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Riparian and Watershed Systems: Degradation and Restoration

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Abstract

Diaries of travelers and emigrants that passed through western rangelands between the years 1812-1880 reported dense and continuous stands of willows interspersed with wide, wet meadows along stream systems. By the turn of the century these riparian corridors were fragmented into thinner and less continuous bunches in many places. Damage to riparian systems was completed after World War II when extensive channelization and phreatophyte control was standard practice. At the same time the uplands, in many areas of the west, were becoming afforested with juniper and extensive stands of sage. This was probably a result of fire suppression and overgrazing. This afforestation has resulted in seeps and small streams drying up, or experiencing much lower summer base flows. The reduction of water, coupled with a lowering of the adjacent streamside water table from channel downcutting, has created conditions favoring the establishment of xeric plant communities. Steams and their floodplains are dynamic, and riparian vegetation density and contiguousness depends on the geomorphic setting. Unconstrained steams (wide valleys or floodplains less than twice the active channel width) have the greatest potential for elevating water tables and restoring native riparian plant communities. In-channel habitat restoration may aid in raising the water table, however, care must be exercised in its use. Riparian exclosures (and livestock reductions) are still the preferred methods for recovery of the shrub component of riparian vegetation by many groups. However, livestock grazing can be present in some areas while streams are improving. Grazing strategies that link the uplands, the riparian areas, and the stream channels must be used if we are going to have an effective and self-sustaining riparian restoration program.

Historical

Historical accounts by the first Euro-americans to venture into the western rangelands of North America often included descriptions of dense stands of willows (*Salix* spp.) that were interspersed with wetland meadows along meandering stream systems (Ogden 1824-26). Since that time a myriad of land uses has dramatically changed the character of western riparian ecosystems. The first major anthropogenic (i.e. human caused) effects that influenced the composition, structure, and function of many western stream systems came through the extirpation of beaver (*Castor canadensis*) by trappers (Kauffman 1987, Kovalchik and Elmore 1991, Naiman et

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al. 1988). The elimination of beavers from streams altered site hydrology with subsequent changes in stream nutrient processes and riparian vegetation dynamics (Kovalchik and Elmore 1991, Naiman et al. 1986, Naiman et al. 1988). The beaver plays a functional role as a keystone species in many riparian ecosystems. Their activities influence stream hydrology including residence times of water in riparian zones, stream temperatures, and nutrient cycles; provide habitats for aquatic organisms; and vegetation dispersal, dynamics, and structure of riparian zones. Their elimination can result in decreased surface water (i.e. loss of ponds), channel diversity, and conversion of wetland plant communities to xeric plant communities.

Following the severe overtrapping of North American beaver populations, the second, and perhaps most influential, human perturbation (i.e. human caused activities which cause a deviation from natural processes) of western riparian ecosystems appeared — the introduction of livestock. It was estimated that by the end of the century there were 26 million cattle and 20 million sheep in the Western United States (Wilkenson 1992). Grazing during this time period was likely year-long resulting in extensive degradation of riparian/stream systems throughout the West. The grazing by livestock continues to influence riparian zones. While the total animal unit months of livestock use has declined on public lands (U.S. Forest Service and BLM), the numbers of cattle have remained relatively stable on BLM lands since the 1940's and on U.S. Forest Service lands since the late 1950's (Wagner 1978). However, over all land ownerships in the 11 western range states the number of cattle and the total forage demand for livestock has steadily risen throughout the 20th Century (Wagner 1978).

Following the recognition of the influences of overgrazing on rangelands, the first legal attempt to reduce livestock numbers on Federal lands came in 1934 with the passage of the Taylor Grazing Act (Wilkenson 1992). The Depression resulted in lower beef and lamb prices and the Dust Bowl was a testament to a half century of land abuse. Congress was also being lobbied by a few far sighted members of the livestock industry who recognized that changes were needed to perpetuate the forage resource (Wilkenson 1992). The results were the establishment of the Grazing Service and the first regulations for grazing on approximately 160 million acres of federal land.

Degradative influences came not only through extractive uses such as beaver trapping, grazing, or mining, but also through ill-conceived engineering activities that permanently modified riparian/stream systems. With the advent of mechanized equipment in the 1930's came the first attempts to modify stream channels through the use of instream structures, channelization, bank modification, and rip-rap. Objectives have included flood control, irrigation development, and wetland conversion.

Riparian management activities following World War II were largely directed at manipulating or controlling the flow and utilization of water. The important interactions between the riparian and aquatic systems, bound by water, was not recognized as an integral factor for maintaining the productivity of these systems. As such, once complex riparian stream systems were dramatically altered through dredging, diking, and channelization (Figure 1). Eradication of phreatophytic vegetation was implemented with the ill-conceived hypothesis that this would reduce transpiration loss and increase the amount of usable water. Channels were cleared

