than one that uses fewer; however, in practical application, rest-rotation grazing has often used a three-pasture system. Cost and simplicity have often been factors in choosing a three-pasture system, and riparian objectives have rarely influenced pasture design and grazing strategy. Variation in ecological conditions and among stream types with different sensitivities to disturbance have contributed to mixed results, sometimes in the same management unit.

Masters and others (1996b) provide examples of two, three-pasture rest-rotation strategies in northern Nevada; one worked, the other did not. The goals on Strawberry Creek, (Figure 17) were to maintain healthy streamside vegetation and stable channel conditions. Continued success since the strategy was implemented in 1969 was attributed to cooperation between agencies and the permittee, inherently stable stream channel conditions, long-term attention to resource conditions, and careful herd management practices, including salt placement and herding livestock to improve distribution. On Wildcat Creek (Figure 18), past management had resulted in unstable eroding banks and deteriorated ecological conditions. Applying a three-pasture, rest-rotation strategy in a degraded system without adjusting livestock numbers resulted in the overgrazing of two pastures, and 1 year of rest did not allow system recovery. (Authors’ note: In this case, temporary exclusion to allow a “jumpstart” in the recovery process was probably warranted.) In addition to limitations imposed by the initial conditions, specified herd management practices were not followed, upland water developments had failed, and salt blocks continued to be placed near the stream channel.



Figure 17. Strawberry Creek maintained riparian condition with a three-pasture, rest-rotation system.



Figure 18. Wildcat Creek did not improve under the same kind of system.

Elmore and Kauffman (1994) cite 10 years of continued channel degradation in a high-gradient, high-energy stream system under three-pasture, rest-rotation grazing (Figure 19). Yet, in the same allotment, with the same system and the same livestock, another stream made an excellent recovery (Figure 20). The differences are due to stream type, sensitivity to disturbance, vegetation potential, and kind of

vegetation required to stabilize each stream. Rest-rotation favors herbaceous bank-forming vegetation, which is entirely adequate for the low-gradient stream depicted in Figure 20. However, willows needed for stabilizing the high-energy stream in Figure 19 continued to show a downward trend.



Figure 19. Higgins Creek, 1984. Channel degradation continued with 10 years of three pasture rest-rotation.



Figure 20. Beaver Creek, 1984. Three-pasture rest-rotation provided recovery of herbaceous bank-forming vegetation and associated channel characteristics.

Other successes with forms of rest-rotation in allotments with riparian areas have been reported:

- On several allotments in the Tonto National Forest in Arizona, rest-rotation systems, together with proper stocking and other management, resulted in cottonwood and willow regeneration along perennial streams. These systems incorporated high-intensity, short-duration grazing, with each pasture receiving spring-summer rest for 2 years out of 3. In 1978, the Sedow Allotment (34,800 acres) on the Globe Ranger District was placed under this system after the permitted 11,125 AUMs were reduced to 5,800 AUMs. When the system was initiated, the Walnut Spring area of the Storm Canyon pasture did not have cottonwood or willow between 0.1 and 10.2 cm (0.4 to 4 inches) in diameter. By 1982, the area supported 650 cottonwoods and 2,275 willows per hectare (263 and 920 per acre, respectively) in this size class (Davis 1982). The Superior Allotment is another that has responded positively to this same grazing system (Flanigan pers. comm.).
- On the Humboldt National Forest in north-central Nevada, a three-pasture, rest-rotation system in effect for 12 years has improved areas of degraded riparian habitat. The Wilson Creek Pasture Allotment is comprised of mixed sagebrush-grassland, with scattered stands of aspen and smaller quantities of fir and spruce. The grazing system provides for rest following seedripeness on the upland key species (Idaho fescue) in the first year, followed by rest from turnout (July 1) to seedripeness in the second year, and season-long rest in the last year of the cycle. This management has resulted in aspen and willow rejuvenation, streambank stabilization, and recovery of some of the former fishery (Easton pers. comm.). Although no utilization was sampled in the riparian area, utilization in the uplands was in the 35-40 percent range in 1985.
- Cooperation from permittees and the U.S. Forest Service, frequent use supervision, and a rest-rotation strategy have maintained and improved riparian habitat in the White Acorn Allotment of the Green River Resource Area of the Rock Springs District. This sagebrush grassland allotment with riparian areas and wet and dry meadows was formerly grazed by sheep, but is now grazed by 800 cattle (Kroosting and Christensen pers. comm.). Three pastures are managed under a deferred rotation system, while three other pastures are grazed under a rest-rotation system. Concern with riparian habitat is focused primarily in the three pastures on Blucher Creek. Prior to the change in management (1981), plant vigor was low, bank trampling damage was apparent, willows were the size of garbage cans, and wildlife habitat was in poor condition (Smith pers. comm.). The allotment management plan required herding for maintaining even distribution and control of livestock in each pasture. Riparian values are being maintained and improved under this management strategy. Most streambanks are stable, willow of all age classes are present, plant vigor is good, and the wildlife habitat is much improved.

10. Holistic Resource Management

Holistic Resource Management (HRM) was developed by Allan Savory. HRM, with its associated grazing and other practices, does not specify any set strategy.

However, most HRM applications use “time-control grazing” to concentrate animal

impacts in time and space, thereby avoiding regrazing before recovery and overresting plants adapted to herbivory. Time-control grazing is like high-intensity, short-duration grazing except that the rate of rotation varies with the rate of plant growth. Depending on how well it is planned and implemented, it can be good for riparian management. Because it specifies that management should focus on objectives and uses many pastures, there is limited opportunity for livestock distribution problems. At any time, a pasture can be skipped if site-specific management needs warrant it.

HRM has been used to improve general range conditions and riparian conditions on the Desert Land and Livestock Company ranch in north-central Utah. Prior to implementation of HRM, much of the rangeland on the ranch was in a deteriorated condition (Secrist pers. comm.). Many sagebrush-filled gullies were present in the lower elevations. Muddy water flowed in the drainages during snowmelt or following heavy rains. Riparian herbaceous vegetation was absent in most drainages including Saleratus, Negro Dan, Stacy Hollow, and others, and no willows could be found.

