Differences in riparian vegetation structure between grazed areas and exclosures

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Abstract

The valuable role that healthy riparian ecosystems play in regional diversity of plant and wildlife communities is just beginning to be recognized. Resource managers need to know how degraded riparian areas respond to changes in management, such as reduction and elimination of grazing. Differences in vegetation structure were examined in a montane riparian zone in northcentral Colorado after 30 years of cattle exclusion and continued, but reduced, grazing pressure. In order to assess the changes in the riparian community, canopy coverage, density, and standing crop of important riparian species were measured in 1985 and 1986. Total vascular vegetation, shrub, and graminoid canopy cover was greater ($P \leq 0.05$) in the exclosures as compared to grazed areas, while forb canopy cover was similar ($P > 0.05$) between treatments. Exclosures had nearly 2 times the litter cover, while grazed areas had 4 times more bare ground. Willow canopy coverage was 8 1/2 times greater in protected areas than in grazed areas. Kentucky bluegrass (*Poa pratensis* L.) cover was 4 times greater in grazed areas than exclosures, while the cover of fowl bluegrass (*Poa palustris* L.) was 6 times greater in the protected sites. Canopy cover of other important riparian species, such as tufted hairgrass (*Deschampsia caespitosa* (L.) Beauv.), Nebraska sedge (*Carex nebraskensis* Dewey), and beaked sedge (*C. rostrata* Stokes), was similar ($P > 0.05$) between treatments. Mean peak standing crop over the 2 years of the study ws 2,410 kg/ha in the exclosures and 1,217 kg/ha in caged plots within grazed areas. Cattle utilized approximately 65% of the current year's growth of vegetation during the 1985 and 1986 grazing seasons.

Key Words: cattle grazing, Colorado, *Poa palustris, Poa pratensis,* Rocky Mountains, *Salix* spp.

Riparian areas provide habitat for wildlife and fish species, while providing forage for domestic livestock. These areas provide a diversity of foraging and breeding sites that permit coexistence of many wildlife species. Intact aquatic ecosystems with abundant streamside vegetation insure healthy fish populations (Kauffman and Kreuger 1984). Improper livestock use of riparian areas can increase erosion and reduce plant vigor, resulting in lowered forage production and altered plant age structure and species composition (Knopf and Cannon 1982, Kauffman and Krueger 1984, Skovlin 1984).

Although many riparian areas have been degraded by heavy livestock use, these ecosystems tend to improve quickly when livestock are removed (Rickard and Cushing 1982, Stuber 1985). Eleven years of protection from grazing dramatically improved riparian vegetation, streambanks, and stream channel conditions in Utah (Platts and Nelson 1985).

Resource managers need to know what the responses of degraded riparian areas will be to elimination or reduction of livestock use. Most of the research on riparian areas has been short-term or unreplicated, long-term studies in the arid Southwest. The objective of this study was to document differences in vegetation structure in a montane riparian area in northcentral Colorado after 30 years with reduced cattle grazing pressure and livestock exclusion.

Study Area

The study was conducted within the riparian zone bordering Sheep Creek, approximately 75 km northwest of Fort Collins in the Roosevelt National Forest in northcentral Colorado. Sheep Creek is typical of many (4–5 m width) headwater streams in the western United States, and is classified according to Rosgen (1988) as a C-1 stream. The study area is approximately 2,500 m in elevation.

According to USDA Forest Service records, the Sheep Creek Grazing Allotment received extremely heavy cattle grazing pressure from the turn of the century until the 1950's. By the late 1940's, Forest Service photos and records showed that the entire riparian area was practically denuded, with little herbaceous plant cover and only a few remnant willow (*Salix* spp.) stumps (Fig. 1a). The U.S. Forest Service and Colorado Division of Wildlife constructed 2 exclosures in the fall of 1956 to protect the riparian area from cattle overgrazing in an effort to improve the fisheries habitat. A third exclosure was constructed 1.4 km upstream from the second exclosure in the spring of 1959. A total of 40 ha of the riparian zone and 2.5 km of stream was fenced. Late fall cattle grazing was allowed for 5 days in 2 of the exclosures from 1967 to 1975 at a rate of 4 ha/AUM. Inspections by Forest Service range conservationists at the time of grazing indicated that this use was very conservative and caused no damage to the riparian area (unpublished data on file at USDA Forest Service). Although deer and elk were not excluded from the riparian zone, their impact has been minimal because of the close proximity of the site to a major forest access road and recreational use in the area. According to Forest Service records, stocking rates of cattle in the Sheep Creek Allotment have been reduced from nearly 1900 AUM's in 1939 to 600 AUM's at present in the grazed area of the allotment. The allotment carrying capacity is estimated at 621 AUM's. Cattle graze this allotment season-long from approximately mid-June until mid-October (unpublished data on file at USDA Forest Service).