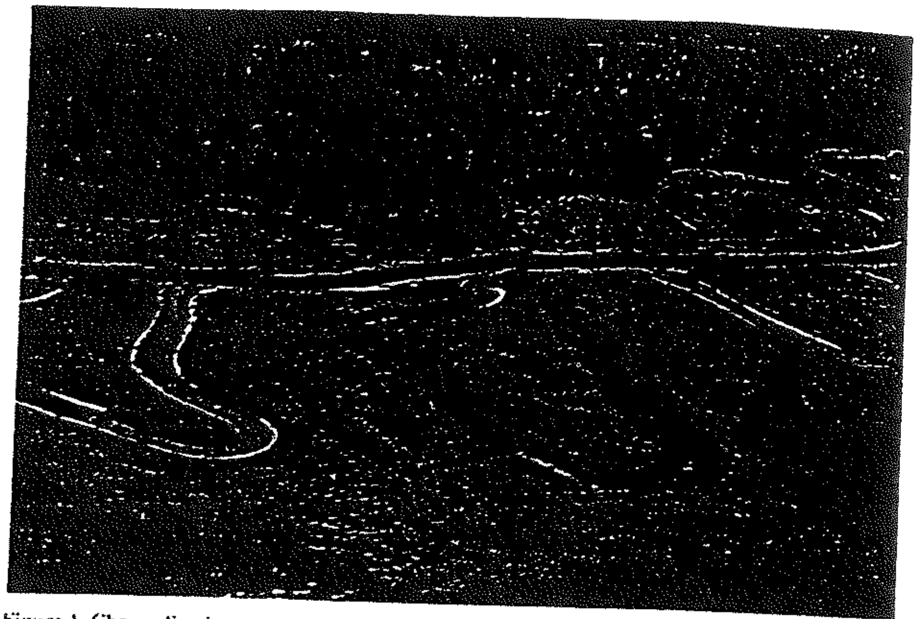
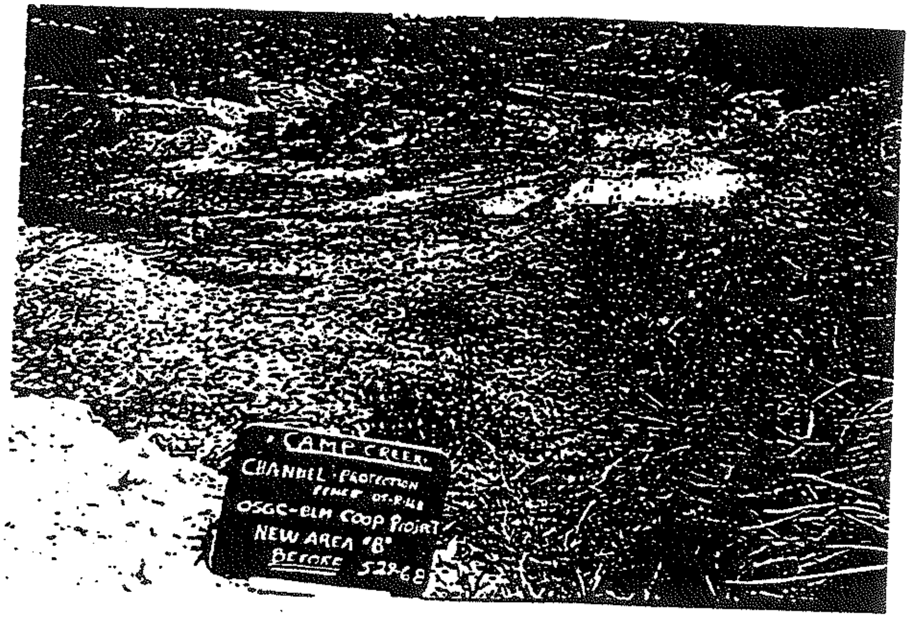


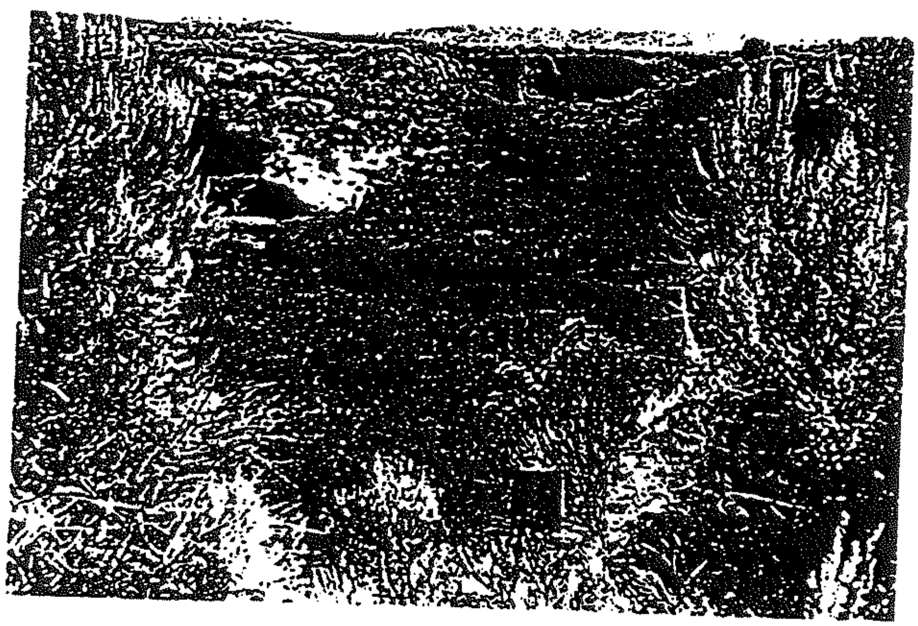
Figure 1. Channelization was a popular method used to increase the drainage of floodplains and wetland areas.

of woody plants and coarse woody debris in order to increase the velocity of streams and reduce flood damage. Floodplains became inactive and without vegetation to buffer energy, erosion of streams increased (Figures 2 and 3). The result was a dramatic simplification of riparian stream ecosystems with decreased interactions, decreased biological diversity, and declines in productivity (Green and Kauffman 1991).