An HRM program was initiated on the ranch in 1979, with the objective of making a profit while improving the health of the range. Since grazing animals were originally part of the ecosystem, livestock were chosen as the tool for accomplishing this objective. Cattle, sheep, and buffalo are managed to control the timing and duration of grazing, as well as animal impact.

Flexibility in time control has been achieved by grouping animals into large herds (from 1,300 yearling heifers to 3,500 pairs and 6,000 yearling steers) and creating more pastures through fencing. Three cattle herds and six bands of sheep use 100 different pastures on the ranch. Depending on range conditions, vegetation, and economic goals, pastures are used one to three times per year; the majority are only used once. Stock density (animals per acre) has ranged from 0.5 to 3.5, depending on pasture size. Time in each pasture is determined by how fast plant growth is occurring. When growth is rapid, pasture moves are frequent. When growth is slow, the livestock stay longer in each pasture. When plants are dormant, lack of forage and animal performance determine when livestock are moved. Time in each pasture has ranged from 3 days (during rapid growth) to 100 days (during dormancy). During the growing season, the grazing animals are moved from pasture to pasture in an attempt to graze each plant severely only once, and then allow it to recover from the effects of defoliation before it is grazed again. Yearling cattle and sheep are moved by herding. The 3,500 pairs are trained to move from pasture to pasture by responding to a whistle.

Herd effects result in animal impact: 1) hooves break up (physical) soil crusts, enrich soil, and provide cover by incorporating manure, litter, and seeds into the soil surface, 2) urine adds urea to the soil, 3) hoofprints create seedbeds and pockets for collection of litter and precipitation where seeds are pressed into contact with mineral soil, and 4) grazing, trampling, crushing, etc., prunes plants to stimulate new plant growth. Animal impact, when properly managed, is very important to the health of these rangelands. The herd effects, particularly the hoofprint seedbeds, improve microsite conditions for the germination of seeds and establishment of seedlings, which can be the weakest link in the natural function of many range ecosystems.

New plants result in additional pathways for water to get into the soil reservoir where it is stored, purified, and slowly released into riparian areas. (Note: The physical effects described above can be detrimental in areas where microbiotic crusts are an important component and/or on soils with vesicular crusts.)

The ranch manager believes that this method of grazing results in an increase in ground cover, water infiltration, and soil moisture, and restores some of the natural hydrologic function to the watershed. Riparian vegetation has reestablished in the drainages, serving as a sediment trap that raises the water table. As this healing process continues, the bottom of the drainage rises in elevation, thus deepening and widening the riparian aquifer. As a result, riparian vegetation expands into the edges of the uplands and floods sagebrush. Clear water flows year-round and willows have established themselves where they did not exist before. The streambed in one drainage has increased more than 6 inches in elevation. Gully banks are slumping and are being vegetated by riparian plants. Sagebrush is dying as the riparian areas expand. Though precipitation and runoff were far above normal, the additional ground cover in the uplands and the improvement in the riparian habitat prevented significant erosion damage on the ranch in spite of increased stocking rates (Table 7) (Simonds pers. comm.).

Table 7. Stocking levels on the Desert Land and Livestock Company ranch.

	1979	1986
Cattle	4,500	10,460
Sheep	12,000	10,000 (approximate)
Elk	350	1,500
Buffalo	0	230

11. Total Rest

Depending on the riparian area objectives, tools and finances available, and time prescribed for reaching objectives, nonuse may be the best alternative for realizing the most rapid improvement. A deteriorated riparian area with few trees or shrubs, or one where the objective is to get woody plant regeneration above the reach of livestock, may require total rest, at least for a few years (Davis 1982).

Exclusion of livestock has produced improved riparian and aquatic habitat following 4 to 7 years of total nonuse, woody plant (shrub) recovery following 5 to 8 years of total rest, a doubling of fish biomass following 3 to 5 years of total rest, and attendant positive responses in birds and small mammals (Skovlin 1984). A study on Big Creek in northeast Utah concluded that a minimum of 6 to 8 years of nonuse was necessary to restore a deteriorated streamside riparian area to the point where livestock grazing could be allowed at reduced levels (Duff 1983). However, substantial recovery of streambanks and vegetation was observed following 4 years of exclusion of grazing by fencing.

C. Techniques that Attract Livestock Away from Riparian Areas

- Water development in upland areas that lack water is often a key factor in reducing livestock concentrations in riparian areas. Where feasible, water development can be achieved by installing solar, hydraulic ram, or conventional pumps; developing springs, seeps, wells, or guzzlers; and piping water to several troughs once collected. Even within riparian areas or riparian pastures, water developments, ponds, or troughs can reduce streambank trampling damage. However, they tend to concentrate disturbance rather than distribute it. Any water development should avoid creating new problems, such as excess soil erosion or vegetation/habitat impacts. Creating shade and locating rubbing posts and oilers nearby may augment water development and help reduce the time livestock spend in riparian areas.
- Planting palatable forage species on depleted upland areas can attract livestock away from riparian areas.
- Prescribed burning often enhances forage production, palatability, and upland use. In fact, the attraction often forces temporary rest until vegetation recovers.
- Placing salt, hay, grain, molasses, and other supplements only in upland areas away from riparian areas improves distribution. Except where salt and supplements are used to intentionally localize animal impacts, they should generally be placed no closer than 1/4 mile, and preferably 1/2 mile or more, from riparian areas and intermittent drainages (Riparian Habitat Committee 1982). Proper salting improves both distribution and utilization. At least one livestock operator relates that sawing salt blocks in half allows frequent movement of salt stations to minimize localized impacts of concentrated use.

Supplements can affect forage preference and selectivity. Energy supplements can increase browse utilization (although it may also depress utilization of fiber). High-protein supplements, such as cottonseed or soybean meals or cake, balance diets and increase consumption of cured grass that is protein-deficient.

However, there is anecdotal evidence that supplements such as cottonseed meal were also used extensively to get livestock to rid pastures of “unwanted” willows.

- Residual vegetation from previous years decreases forage palatability and quality and diverts grazing from new areas. Use patterns perpetuate themselves, and thus, when carefully planned, periodic forced intense use of pastures (e.g., by dry cows in an off season), can reduce “wolf plant” problems, improve distribution, and increase forage quantity and quality.