Methods

Riparian vegetation density and cover were compared between grazed riparian areas and exclosures in July–August 1985 and 1986. Each year of the study, 60 10-m transect lines were established perpendicular to the stream (10 in the grazed area and 10 in the exclosures with 3 replicates, for a total of 60 transect lines). The density of each woody species within 0.5 m of either side of the transect line was recorded. Because of the difficulty in identifying individual willow species in the field, data were grouped and

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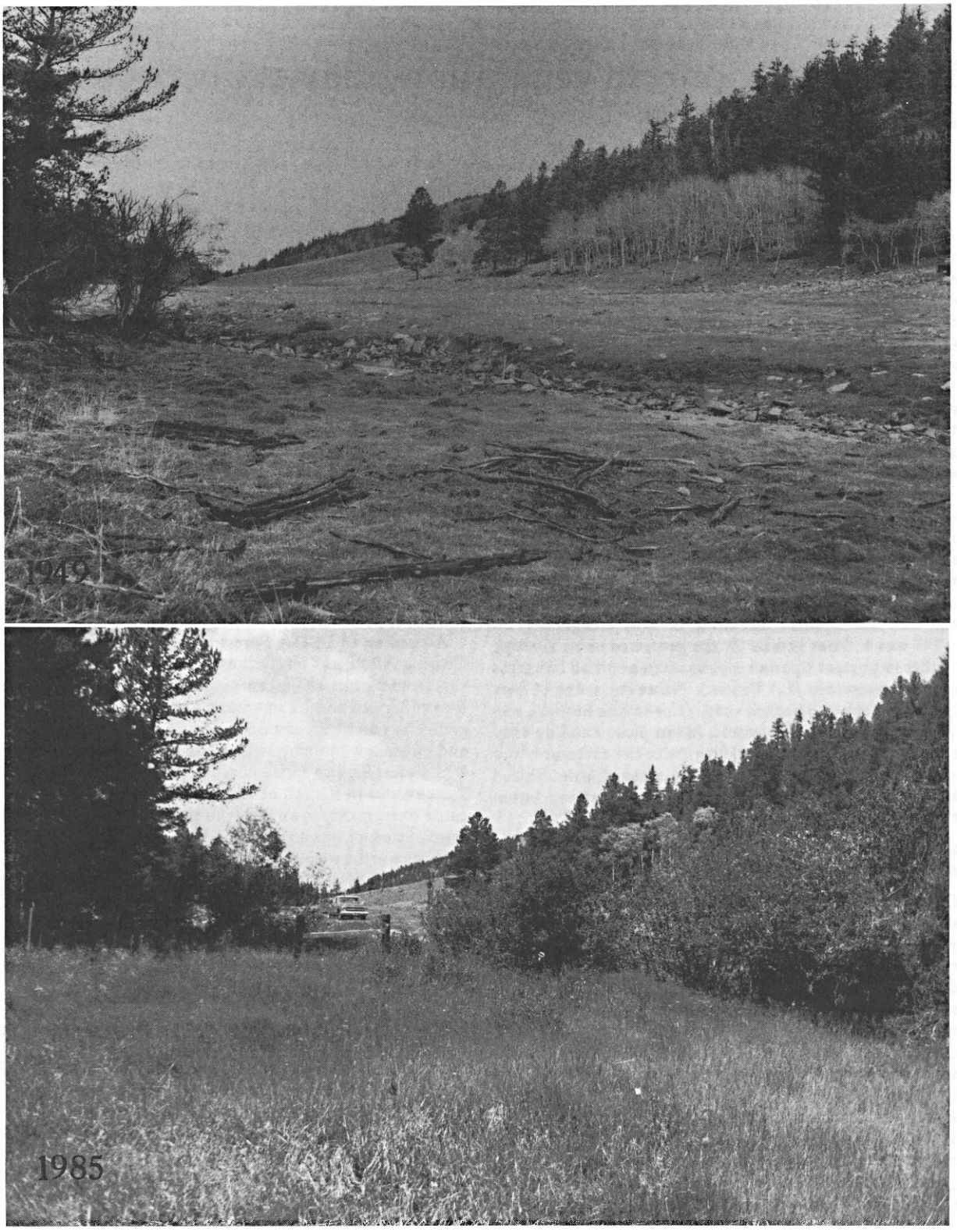

Fig. 1. Sheep Creek riparian area: (a) before fencing in 1949 (the stream channel runs from left to right in the center of the photograph) (photo courtesy U.S. Forest Service); (b) the same spot 29 years after reduced grazing and fencing (notice how the stream channel is hidden by lush understory vegetation and abundant willows).

recorded as *Salix* spp. Season-long collections from the site have shown that the dominant willow species is planeleaf willow (*S. planifolia* Pursh), with associated species including blue willow (*S. drummondiana* Barratt ex Hook.), Wolfs willow (*S. wolfii* Bebb), and mountain willow (*S. monticola* Bebb). Analysis of variance was used to compare densities of individual woody plant species from transects within the exclosures and those in the grazed areas.