Paradoxically, similar activities were implemented with the objective of fish habitat "enhancement". Fish populations and stream habitat conditions were declining dramatically. Engineering approaches were implemented with few considerations or little understanding of fish habitat needs or riparian ecosystem dynamics. Thousands of structures (e.g., check dams) were installed in streams throughout the West and midwest (Heady 1977, White 1990). Fifty years later similar engineering activities or stream manipulations continued to be applied in attempts to restore degraded riparian zones and stream channels for salmonid recovery. At the same time natural woody debris was being removed from many streams to improve fish passage. Again, little consideration for the ecological dynamics of riparian/stream ecosystems were included in the implementation process. In terms of restoring fish populations, and accelerating riparian recovery these approaches have largely been ineffectual, and in some cases counter productive (Beschta, Platts, and Kauffman 1991, Sedell and Beschta 1991, Li et al. 1992, and Ahlborn et al. 1992). However, some success have been achieved in increasing spawning area, number of fish redds (i.e. egg deposition areas), and juvenile survival (House et al 1989, House et al 1990, Crispin et al 1993).

For stream recovery projects to be successful, managers must begin by halting those human activities that are causing the decline or preventing recovery (Kauff-





Figures 2 & 3. A wide, entrenched channel system that has incised 5 to 20 feet into silty-clay deposits. Figure 2 shows the area in 1968. Figure 3 shows the same area 16 years later, after exclusion from grazing. Note the expanded riparian area, as the water table influences vegetation composition across the entire bottom.

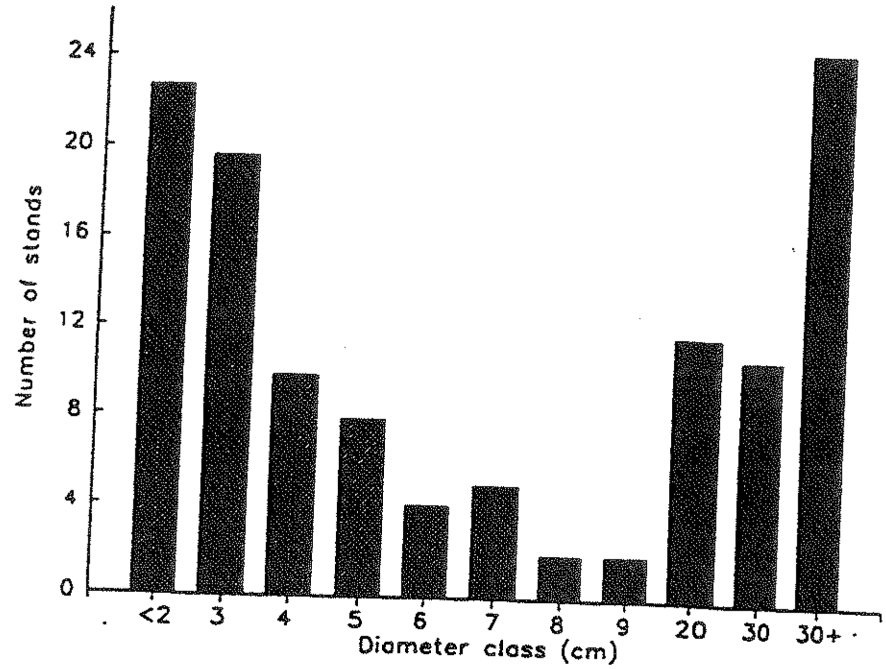


Figure 5. Diameter class distribution of the Salicaceae in livestock exclosures (n=125) at the Crooked River National Grasslands, Oregon, following cessation of grazing for 1-29 years. Data are from Busse (1988).

textured gravel bars (Figure 5). It is apparent that following cessation of improper livestock grazing, barriers to the re-establishment of these riparian-obligate communities were eliminated.

There are many problems with using exclosures as a solution to halt overuse by livestock. They include wildlife access, cost of construction, and maintenance. In addition, the management outside of the exclosures frequently is not changed, subsequently, unfenced riparian zones and uplands continue to decline or fail to recover.

Present

Restoration

The closer an ecosystem is managed to allow for natural ecological processes to function, the more successful that management strategy will be. While a number of factors are negatively influencing riparian ecosystems today (e.g., grazing, roads, dams, farming, urbanization, irrigation withdraw, mining etc.) in this chapter we focus on those areas where livestock influences are the ecological perturbation needing attention.

Attempts at the development of livestock grazing strategies that allowed for riparian restoration were begun in the late 1970's and early 1980's. To be successful, management must consider the complexity of riparian ecosystem function and the integral role that vegetation plays in these functions (Swanson et al. 1982, Elmore and Beschta 1987). Stream/riparian functions are those processes influenced by the interaction of soil, water (hydrology), and vegetation (Elmore 1992). They include the physical filtering and retention of sediment and nutrients by vegetation. The processes associated with high water, sediment retention, and vegetation structure are intimately linked to bank building, biotic composition, recharge of subsurface aquifers, and hydroperiod.

Every stream has a certain suite of natural disturbances, or stresses that are related to soil type, stream gradient, climate, geology and, other physical features. It must be recognized that every management activity (road construction, logging, grazing, etc.) will either alter these natural disturbance processes or exacerbate their effects. The response of a given stream to a given suite of management stresses depends on the inherent level of ecological resilience of the ecosystem and how far the management system departs from a natural ecosystem equilibrium. Resilience is defined as the degree and rapidity of ecosystem recovery following a natural disturbance or human perturbation. Some streams with high levels of natural stress (such as those with bentonitic soils and high erosion potential) are rapidly degraded by almost any additional disturbances from human activities. In contrast, streams of low natural stress (such as those with low gradients and sandy loam soils) are resilient to a much higher level of management perturbations. The inherent natural disturbance factors, as well as the capacity of ecological resilience of riparian zones, and the suite of ecological processes necessary for intact ecosystems to function must be properly integrated in management strategies for recovery or maintenance to occur (Figure 6) (Elmore and Beschta 1987, Elmore 1992).