D. Techniques that Exclude or Promote Avoidance of Riparian Areas

- When properly located, well-constructed, and maintained, fencing can be an effective tool for controlling distribution. Fencing facilitates management of riparian areas by either including or excluding livestock use, depending on

management objectives. Sometimes exclusion fencing can be the most practical approach for initiating rapid riparian recovery or improving highly sensitive areas, or it can be a temporary measure for initiating recovery. The loss of forage from exclusion fencing may be inconsequential in many allotments. On 365 miles of Oregon streams, riparian areas comprise only 3.5 acres, 7 AUMs, or 100 cows for 2 days per mile (Elmore pers. comm.). Fencing water sources at springs and seeps and piping the water to adjacent areas is often the only effective measure for protecting small riparian areas. However, fencing may restrict wildlife and livestock movements in an undesirable manner. In addition, fence construction and maintenance can be costly and time-consuming.

- Barriers formed by placing trees and brush on streambanks may discourage livestock use and help stabilize eroding banks. Placing boulders (10 to 20 inches or larger) along streambanks where livestock trail and cause trampling damage can effectively displace livestock use and promote recovery (Myers pers. comm.).
- Hardened crossings and water access points are gravel pads that provide livestock sure footing on a gentle grade to water, either for crossing a stream or for drinking. Livestock prefer gravel pads over trying to negotiate steep, overhanging streambanks. During a roundup, cows will run for the gravel pad before trying to cross the stream (Massman ed. 1995).
- Frequent riding and herding can effectively control livestock distribution in some situations. On some rough or poorly watered ranges, proper herding may increase breeding, conception, and calf crops (Stoddart et al. 1975). Several of the successful strategies reported by Massman (1995) and Masters et al. (1996a and 1996b) also incorporate riding and herding into overall management.
- Bed grounds and other livestock handling facilities should be located away from riparian areas (Riparian Habitat Committee 1982).
- Locating livestock turnouts far away from overused riparian areas may help regulate the timing, duration, and amount of riparian use in large pastures that contain adequate stock water (Gillen et al. 1985).
- Gap fencing in conjunction with gullies, cliffs, and other natural barriers can regulate natural trailing or loafing by livestock in some riparian areas.
- Locating water gaps in rocky areas (natural or manmade) minimizes trampling damage to streambanks and streambeds. Narrow water gaps discourage livestock from loafing at the water source.

E. Herd Management and Animal Husbandry Practices

- Culling practices are traditionally aimed at improving animal performance in conception rates, weaning weights, conformation, etc. However, some operators also cull on habitat use tendencies and foraging characteristics. Roath (1980)

and Bailey et al. (1996) indicate that within breeds, or even herds, certain individuals tend to spend more time in the bottoms while others tend to forage widely. George (in press) found that culling could rid herds of individuals that spend disproportionate time in the bottoms. The permittee on the Bruneau Allotment in Nevada culled “riparian loafers” and stated that this practice led to a more robust herd of mother cows that remained on hillslopes more and produced larger calf crops with higher weaning weights.

- Unrestricted use by cow-calf pairs generally impacts riparian areas more than use by other kinds/classes of livestock. They tend to concentrate, loaf, and forage in bottoms. Yearling cattle, particularly steers, generally tend to be wider ranging and use more of the adjacent uplands.
- Changing the kind of livestock adjusts both the distribution pattern and forage preference. Herded sheep offer several options for achieving proper management in certain riparian areas. Sheep use may be more desirable than cattle use in some areas due to the herders' control over location, timing, degree, duration, and frequency of use. Sheep prefer hillsides to the confining nature of riparian bottoms. If not bedded in a riparian area meadow, the herder can easily move them to uplands or ridge tops. Generally, herders want to keep flocks or bands moving so as to facilitate forage selectivity. The quality of herding controls riparian effects and the rate of gain (Glimp and Swanson 1994). Sheep may do less physical damage to herbaceous plants due to their nibbling characteristics, whereas cattle and horses can dislodge plants from the soil because they graze with a pulling motion. When properly herded, sheep cause less trampling damage than cattle (Stoddart et al. 1975).

Sheep under unherded conditions have been observed to consume spring willow growth in Oregon when adequate herbaceous forage was available (Elmore, pers. comm.). Heavy browsing of young willow growth by unherded sheep was observed in southern Wyoming during spring, summer, and fall where the herbaceous vegetation was dominated by coarse forage such as sedges and rushes.

Horse use during the winter in some areas may result in bark being stripped from deciduous trees (Kindschy pers. comm.). However, horses are primarily regarded as grass eaters, and they generally congregate less than cattle (Stoddart et al. 1975). The concentration of wild horses on riparian meadows has been reported to result in severe riparian impacts (Platts pers. comm.). Concentrated spring or seep use causes problems in other areas.

- Most livestock operators would not consider a change in breed of livestock simply to improve distribution. However, breed habits might become a consideration if an operator is considering a change for other reasons. Higher heat tolerance (and related foraging characteristics) of Brahman, Brahman crosses, and other zebu types is often a consideration in southern and southwestern states, for example. Extension livestock specialists are a good source of information about animal characteristics and habits.

VI. Monitoring

No discussion of grazing management would be complete without considering monitoring. Once objectives have been established and a grazing strategy selected and implemented to achieve those objectives, the only way to evaluate success or failure is through monitoring. Monitoring should include both short-term and long-term strategies. Short-term monitoring includes annual documentation of implementation activities, events, and interpretive measurements or observations of effects that influence progress toward objectives. Long-term monitoring documents and measures trends toward or achievement of objectives, usually over a period of years.

Many agency, interagency, and extension references guide planning, method selection, and analysis and interpretation of monitoring data. A few examples are presented below (full citations are presented in the References section):

- Rangeland Monitoring - Planning For Monitoring (USDI 1984) and others in the BLM TR 4400 series
- Methods for Evaluating Riparian Habitats With Applications to Management (Platts et al. 1987)
- Inventory and Monitoring of Riparian Areas (Myers 1989b)
- Monitoring Protocols to Evaluate Water Quality Effects of Grazing Management on Western Rangeland Streams (Bauer and Burton 1993)
- Herbaceous Stubble Height as a Warning of Impending Cattle Grazing Damage to Riparian Areas (Hall and Bryant 1995)
- Rangeland Analysis and Management Training Guide (USDA 1996) and other USFS regional guides
- Sampling Vegetation Attributes (Interagency Technical Team 1996a)
- Utilization Studies and Residual Measurements (Interagency Technical Team 1996b)

It would not be feasible to summarize the measurement techniques in these references or even list all of the applicable references, but there are a few points worth emphasizing.