Canopy cover of all plant species, litter, bare ground, and rock coverage along the transects was estimated using 300 20- by 50-cm cover plots (150 in grazed areas and 150 in exclosures). *Poa* spp.

and *Carex* spp. were not separated in 1985. Five cover plots were placed on the right side of each transect line at distances from the stream of 1, 3, 5, 7, and 9 m. Methods for determining cover followed Daubenmire (1959), except percentages were estimated rather than categorized. An $\arcsin(x)^{1/2}$ transformation was used on the cover data prior to statistical analysis (Sokal and Rohlf 1969). Data were evaluated with analysis of variance using a randomized split-plot design, with grazing as main plots, exposure and years as subplots, and sites as replications.

Basal stems from 60 random willows (30 from the exclosures and 30 from the grazed areas) were clipped in 1986. Diameter was measured and age estimated by counting growth rings (Danell et al. 1981). Students *t*-test was used to determine any differences between grazing treatments.

Sixty 0.25-m² plots were established in 1985 and 1986 to measure peak standing crops in grazed areas and exclosures. Utilization cages, covering the 30 plots in the grazed areas, were used to estimate standing crop of riparian vegetation in the grazed area. Thirty additional plots, paired with the caged plots in the grazed area based on similar vegetation composition at the beginning of the growing season, were used to estimate forage utilization by cattle. At the end of the grazing season, current year's growth of vegetation was clipped at ground level, separated by species, oven dried, and weighed. Data were evaluated with analysis of variance using a randomized split-plot design, with grazing as main plots, exposure and years as subplots, and sites as replications.

The main effect of years and treatment by year interaction were not significant ($P>0.05$) for any analysis. Therefore, only treatment means over the 2 years of the study are reported.

Results

Twenty-nine years after fencing, abundant riparian vegetation within the exclosures concealed the stream channel from view (Fig. 1b). By 1985, herbaceous vegetation had increased over the entire allotment, while the rested sections of Sheep Creek also exhibited abundant shrubby vegetation (Fig. 2).

Willow and other individual woody species densities within the transect belts were similar ($P>0.05$) between the exclosures and grazed areas (Table 1). The total density of woody species falling within the transect belts, however, was higher inside the exclosures ($P\leq0.02$) than in grazed riparian areas (Table 1).

Table 1. Density of woody species (#0-m²) in montane riparian zone. Data are 2 year averages.

Species	Grazed	Exclosures
Willow (*Salix* spp.)[1]	2.6	4.0
Shrubby cinquefoil *(Potentilla fruticosa)*	2.5	4.6
Sagebrush *(Artemisia tridentata)*	2.2	2.1
Thin-leaf alder *(Alnus tenufolia)*	0.2	0.3
Aspen *(Populus tremuloides)*	0.0	0.6
Lodgepole pine *(Pinus contortus)*	0.5	0.4
Other woody species	0.8	1.6
Total	8.8	13.6*

*Differences between treatments were significant at the 0.05 level.
[1]Comprised of *S. planifolia, S. drummondiana, S. wolfii,* and *S. monticola.*

Total vascular vegetation cover was greater ($P=0.02$) in the exclosures as compared with the grazed areas (Table 2). Moreover, litter cover in the protected areas was nearly 2 times ($P=0.001$) that found on grazed plots. The grazed areas had approximately 5 times ($P<0.001$) as much bare ground as did the exclosures (Table 2). Total shrub cover in the exclosures was 5 1/2 times ($P=0.012$) that of the grazed areas. Total graminoid cover was also greater ($P<0.001$) in the exclosures than in adjacent grazed areas. In contrast, total forb cover ($P>0.17$) and total tree cover ($P>0.05$) was similar in both treatments (Table 2).

Over the 2-year sampling period, willow cover averaged 8 1/2 times greater ($P=0.004$) in the exclosures than in adjacent grazed areas (Table 3). Tufted hairgrass (*Deschampsia caespitosa* (L.) Beauv.) cover was similar ($P>0.2$) between treatments. The grazed areas had 9 times ($P=0.007$) as much clover (*Trifolium repens* L.) cover as the exclosures, while dandelion (*Taraxacum officinale*

Fig. 2. Fenceline contrast of Sheep Creek in 1985: the right side is grazed; the left side is inside the exclosure.