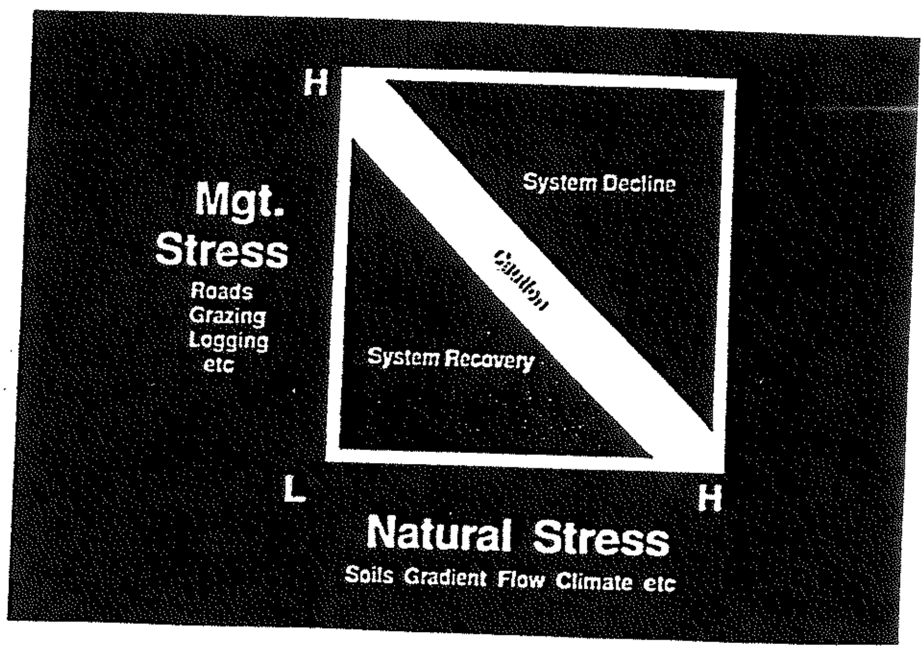


Figure 6. Management Stress verses Natural Stress.

Grazing Management

There are many grazing strategies that have been devised to achieve specific ecological or management goals. Depending upon the unique features of the ecosystem and goals of management, successful strategies range from loosely supervised season-long use, to intensively managed multi-pasture rotational systems (Elmore 1992). The effectiveness of a given system with respect to sustainability and restoration of ecosystem structure, and diversity will depend upon the ecological characteristics of the stream system. This is important because failures in management often occur when a grazing strategy developed for a certain stream system is applied in another stream/riparian reach with different ecological and/or management characteristics. With the exception of exclusion, there is no single grazing management strategy that has been proven to consistently improve degraded western riparian areas (Kinch 1989, Clary and Webster 1989, Marlow 1985).

The difficulties in devising proper grazing strategies is further complicated by the inherent complexity of riparian zones. Green (1991) quantified a highly variable response by plant communities to livestock grazing within the same stream reach. Under moderate, late season use, productivity and diversity of riparian meadows was maintained. However, woody plant succession and growth was negatively influenced on gravel bars. Meyers (1989) evaluated 34 grazing strategies in Montana and found 74% were unsuccessful in accommodating a positive riparian vegetation response within a 10-to-20 year period. Upland areas, however, did show a positive response on most of the areas. Marlow (1985) addressed the failure of grazing strategies to restore riparian ecosystems and recommended the length of the grazing period should be based on the areas cattle are actually using, not the entire area. Often this may be the community type of interest within the riparian zone. Green (1991) described phenomena in northeastern Oregon where livestock preference and utilization was greatest (40-70%) for dry and moist meadows in late season grazing schemes. Willow-dominated gravel bars were intermediate in preferences with a utilization of 20–45% and the understory of mature cottonwood and alder communities were utilized at levels of ≤20%. Therefore, management strategies should focus on the specific components of the ecosystem in need of restoration. In this study the levels of herbaceous utilization in meadows were not an adequate indicator of willow recovery. The productivity of meadows was maintained, but these levels of utilization did influence willow and cottonwood establishment.

Throughout river basins of the Pacific Northwest, salmonid populations have precipitously declined or have been completely extirpated (Armour 1977; Benhke 1977; Williams et al 1989). Many key riparian plant communities (e.g., gallery forests of black cottonwood, quaking aspen, alders, or willows) have been eliminated from stream reaches (Busse 1989; General Accounting Office 1988; Chaney et al 1990; Kauffman, Beschta and Platts 1993). There is a general acceptance by managers today that most riparian areas are in an unacceptable condition and that approaches to restoration in the past have had limited success. Hansen (1993), Kauffman, Beschta, and Platts (1993), Kinch (1989), and Skovlin (1984) have outlined ecological approaches for developing successful grazing management or ecological restoration strategies for riparian\wetlands restoration. It is recommended that these strategies be developed with interdisciplinary teams representing several disciplines. These would include, but not be limited to, range specialists, wildlife and or fisheries biologists, soil scientists, botanists, and foresters depending on the resources present in each area. Generalized recommendations include:

1. Each grazing strategy must be tailored to a particular stream or stream reach. Management objectives and components of the ecosystem that are of critical value must be identified (i.e. woody species recovery, streambank restoration, increased stream channel diversity, etc.). Other information that should be identified includes present vegetation, potential of the site for recovery, the desired future condition and the current factors that are causing habitat degradation or limiting its recovery.
2. Describe the relationships between ecological processes that must function for riparian recovery. Assess factors affecting present condition (i.e., management stress versus natural stress) and what conditions will be needed to allow the stream to resume natural functions. Anthropogenic factors that are causing stream degradation must be identified and changed.
3. Design attainable goals, objectives, and management activities that will achieve the desired future condition of the riparian/stream ecosystem.
4. Implement the plan.
5. Design and implement a monitoring plan that will evaluate management, allowing for corrections or modifications in management, if necessary.
6. Implement a strong compliance and use supervision program.

Generalized responses of riparian ecosystems to livestock grazing strategies have been discussed by Elmore (1992), Platts and Nelson (1989 Fig. 7), Kovalchik and Elmore (1991 Fig. 8), Buckhouse and Elmore (1991 Fig. 9), and Meyers (1989 Fig. 10). The ratings by these authors are based on observations in different riparian/stream systems, and therefore should be viewed with caution. However they do contain similarities for assessing management potential for success in the northern Rocky Mountains or Pacific Northwest. All of these reviews recognized that the rates of recovery and resultant vegetation composition for each riparian/stream system are dependent on many factors including site potential, current ecological condition, stream geomorphology, and climate.

Some generalized characteristics that are commonly observed are reviewed here.

Three Pasture Rest Rotation

This grazing system typically has provided total annual rest for each pasture on a regular basis. This strategy was designed for upland vegetation to promote plant vigor, seed production and seedling establishment, root production, and litter accumulation for herbaceous plants in upland ecosystems. In general, woody riparian species have been observed to decline under this strategy. Like most grazing systems, this strategy was designed for the physiological needs of herbaceous plants and can be very successful on low gradient sedge (*Carex*), rush (*Scirpus*), and grass-dominated sites. It is usually inappropriate for early seral shrub dominated sites because heavy utilization of riparian areas will retard establishment and growth of willow dominated communities (Figures 11 and 12). However, it has been successful in maintaining late seral condition on woody dominated sites in

Figure 7. Platts 1989. Evaluation and rating of grazing strategies based on the author's personal observations, as related to stream-riparian habitats.

Strategy	Level to which riparian vegetation is commonly used	Control of animal distribution (allotment)	Stream-bank stability	Brushy species condition	Seasonal plant regrowth	Stream-riparian rehabilitative potential	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).

some areas where the shrubs have grown out of the reach of grazing animals (Laura Gutzwiller pers. comm.). This, however, may ultimately result in a population of only mature decadent stands and woody vegetation with no ongoing replacement of younger stands (Figure 4).

Winter Grazing

This system prevents utilization during the growing period annually because grazing occurs only during plant dormancy. Dormant woody riparian species can be negatively affected by browsing or trampling in areas where winter temperatures are moderate or livestock movements are restricted. However, dramatic recovery rates have been observed where light use occurs because of cold drainage patterns and livestock avoidance of the riparian zone or availability of alternate livestock water systems away from streams (Figure 13 & 14). A full understanding of expected livestock use patterns is necessary using this strategy or land use objectives may not be achieved. For instance, in wide valley bottoms in Montana, winter use resulted in an increase in sedge (Carex) communities but continued overuse of woody riparian vegetation. Livestock did not move to adjacent hillsides but continued to concentrate in the bottoms. Soils were frozen resulting in little bank damage (Lew Meyers pers. comm.).

Early Growing Season

Regrowth of riparian vegetation is facilitated by the absence of summer utilization. Utilization on woody plants, (e.g., willow and alder), may be low because upland grasses are green and more palatable. If periods of use allow for adequate

Figure 8. Meyers 1989. Characteristics of successful and unsuccessful grazing systems with means and 95% confidence intervals.

Characteristics	Grazing systems	
	Successful	Unsuccessful
Number of grazing systems	9	25
Stocking rates (Hectares/AUM)	4.9 (2.3)	3.8 (1.1)
Days of post-grazing regrowth (up to 9/15)	34.9 (17.8)	20.8 (7.3)
Percentage of grazing treatments providing residual cover through rest or regrowth	74.9 (12.8)	37.8 (13.2)
Duration (days) of hot season (7/1-9/15) treatments	12.5 (10.5)	33.4 (10.4)
Duration (days) of all grazing treatments	28.2 (3.7)	59.3 (8.1)
Duration (days) of fall grazing treatments (8/15-1/10)	21.0 (9.1)	36.5 (8.1)
Percentage of grazing treatments with fall use	31.1 (20.7)	51.1 (9.8)