A. General

All stated management objectives require some strategy for monitoring their accomplishment. Likewise all monitoring should tie directly to the analysis of and accomplishment of specified objectives. This may seem obvious, but in an analysis of 20 grazing allotments in northeastern California and northwestern Nevada, Olson (1989) found that not one combined all the elements of a systematic process by

linking goals, issues, and objectives with action, monitoring, and evaluation. Olson states, "Management objectives, overall, were not measurable or realistic, providing no solid vegetative benchmarks for determining management successes. In the cases where management objectives were both measurable and obtainable, the supporting monitoring studies and evaluations were incomplete." Subsequent program reviews have identified similar problems in virtually every location to one degree or another. Monitoring that has no direct relationship to objectives is another frequent problem that increases costs and usually detracts from necessary monitoring and administrative tasks.

B. Short-Term Monitoring

1. Implementation

The best strategy will surely fail if it is not followed. Therefore, implementation or "compliance" monitoring is essential. Implementation monitoring is simply ensuring that livestock are in the right place, at the right time, in the right numbers, and that any additional measures to improve distribution are being taken. Without tracking what was done and where which animals were when, managers will not understand why strategies worked or failed.

Compliance with a grazing system is critical. When stock are moved from a management pasture, it is commonplace for a few animals to be overlooked. If a few undetected livestock drift back or reenter a grazed pasture through faulty fences or ineffective natural barriers, they can quickly "undo" any progress that deferment or rest might have accomplished. It only takes a few weeks of unauthorized use or overgrazing to set back years of progress in improving riparian systems (Duff 1983). In one stream, annual use by a few head of unauthorized livestock throughout most of the hot season period has nullified positive riparian habitat responses in an otherwise excellent grazing system (Myers 1981).

2. Seasonal, Annual, and Cyclic Events

Long-term monitoring studies or use maps require documentation of seasonal, annual, and cyclic events such as fire, insect infestations, disease, weather, and associated hydrologic phenomena. Such effects must be distinguished from the effects of grazing for evaluation. The effects of weather-associated phenomenon are often less distinct. Floods and droughts can have both beneficial and detrimental effects on riparian plant communities, as well as on channel characteristics.

Floods may widen channels and increase width/depth ratios, which is generally not beneficial. However, floods may also redistribute sediments to floodplains, recharge shallow aquifers, and initiate recruitment of many plants (especially willows and cottonwoods) depending on timing, discharge, channel shape, and floodplain access. Key points to be considered are: 1) whether or not livestock grazing or bank disturbance before or after a flood led to additional widening, and 2) whether the grazing strategy allowed for establishment of plant species dependent on floods for recruitment.

Droughts increase moisture stress on plants and plant communities, which tends to concentrate livestock and wildlife in riparian areas even more than normal. They also tempt the use of pastures slated for rest. However, low flows associated with droughts reduce the stress on banks, and there is usually enough water in channels to continue to support hydric, bank-forming vegetation. Given the chance, most perennial vegetation helps channel narrowing and bank building with fine sediments transported after reduced flows. Key points to be considered are: 1) whether or not the timing, intensity, and duration of grazing during the drought allowed for plant colonization and stabilization of exposed banks or wide channel edges, and 2) whether the grazing strategy leaves enough residual vegetation (or regrowth) to trap and retain fine sediments for bank building.

3. Utilization and Stubble Height

Measurements of utilization and stubble height (residual vegetation) help interpret whether or not long-term objectives were met. Utilization or stubble height can be monitored annually or more frequently, and can guide stock movement decisions where needed or appropriate. However, measuring progress toward long-term resource objectives, such as bank stabilization, rebuilding of the streamside aquifer, or reestablishment of beaver, fish, or moose habitat, requires years of intervening management. Herbaceous stubble height is usually easier to document. It is easier to measure what is there than what is gone. Stubble height can be an excellent tool for warning of impending damage to riparian areas (Hall and Bryant 1995).

Timing of utilization of key species with respect to plant phenology often affects subsequent growth and reproduction more than amount of utilization. Therefore utilization mapping relative to plant growth and community distribution can provide more insight to the appropriateness of a particular grazing strategy than utilization of a key area alone. Utilization maps also describe the pattern of livestock use relative to topography, vegetation, water, salt, season, and all other management factors. It therefore can guide adjustments better than most other forms of monitoring information. However, accuracy and precision limitations of utilization measurements should be recognized in all interpretations. There is often high sampling variability among sites and among observers, especially for shrubs. Because of these limitations, high confidence levels require intensive sampling and more time and money. In addition, relative utilization (utilization determined at any time other than peak standing crop) has little relationship with utilization at peak standing crop for determining plant or community response to defoliation. Therefore, interpretations should be made with caution!

In spite of the potential limitations and for lack of a better tool, many managers have had to establish utilization guidelines for short-term management considerations. To establish utilization guidelines, the manager should know and consider the growth habits and characteristics of the important plant species; how they respond to grazing and browsing; and the characteristics, preferences, and requirements of the grazing-browsing animals. Utilization guidelines, where used for riparian areas and riparian pastures, should:

- Maintain both herbaceous and woody species (where present) in a healthy and vigorous condition and facilitate their ability to reproduce and maintain different age classes in the desired riparian plant community.
- Leave sufficient plant residue to protect banks, filter sediment, and dissipate flood energy during runoff events.
- Maintain consistency with other resource values and objectives; e.g., esthetics, water quality, etc.
- Limit streambank shearing and trampling to acceptable levels. (However, bank trampling guidelines should be set separately for stream reaches where this is important.)

In some cases, setting proper utilization guidelines requires trial and error through monitoring, analysis, and evaluation of the results after adjusting management. Because initial results may vary from expectations, the manager should not hesitate to change key species or utilization guidelines to meet objectives.