Figure 9. Generalized relationships between grazing system, steam 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	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+
Grazing	Banks	0	Banks	0 to +	Banks	0	Banks	+	Banks	+	Banks	+
Winter or	Shrubs	+	Shrubs	+	Shrubs	+	Shrubs	+	Shrubs	+	Shrubs	+
Dormant	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+
Season	Banks	0	Banks	0 to +	Banks	+	Banks	+	Banks	+	Banks	+
Early	Shrubs	+	Shrubs	+	Shrubs	+	Shrubs	+	Shrubs	+	Shrubs	+
Growing	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+
Season	Banks	0	Banks	0 to +	Banks	+	Banks	+	Banks	+	Banks	+
Deferred	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-
or Late	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+
Season	Banks	0 to -	Banks	0 to -	Banks	0 to +	Banks	+	Banks	+	Banks	+
Three-Pasture	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-
Rest	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+
Rotation	Banks	0 to -	Banks	0 to -	Banks	0 to +	Banks	+	Banks	+	Banks	+
	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	+
Deferred	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+
Rotation	Banks	0 to -	Banks	0 to -	Banks	+ to 0	Banks	+	Banks	+	Banks	+
	Shrubs	+	Shrubs	+	Shrubs	+	Shrubs	+	Shrubs	+	Shrubs	+
Early	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+
Rotation	Banks	0 to -	Banks	0 to +	Banks	+ to 0	Banks	+	Banks	+	Banks	+
	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-
Rotation	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+	Herbs	+
	Banks	0 to -	Banks	0 to -	Banks	0 to +	Banks	+	Banks	+	Banks	+
	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-
Season-	Herbs	-	Herbs	-	Herbs	-	Herbs	-	Herbs	-	Herbs	-
Long	Banks	0 to -	Banks	0 to -	Banks	-	Banks	-	Banks	-	Banks	-
	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-
Spring and	Herbs	-	Herbs	-	Herbs	-	Herbs	-	Herbs	-	Herbs	-
Fall	Banks	0 to -	Banks	0 to -	Banks	-	Banks	-	Banks	- to 0	Banks	0 to +
	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-	Shrubs	-
Spring and	Herbs	-	Herbs	-	Herbs	-	Herbs	-	Herbs	-	Herbs	-
Summer	Banks	0 to -	Banks	0 to -	Banks	-	Banks	- to 0	Banks	- to 0	Banks	0 to +

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

regrowth and do not correspond to the seasons of willow reproduction, this grazing strategy can be very beneficial to riparian areas, especially in establishing woody plants. However, the influence of livestock grazing on willows during flowering and early seedling establishment has also not been quantified. Conversely, this system can be detrimental to upland grasses if grazing strategy results in utilization during the critical part (shoot elongation) of their growing season. In addition, this system may not be applicable on finer textured soils or those riparian zones associated with steep gradients. Under these scenarios, soil compaction, accelerated streambank losses or increased erosion rates may result.

Figure 10. Kovalchik and Elmore 1991. Generalized relationships between grazing system and willow and sedge response on willow-dominated plant associations.

	Systems highly compatible with willow management		
Corridor fencing	Willows ⇑ Sedges ⇑	Riparian pasture	Willows ⇑ Sedges ⇑
Spring grazing	Willows ⇑ Sedges ⇑	Winter grazing	Willows ⇔ to ⇑ Sedges ⇑
	Systems moderately compatible with willow management		
Two-pasture rotation	Willows ⇔ to ⇑ Sedges ⇑	Three-pasture rotation	Willows ⇔ to ⇓ Sedges ⇑
Three-pasture deferred rotation	Willows ⇔ to ⇓ Sedges ⇔ to ⇑		
	Systems incompatible with willow management		
Spring-fall grazing	Willows ⇓ Sedges ⇔ to ⇓	Deferred grazing	Willows ⇔ to ⇓ Sedges ⇔ to ⇓
Late-season grazing	Willows ⇓ Sedges ⇓	Season-long grazing	Willows ⇓ Sedges ⇓

⇑ = highly compatible
⇓ = incompatible
⇔ = no change

Deferred Grazing (after seed ripe) and Deferred Rotation (three pasture)

These strategies can be beneficial to sedge/grass communities especially if sufficient regrowth is allowed to provide for adequate riparian function (i.e., enough regrowth to retain a capacity to trap sediment) during the next high flow event. Late season grazing strategies have been found to be very beneficial in maintaining species diversity and productivity of meadow systems (Kauffman et al. 1983, Green 1991). Levels of utilization of woody riparian species must be carefully monitored because use always occurs during the summer months when livestock tend to concentrate in riparian areas. Levels of utilization that maintain the diversity and productivity of the meadow communities have been found to retard woody plant succession on gravel bars (Green 1991).

Rotation Grazing (two pasture)

This strategy consists of an early use treatment one year followed by a deferred use period the next. It provides total growing season rest every other year for herbaceous plants. However this system can be detrimental to woody riparian vegetation if the summer use that occurs every other year exceeds the regrowth of one year of nonuse. It can be acceptable on low gradient wide valley bottom sedge-rush-grass sites especially if adequate regrowth time is allowed at the end of the deferred use period.

Spring-Summer Grazing or Season Long Grazing

This strategy typically provides no rest during the growing period for plant vigor, reproduction, or litter accumulation. It generally has resulted in heavy utilization

Figure 11 & 12. Ten years of continued channel degradation in a high gradient, high energy stream system under three-pasture rest rotation grazing. Willows, which show a downward trend from 1976 (fig. 11) to 1986 (fig 12), are needed to help stabilize this laterally unstable channel man, Beschta and Platts 1993). Riparian zones are characterized as areas with inherently high levels of natural disturbance. As such, they often have a remarkable resilience once degradative land use activities cease. Rather than engineering approaches that many times disregard ecological processes, a more feasible approach is to facilitate the natural recovery of riparian biotic and hydrological features by restoring natural ecosystem processes (Elmore and Beschta 1988).

On western forests and rangelands where grazing by livestock resulted in declines in riparian condition, exclusion was implemented as a technique of stream restoration. This includes removal of livestock from degraded rangelands or the construction of corridor fencing. Most early exclosures were corridor fences that were built close to the stream channels resulting in very narrow areas of protection and high susceptibility to flood damage.