C. Long-Term Monitoring

If the relationships between objectives and monitoring are maintained, the establishment of long-term trend studies is well underway. Because of the central role and inherent variety in appropriate management objectives, useful and appropriate measurement/monitoring techniques vary widely. No short list could be complete, and each technique requires a detailed description to guide its proper application.

However, there is one aspect of long-term vegetation monitoring in riparian areas that is significantly different than monitoring in uplands and often leads to confusing interpretations. Riparian ecological sites or plant communities can move as streams move and change their distribution and extent over time (Gebhardt et al. 1990) (Winward and Padgett 1986) with changing water tables, etc. Many objectives tied to kind, proportion, or amount of vegetation are best monitored by methods that account for changes along the stream edge (green line) or throughout the riparian complex. The Integrated Riparian Evaluation Guide (USDA 1992) and others describe methods to account for these phenomena rather than rely on a fixed point or plot as is common for upland sites.

VII. Learning from Experience

Grazing prescriptions and associated management of riparian areas should be monitored, evaluated, and reconsidered regularly. Managers should not hesitate to identify problems and make changes in grazing treatments, and to take risks and try new alternatives to achieve objectives. But along with this, it is important that the conditions under which each system does and does not work be documented.

Existing documentation of successful grazing management in riparian areas is only marginal. Documentation of successes, as well as of failures, is essential for learning from past efforts. Any riparian monitoring plan should mandate before and after photos, with backup data, to show the effects of management. Documenting pre-treatment resource conditions provides a basis for interpreting results and avoiding past mistakes, and provides a “springboard” for exploration of other options. Successes and lessons learned should be shared through presentations at meetings of professional societies, the livestock community, conservation groups, and agency workgroups, and in professional and popular publications.

VIII. Cardinal Rules for Planning and Managing Grazing in Riparian Areas

- Adapt grazing management to the conditions, problems, potential, objectives, public concerns, and livestock management considerations on a site-specific basis.
- Manage grazing to grow and leave sufficient vegetation stubble on the banks and overflow zones to permit the stream to function naturally.
- Identify and implement alternatives to passive, continuous grazing.
- Take advantage of seasonal livestock preference for uplands in grazing prescriptions.
- Employ rest from livestock grazing whenever appropriate.
- Consider the whole watershed and all important resource issues.
- Include all those willing to learn the details and contribute ideas or work for better management, including the livestock user and other interests. Everyone involved should understand and agree on the problems and objectives, as well as understand the changes that can occur and how they can benefit from proper management and improved riparian conditions.
- Involve the livestock user in designing the grazing system and monitoring the results.
- Build flexibility into grazing management to accommodate changes based on need.
- Implement frequent (sometimes daily) use supervision by the parties involved once management is in progress so that adverse impacts (e.g., trampling damage and excessive utilization) can be foreseen and avoided.
- Document mistakes so they are not repeated.
- Use management successes to promote good riparian area management elsewhere.

Appendix A

I. Indicators of High-Quality Riparian Habitat

Riparian areas are the most important wildlife habitat type. Following are indicators of quality habitat which can be considered when designing management objectives for riparian area management in the Great Basin and similar areas, including the Great Plains, and toward which grazing management practices can be designed. These factors can also be used as indicators of quality habitat for other species as well.

A. Fish Habitat

Platts et al. (1977) list the following indicators of good fish habitat in the Great Basin (these are also good indicators of bank stability):

- Adequate vegetation canopy to maintain acceptable water temperatures for the fish species involved
- Well-vegetated streambanks to minimize soil loss and trampling damage
- Overhanging vegetation (within 1-2 feet of water surface) on 50 percent or more of the streambank, and especially on outside bends of streams, to provide fish cover

Individual sites may possess limitations that preclude accomplishing all of the above. However, the type, density, height, diameter, and age class of vegetation needed for good fish habitat should be included in the management objectives.

Bisson et al. (1992) provide further that management practices for quality fish habitat should:

- Provide for habitat complexity—land use practices that have led to simplified streams characterized by straightened, confined channels have had the most pervasive cumulative impacts on fish populations
- Preserve physical and biological linkages between streams, riparian zones, and upland areas that provide transfer processes for woody debris, coarse sediment, and organic matter
- Provide a greater range of vegetative species and structural diversity, thus providing future sources of large woody debris, floodplain connections, and other linkages important to ecosystem function

In designing grazing systems to improve fisheries, a fisheries biologist should be consulted to ensure the treatments are tailored to the site-specific and watershed resources present.

B. Waterfowl Habitat

Mazzoni et al. (1977) made several recommendations for management of waterfowl production habitat in the Omat Basin:

- Manage for native plant communities where possible. Where this is not practical, manage for introduced species best adapted to the site that give the greatest density with the tallest and most erect growth form.
- Ideally, areas managed for production should contain one-third open water and two-thirds marsh vegetation.
- Fence critical areas or place salt, water, and supplements for livestock away from critical production areas. Where fencing is impractical, islands or artificial structures are recommended.
- Where maximum nest density and nesting success is desired, manage for high, erect growth forms in 80-acre or larger blocks. These areas should be ungrazed until the vegetation begins to mat.
- Several years of nonuse may be required to promote homing, larger clutches, and earlier nesting of waterfowl species.
- Most nesting starts before the current year's vegetative growth is useable (tall enough or long enough) for nesting. Grazing should be managed to provide for increases in residual nesting cover which will carry over for the following year. This carryover should be comprised of abundant ground litter and erect and recumbent vegetation. These characteristics help deter predation and provide ideal temperature and moisture conditions for a good hatch.
- Grazing formulas that prescribe deferred grazing in areas with good residual vegetation from the previous year provide maximum benefits to nesting waterfowl (Mazzoni et al. 1977).

In a study of rest-rotation grazing and waterfowl production in Montana, Gjersing (1975) suggested that:

- Livestock should be moved from the pasture and gates closed at the end of the early treatment (spring and summer grazing) to provide for residual cover and regrowth.
- Grazing of these or other rested pastures with residual cover should be delayed the following year until incubation is complete (Gjersing 1975).

II. Willow and Cottonwood Stand Regeneration and Management

Although the following items do not specifically relate to grazing management, some are indirectly related and may prove useful in planning for proper management.

A. Willows

Pillmore (1983) reported the following findings on willow:

- Bare soil with moisture above or at the surface and temperatures above freezing are required for germination.
- The duration of seed viability is short (6-7 weeks).
- For survival, seedlings require continuous high soil moisture availability.
- Willows can tolerate 2 to 4 weeks of flooding, but no more than 200 to 400 mg/L of total dissolved solids.
- Willows can only tolerate 2 to 4 weeks of moisture stress and require that the water table be within 12 feet of the surface.

There are many species of willow native to the western rangeland. Habitat preference and growth form vary widely.

B. Cottonwoods

Cottonwoods usually don't regenerate naturally in existing stands until the overstory has declined due to harvest or death. This is due to competition for moisture and light. The best conditions for seed germination are moist gravel, sand, or silt exposed to full sun.

Soil disturbance or exposure is usually necessary to achieve sprouting or reproduction from seed (Beeson 1983). Seed viability is short-lived. A constant supply of moisture is essential during the first few weeks of seedling growth to ensure survival. Cottonwood seedlings frequently appear following high runoff and silt deposition in conjunction with peak seed dispersal (Fenner et al. 1985).

Studies on cottonwood in northeastern Colorado indicated that although the most important factor in cottonwood regeneration is water management, livestock and fire are beneficial in controlling competition from herbaceous vegetation during the period of the summer when cottonwood seed is disseminated and seedling growth is likely (Crouch 1979). If an area contains inadequate forage, grazing will likely result in loss of seedlings.

There should also be a number of age classes of cottonwoods. To obtain this result, the manager will need to ensure suitable site conditions and require protection from browsing or other damage of seedlings during establishment. Additionally, Pillmore (1983) found that cottonwoods:

- Can stand flooding for only 7-16 days
- Can tolerate only 200 to 400 mg/L of total dissolved solids
- Are capable of living under only 24 weeks of moisture stress
- Can survive when the water table is within 20 feet of the soil surface

Some streams in Colorado with much greater concentrations of dissolved solids support cottonwoods.

Willow, cottonwood, and aspen sprout from stumps and roots. Livestock, especially cattle, annually consume this reproduction when “overgrazing” during summer and fall is allowed. Beaver play a natural role in stimulating suckering and sprouting. If good beaver habitat is to be maintained, it is essential that stumps be protected from summer livestock use for 3 to 5 years following cutting by beaver (Kindschy pers. comm.). USDA (1985) provides an exhaustive treatment of aspen ecology and management.

Literature Cited

- Bailey, D.W., J.E. Gross, E.A. Laca, L.R. Rittenhouse, M.B. Coughenour, D.M. Swift, and P.L. Sims. 1996. Mechanisms that result in large herbivore grazing distribution patterns. *J. of Range Manage.* (49)5.
- Bauer, S.B. and T.A. Burton. 1993. Monitoring protocols to evaluate water quality effects of grazing management on western rangeland streams. Idaho Water Resources Research Institute, University of Idaho. Moscow. 179 p.
- Beeson, T. 1983. Monitoring the cottonwood - willow association. In: Management of cottonwood - willow riparian associations below elevation 8000 in Colorado. Colorado Chapter-The Wildlife Society. p. 37-39.
- Binns, M. and R. Remmick. 1986. Effect of drainage-wide habitat management on Bear River cutthroat trout (*Salmo clarki* Utah) populations and habitat. In: Proc. Colorado-Wyoming Chapt. Am. Fish. Soc. Ann. Meeting. Fort Collins, CO.
- Bisson, P.A., T.P. Quinn, G.H. Reeves, and S.V. Gregory. 1992. Best management practices, cumulative effects, and long-term trends in fish abundance in Pacific Northwest river systems. In: Naiman, R.J. (Ed.). 1992. Watershed management. Springer-Verlag, New York. 542 p.
- Buckhouse, J.C. and W. Elmore. 1991. Grazing practice relationships: predicting riparian vegetation response from stream systems. In Bedell, T.E. (Ed.), Watershed management guide for the interior Northwest. Oregon State University Publication EM 8436. Oregon State University, Corvallis.
- Cheney, E., W. Elmore, and W.S. Platts. 1990. Livestock grazing on western riparian areas. U.S. EPA, Northwest Information Center, Inc., Eagle, ID. 45 p.
- Clary, W.P. and B.F. Webster. 1989. Managing grazing of riparian areas in the Intermountain Region. Ogden, UT:USDA, Forest Service, Intermountain Research Station. Gen. Tech. Rep. INT-263. 11 p.
- Crouch, G. 1979. Long-term changes in cottonwoods on a grazed and an ungrazed plains bottomland in northeastern Colorado. USDA, Forest Service. Rocky Mountain For. and Range Exp. Sta. Res. Note RM-370. Fort Collins, CO.
- Davis, J. 1982. Livestock and riparian habitat management - Why not? In: Proc. of 62nd Western Assoc. of Game and Fish Commissioners Meeting. Las Vegas, NV. p. 225-232.
- Duff, D.A. 1983. Livestock grazing impacts on aquatic habitat in Big Creek, Utah. In: Menke, J.W. (Ed.) Proc. of the Workshop on Livestock and Wildlife - Fisheries Relationships in the Great Basin. May 3-5, 1977. Sparks, NV. Special Publication 3301. University of California, Berkeley. p. 129-142.