Livestock exclusion has consistently resulted in the most dramatic and rapid rates of ecosystem recovery (Beschta, Platts and Kauffman 1991, Figures 4 & 5 Busse 1989). In Figure 4, the pre-exclusion population of all Salicaceae-dominated stands from the Crooked River National Grasslands, Oregon, clearly indicate the young size classes were greatly underrepresented; successful establishment of willow and cottonwood communities was not occurring. Persistence of these relatively short-lived species was not likely under the prevailing livestock management scenarios given the underrepresentation of young size classes in an environment of high fluvial disturbances. Following livestock exclusion in the same riparian zones, the population is represented by numerous young stands establishing on coarse-

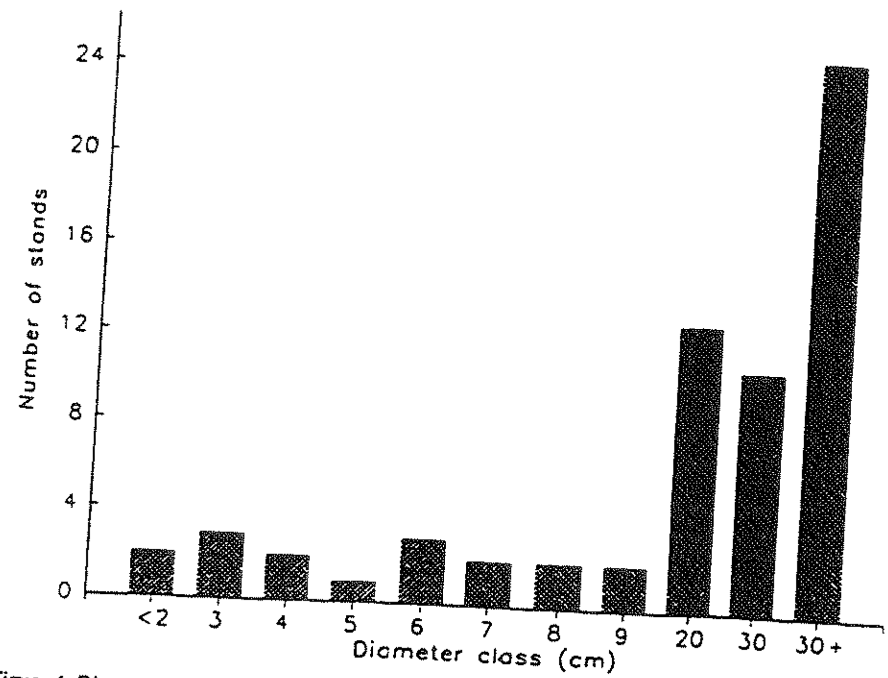


Figure 4. Diameter class distribution of the Salicacea stands present prior to riparian exclosure construction (n=65) on the Crooked River National Grasslands, Oregon. Data are from Busse (1988).

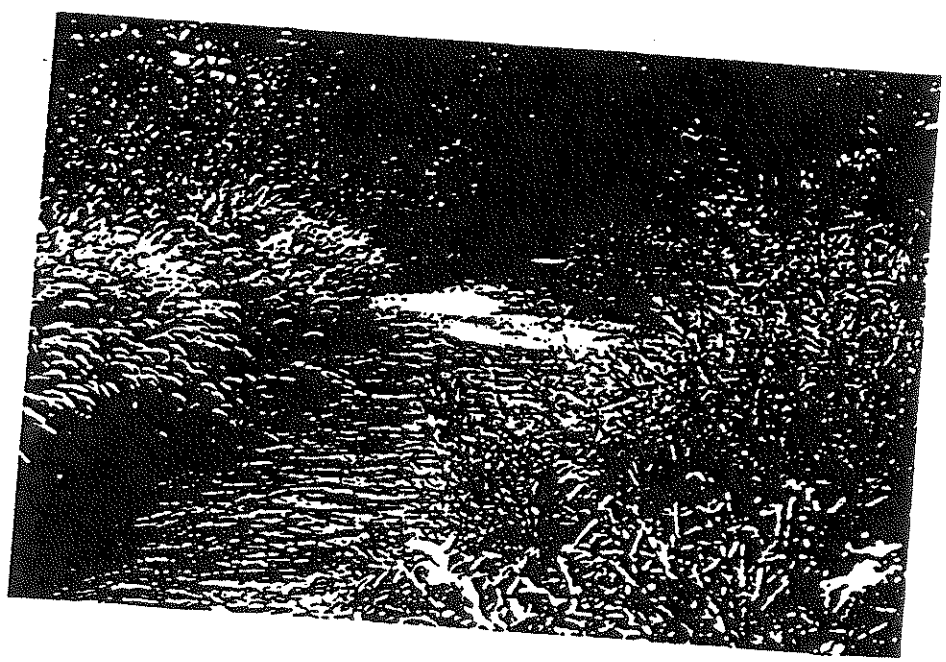


Figure 13 & 14. Willow and herbaceous vegetation response after eleven years. Grazing was changed in 1976 (figure 13) from season long grazing to winter grazing (1987 fig. 14).

of woody riparian vegetation. Trampling damage, soil compaction, and accelerated streambank erosion are likely. This strategy is most commonly associated with the wide spread decline of riparian and watershed conditions in the West. This strategy should be eliminated in most areas where it is still being used.