- Easton, R. Jarbidge District Ranger. USFS, Buhl, ID. Personal communication.
- Ehrhart, R. (In press). Riparian grazing guidelines and techniques. University of Montana extension bulletin. University of Montana, Missoula, MT. 11 p.
- Elmore, W. Riparian Management Specialist. BLM, Prineville, OR. Personal communication.
- . 1987. Riparian management - back to basics, the public lands during the remainder of the 20th Century. Unpublished paper presented at "The Public Lands During the Remainder of the 20th Century," 8th Annual Summer Program, Natural Resources Law Center, University of Colorado School of Law, Boulder, CO. June 8-10, 1987. 8 p.
- Elmore, W. and B. Kauffman. 1994. Riparian and watershed systems: degradation and restoration. In: Ecological implications of livestock herbivory in the west. Vavra, M., W.A. Laycock and R.D. Pieper (Eds.). Society for Range Management, Denver, CO. 297 p.
- Evans, C. Fisheries biologist. BLM, Elko District, NV. Personal communication.
- Fenner, P., W. Brady, and D. Patton. 1985. Effects of regulation of water flows on the regeneration of Fremont cottonwood. *J. of Range Manage.* 38(2):135-138.
- Flanigan, D. District Range and Wildlife Staff Officer. USFS, Globe, AZ. Personal communication.
- Forage and Grazing Terminology Committee. 1991. Terminology for grazing lands and grazing animals. Pocahontas Press, Inc., Blacksburg, VA. 38 p.
- Gebhardt, K., S. Leonard, G. Staidl, and D. Prichard. 1990. Riparian area management—riparian classification review. TR 1737-5. USDI, Bureau of Land Management - Service Center, Denver, CO. 56 p.
- George, M. (In press). Management practices to change livestock behavior in grazed watersheds. In: S. Swanson, M. George, J. Buckhouse and R. Larson. Evaluation of effectiveness of livestock and range management practices in grazed watersheds. U.S. EPA. 42 p.
- Gillen, R., W. Krueger, and R. Miller. 1985. Cattle use of riparian meadows in the Blue Mountains of northeastern Oregon. *J. of Range Manage.* 38(3):205-209.
- Gjersing, F. 1975. Waterfowl production in relation to rest-rotation grazing. *J. of Range Manage.* 28(1):37-42.
- Glimp, H.A. and S.R. Swanson. 1994. Sheep grazing and riparian and watershed management. *Sheep Research Journal, Special Issue:* 65-71.

- Green, D.M. 1991. Soil conditions along a hydrologic gradient and successional dynamics in a grazed and ungrazed montane riparian ecosystem. Ph.D. Diss. Oregon State University, Corvallis, OR. 236 p.
- Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian zones. *Bioscience* 41:540-551.
- Hagener, L. Range Conservationist. BLM, Dillon, MT. Personal communication.
- Hall, F.C. and L. Bryant. 1995. Herbaceous stubble height as a warning of impending cattle grazing damage to riparian areas. GTR PNW-GTR-362. Portland, OR. USDA, Forest Service, Pacific Northwest Research Station. 9 p.
- Hormay, A. 1976. Memo to Manager, BLM Rock Springs District, WY, documenting a discussion with Bruce Smith, Fisheries Biologist.
- Interagency Technical Team. 1996a. Sampling vegetation attributes. USDI, Bureau of Land Management - National Applied Resource Sciences Center, Denver, CO. 172 p.
- . 1996b. Utilization studies and residual measurements. USDI, Bureau of Land Management - National Applied Resource Sciences Center, Denver, CO. 176 p.
- Kindschy, R. Wildlife Biologist. BLM, Vale, OR. Personal communication.
- Kovalchik, B.L. and W. Elmore. 1991. Effects of cattle grazing systems on willow-dominated plant associations in central Oregon. In: Symposium on ecology and management of riparian shrub communities. May 29-31, 1991. Sun Valley, ID. p. 111-119.
- Kroosting, D. and T. Christensen. Range Conservationists. BLM, Rock Springs, WY. Personal communication.
- Krueger, W.C. 1996. Managing ungulates to allow recovery of riparian vegetation. In: Proceedings of Sustaining Rangeland Ecosystems, August 1994, La Grande, OR. Agric. Exp. Sta. Special Rpt. 952, Oregon State University, Corvallis.
- Marlow, C. 1985. Controlling riparian zone damage with little forage loss. *Montana Agresearch*. Fall 1985. 2(3):1-7.
- Marlow, C. and T. Pogacnik. 1985. Time of grazing and cattle-induced damage to stream banks. In: Proc. of the First N. Am. Riparian Conf. U.S. Dep. Agric., For. Serv. General Tech. Report RM- 120. p. 279-284.

- Massman, C. (Ed.). 1995. Riparian grazing successes on Montana ranches. Conservation Districts Bureau, Montana Dept. of Nat. Resources and Conservation, Helena. 30 p.
- Masters, L., S. Swanson, and W. Burkhardt. 1996a. Riparian grazing management that worked: I. Introduction and winter grazing. *Rangelands* 18(5) 192-195.
- . 1996b. Riparian grazing management that worked: II. Rotation with and without rest and riparian pastures. *Rangelands* 18(5) 196-200.
- Mazzoni, J., M. Barber, R. Critchlow, and W. Miller, and G. Studenski. 1977. Livestock and waterfowl. In: Proc. of the Workshop on Livestock and Wildlife - Fisheries Relationships in the Great Basin. May 3-5, 1977. Sparks, NV. University of California, Berkeley. Special publication 3301. p. 87-91.
- Moore, E., E. James, F. Kinsinger, K. Pitney, and J. Samsbury. 1979. Summary of best management practices for minimizing or preventing adverse water quality impacts. In: Livestock Grazing Management and Water Quality Protection (State of the Art Reference Document) - EPA Publication 9190/9-79-67. p. 13-19.
- Mosley, J. 1996. Grazing management to enhance riparian habitat. Presentation at 25th Annual Pacific Northwest Range Management Short Course, Boise, ID.
- Myers, L. 1981. Grazing on stream riparian habitats in southwestern Montana. In: Proc. Montana Chapter of the Wildlife Society Meeting.
- . Wildlife Biologist. BLM, Dillon, MT. Personal communication.
- . 1989a. Grazing and riparian management in southwestern Montana. Fifteen years experience. Proc., Practical Approaches to Riparian Resource Management an Educational Workshop. Billings, Montana.
- . 1989b. Riparian area management—inventory and monitoring of riparian areas. TR 1737-3. USDI, Bureau of Land Management - Service Center, Denver, CO. 89 p.
- Netherly, P. and D. Hendersen. Range Conservationists. BLM, Kemmerer, WY. Personal communication.
- Olson, N.C. 1989. Quality assessment of twenty allotment management plans from the Surprise Valley Resource Area. MS thesis, University of Nevada - Reno. 89 p.
- Pillmore, R. 1983. Maintaining the cottonwood - willow association. In: Management of cottonwood-willow association below elevation 8000 in Colorado. Colorado Chapter - The Wildlife Society. p. 37-39.

- Platts, W.S. Research Fishery Biologist. Intermountain Forest and Range Experiment Station, Boise, ID. Personal communication.
- Platts, W.S. and R. Nelson, 1985. Will the riparian pasture build good streams. *Rangelands*, 7(1):7-10.
- Platts, W.S. and R.L. Nelson. 1989. Characteristics of riparian plant communities with respect to livestock grazing. In: Gresswell, R.E. (Ed.), *Practical approaches to riparian resource management*, May 8-11 1989, Billings, MT. USDI, Bureau of Land Management. p. 73-81.
- Platts, W.S. and R. Raleigh. 1984. Impacts of grazing on wetlands and riparian habitat. In: *Developing Strategies for Rangeland Management*. p. 1105-1128.
- Platts, W.S., C. Armor, G.D. Booth, M. Bryant, J.L. Burford, P. Cuplin, S. Jensen, G.W. Lienkemper, G.W. Minshall, S.B. Monson, R.L. Nelson, J.R. Sedell, and J.S. Tuhy. 1987. Methods for evaluating riparian habitats with applications to management. GTR INT-221. Ogden, UT: USDA, Forest Service, Intermountain Research Station. 177 p.
- Platts, W.S., R.J. Behnke, J.C. Buckhouse, O.E. Casey, E.W. Claire, J. Cooper, D.A. Duff, W.A. Evans, G. Haugen, P.E. Marcuson, W.R. Meehan, R.W. Phillips, R.F. Raleigh, and J.M. Skovlin. 1977. Livestock interactions with fish and their environments. In: Menke, J.W. (Ed.). *Proc. of the Workshop on Livestock and Wildlife - Fisheries Relationships in the Great Basin*. May 3-5, 1977. Sparks, NV. Special Publication 3301. University of California, Berkeley. p. 36-41.
- Prichard, D., H. Barrett, J. Cagney, R. Clark, J. Fogg, K. Gebhardt, P.L. Hansen, B. Mitchell, and D. Tippy. 1993. Riparian area management—process for assessing proper functioning condition. TR 1737-9. USDI, Bureau of Land Management - Service Center, Denver, CO. 60 p.
- Prichard, D., C. Bridges, R. Krapf, S. Leonard, and W. Hagenbuck. 1994. Riparian area management—process for assessing proper functioning condition for lentic riparian-wetland areas. TR 1737-11. USDI, Bureau of Land Management - Service Center, Denver, CO. 46 p.
- Riparian Habitat Committee - Western Division American Fisheries Society. 1982. *The best management practices for the management and protection of western riparian stream ecosystems*. American Fisheries Society, Western Division. 45 p.
- Roath, L.R. 1980. Cattle grazing and behavior on a forested mountain range and their relationship to acute dietary Bovine Pulmonary Emphysema. Ph.D. dissertation. Oregon State University, Corvallis.

- Rosgen, D. 1996. Applied river morphology. Wildland Hydrology, Pagosa Springs, CO.
- Secrist, G. Range Conservationist. BLM Washington, DC. Personal communication.
- Simonds, G. Manager, Desert Ranch. Woodruff, UT. Personal communication.
- Skovlin, J. 1984. Impacts of grazing on wetlands and riparian habitat: A review of our knowledge. In: Developing Strategies for Rangeland Management. p. 1101- 1103.
- Smith, B. Wildlife Biologist. BLM, Rock Springs, WY. Personal communication.
- Stoddart, L., A. Smith, and T. Box. 1975. Management for proper range use. In: Range Management, Third Edition. McGraw-Hill Book Co. New York, NY. p. 256-289.
- Stuth, J.W. 1991. Foraging behavior. In: Heitschmidt, R.K. and J.W. Stuth (Ed.). Grazing management: an ecological perspective. Timber Press, Inc., Portland, OR.
- Thomas, J.W. and C. Maser (Eds.). 1986. Wildlife habitats in managed rangelands - The Great Basin of southeastern Oregon, Riparian zones. USDA Forest Service and USDI Bureau of Land Management General Tech. Report PNW-80. Special edition. Portland, Oregon. 18 p.
- Thomas, J.W., C. Maser, and J.E. Rodiek. 1979. Riparian zones in managed rangelands - Their importance to wildlife. In: Proc. of the Forum on Grazing and Riparian Stream Ecosystems. Trout Unlimited. Denver, CO. p. 21-31.
- USDA. 1985. Aspen: Ecology and management in the western United States. General technical report RM-119. USDA Forest Service. Rocky Mountain Forest and Range Experiment Station. 283 p.
- . 1992. Integrated riparian evaluation guide. USDA, Forest Service. Intermountain Region, Ogden, UT.
- . 1996. Rangeland analysis and management training guide. USDA, Forest Service. Rocky Mountain Region. Denver, CO.
- USDI. 1984. Rangeland monitoring—planning for monitoring. TR 4400-1. USDI, Bureau of Land Management - Service Center, Denver, CO. 25 p.
- . 1995. Riparian-wetland initiative for the 1990's - annual report of accomplishments for fiscal year 1995. USDI, Bureau of Land Management. 43 p.
- Van Haveren, B. and B. Jackson. 1986. Concepts in stream riparian rehabilitation. In: Trans. 51st North American Wildlife and Natural Resources Conference. Wildlife Management Institute. Washington, DC. p. 280-289.

Winward, A.H. and W.G. Padgett. 1986. Special considerations when classifying riparian areas. In: Proceedings—Land classifications based on vegetation: applications for resource management. USDA Forest Service Intermountain Research Station. Gen. Tech. Rep. INT-257:176-179.

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13. ABSTRACT *(Maximum 200 words)*

This document presents information from various land managers and researchers to guide livestock management in riparian areas using their unique responsiveness to accomplish management objectives. An ecosystem approach, in which riparian areas are considered as part of a larger landscape, is used. Development of site-specific grazing prescriptions based on the function, capability, and potential of the site is discussed, and examples of grazing treatments are provided

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