Fall Grazing

This strategy provides growing period rest every year however can be detrimental to riparian vegetation depending on site specific criteria (elevation, magnitude of peak flows, etc.). Interactions between high flows over floodplains can be negatively influenced if there is a lack of residual vegetation to facilitate sediment retention. Woody riparian species are commonly used heavily in the fall if green herbaceous materials are limiting. Riparian areas can improve with this strategy if fall use occurs when temperatures are cool, fall green up has occurred, and utilization is closely monitored. Upland areas also benefit depending on when livestock are removed and if rest and regrowth are allowed.

Riparian Exclusion

The complete elimination of livestock provides total protection from domestic grazing animals. The rate of recovery of the stream features and riparian vegetation, both woody and herbaceous, has been the most rapid under this management scenario. Beschta, Platts and Kauffman (1991) reported willow and cottonwood growth in ungrazed exclosures to be as high as 60-100 cm per year. However, simply excluding the riparian area does not address the needs of the upland vegetation or the overall condition of the watershed. Unless a landscape-level approach is taken, important ecological linkages between the uplands and aquatic systems cannot be restored and riparian recovery will likely be limited. Exclusion should only be used in conjunction with an upland management plan designed to restore the entire landscape or when there are situations where the most rapid recovery possible is necessary (i.e., for habitat restoration of federally listed threatened or endangered salmonids).

Riparian Pasture

This strategy is applicable in areas where riparian zones encompass a large enough area to manage them separately from uplands. The riparian area may be managed separately or in combination with other allotments or pastures. The use of the forage in a riparian pasture is typically designed to specifically meet certain stream/riparian restoration goals. Because the pasture is separate from the rest of the allotment, it can be grazed or rested depending on current conditions and stream riparian needs. It can provide flexibility in the design of strategies for both woody and herbaceous species.

Conclusion

Whether riparian zones are currently improving in ecological condition is a debatable question. In areas where progressive management steps have been taken, trends towards improvement have occurred. However, given the declines in anadromous and resident native salmonid fish populations, lack of reproduction of riparian woody species and the preponderance of streams greatly lacking in channel diversity, it is apparent that many riparian zones are not receiving adequate management. Riparian restoration has been, and will continue to be among the most important natural resource issues affecting land use decisions on public as well as private lands. In addition, livestock grazing in riparian zones will continue to be one of the most controversial of land management issues.

The major short-comings of grazing strategies that fail to result in the restoration of degraded riparian zones are: (1) They are applied with a cookbook approach with little analysis of riparian effects or recognition of the complex and heterogenous nature of riparian zones; (2) the grazing strategies utilized were developed for uplands and/or for herbaceous recovery with little consideration of woody vegetation, streambank integrity, or riparian function; or (3) they were developed for increased livestock production with similar shortcomings in consideration of riparian values. Few grazing strategies or monitoring programs have been developed for the maintenance of riparian woody species such as willows, cottonwood or alder nor have they been developed with considerations of streambank structure. Most riparian management strategies are oversimplified by suggesting a single level of desired utilization. This may result in maintenance or improvement of one component of the ecosystem but continued declines in others. New approaches to grazing management should be implemented to include a watershed-level perspective. This would often result in cooperative efforts of all ownerships in a watershed. Strategies that are developed with interdisciplinary groups and are designed to allow flexibility addressing the entire stream and riparian ecosystem are likely necessary for long-term recovery and sustainability to occur. To manage riparian areas from an ecosystem perspective we must determine the functions and needs of an ecosystem before we can devise a sustainable mix of uses among the wide array of competing natural resource interests. Management decisions should be based on the ecological needs or functions of the system that will result in a sustained high level of biological diversity and site productivity. Management should not be driven by the needs or objectives of special interests.

If we are going to successfully manage our riparian areas from an ecosystem perspective then we must consider the following when we develop our objectives and design our plans.

1. We must consider the linkages and processes that are associated with full floodplain function — preferably the 100 year floodplain. Further, objectives should focus on the reconnection of the ecological linkages between uplands, floodplains, and the aquatic zone. Land management activities that degrade or sever these linkages should be modified or discontinued.
2. Riparian zones are extremely complex. The complexity is far greater than scientists and land managers are capable of understanding. We must manage riparian ecosystems within the context of the environment in which they are located, recognizing their unique value, and remembering that what works for one may not work for another.

3. Headwater streams have not received levels of management attention necessary to achieve landscape-level goals. We must recognize the importance of all stream systems, regardless of size, particularly in consideration of cumulative effects of land management in watersheds.
4. Restoration activities within the stream channel and the riparian management zone should reestablish natural ecological processes and communities. Revegetation utilizing offsite or exotic species are similarly counter to goals of the restoration of the inherent biological diversity of the riparian ecosystems. Approaches that sever linkages, retard recovery or degrade riparian stream function should be discontinued. These are usually engineering approaches that give little attention to the ecological function of a riparian/stream ecosystem.
5. We must manage to maintain connectivity across landscapes and minimize ecosystem fragmentation. No other landscape feature is as effective as riparian zones in linking ecosystems.

Society has a responsibility to ensure that future generations have the opportunity to benefit from intact riparian/stream ecosystems. The restoration or maintenance of long-term ecosystem structure, function, and productivity should be a primary consideration among land managers. We have learned much from the degradation that has occurred to watersheds and riparian ecosystems over the last century. This legacy has lead us to a better understanding of ecosystem function and processes and has identified the needs for restoration. Now is the time to initiate management strategies that will allow our riparian and watershed systems to approach their productive potential.

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