Table 2. Mean percentage cover of litter, bare ground, plant species groups, and total vascular vegetation in grazed areas and exclosures. Data are 2 year averages.

Parameter	Grazed	Exclosures
Litter	41	76*
Bare ground	33	7*
Shrub	5	28*
Graminoid	62	82*
Forb	53	43
Tree	6	5
Total vascular vegetation	126	159*

*Differences between treatments were significant at the 0.05 level.

Weber) cover ($P>0.2$) and *Juncus* spp. cover ($P=0.214$) was not different between treatments.

Kentucky bluegrass (*Poa pratensis* L.) cover was greater ($P\leq0.05$) in the grazed areas, while fowl bluegrass (*P. palustris* L.) cover was greater ($P\leq0.05$) in the exclosures. Nebraska sedge (*Carex nebraskensis* Dewey), and beaked sedge (*C. rostrata* Stokes) cover were not different ($P>0.05$) between grazed and excluded riparian areas (Table 3).

Table 3. Mean percentage canopy cover of major plant species in grazed areas and exclosures. Data are 2 year averages unless indicated.

Species	Grazed	Exclosures
Salix spp.[1]	2	17*
Poa pratensis[2]	27	7*
Poa palustris[2]	5	31*
Deschampsia caespitosa	5	5
Carex nebraskensis[2]	4	5
Carex rostrata[2]	10	7
Carex spp.[2]	21	3
Juncus spp.	3	6
Trifolium repens	18	2*
Taraxacum officinale	14	12

*Differences between treatments were significant at the 0.05 level.
[1]Comprised of *S. planifolia, S. drummondiana, S. wolfii,* and *S. monticola.*
[2]Data from 1986 only.

Willows within the exclosures were older ($P<0.001$) than those in adjacent grazed areas. Mean ages were 8.1 and 4.8 years, respectively. Diameter of willow stems from the exclosures was greater ($P<0.001$) averaging 11 mm, while the mean diameter from the grazed areas was only 7 mm.

Mean peak standing crop of vegetation was greater ($P\leq0.005$) in the exclosures than caged plots within grazed areas. Averaged over the 2 years of the study, values were 2,410 and 1,217 kg/ha, respectively (Table 4). Cattle utilized 65% of the current year's

Table 4. Standing crops of vegetation (kg/ha) and utilization (%) in a montane riparian zone.

Treatment	1985	1986
Exclosure	2,300 (337)[1]	2,521 (282)
Caged	1,198 (412)	1,236 (270)
Grazed	423 (104)	427 (55)
Utilization	65	65

[1]Numbers in parentheses are standard errors of the means.

growth of vegetation during 1985 and 1986 within the riparian zone (Table 4).

Discussion and Conclusions

Photographs taken along Sheep Creek before fencing (e.g., Fig. 1a) and Parker—3 step data from 1959 (unpublished data on file at USDA Forest Service) indicated no differences in vegetative cover or composition and bare ground estimates across the entire riparian area. Therefore, the vegetation differences seen today between exclosures and grazed areas can be assumed to be the result of 30 years of reduced stocking levels of cattle and rest from grazing. The grazed areas in this study show increased herbaceous vegetation with reduced stocking rates, while the Sheep Creek exclosures show greatly increased woody and herbaceous vegetation coverage and biomass. Photo plots and other data showed a considerable increase in aspen and willow growth in exclosures between 1959 and 1964, while grazed plots with reduced stocking rates showed similar values in both years (Unpublished data on file (USDA Forest Service).

Woody plant species increase rapidly when riparian areas are protected from livestock grazing. Marcuson (1977) found shrub production in Montana to be 13 times greater in control areas when compared with riparian sites grazed by cattle. Our study showed greater density and 5 1/2 times more shrub canopy coverage in protected areas compared with areas receiving continued, but reduced, cattle grazing pressure. This woody structural component of the vegetation is essential for wildlife species that are obligate inhabitants of willow thickets such as the Wilson's warbler (Tucker 1987, Finch 1988), and in providing hiding cover and stabilizing streambanks for fish habitat (Marcuson 1977, Stuber 1985).

Willows in the exclosures were older and larger than those found in grazed areas. Canopy coverage of willow was 8 1/2 times greater in the exclosures compared with grazed areas. Continued cattle grazing appears to limit the size of willows but not their density. Despain (1989) reported that elk grazing in Yellowstone National Park had no effect on willow densities, but a significant effect on their age structure. His data showed that willows inside elk exclosures had nearly all adult branches, while those on the outside had predominantly juvenile branches.

Data from this study are consistent with published results which have documented higher amounts of litter in exclosures compared with grazed areas. Leege et al. (1981) found litter to be twice as great in livestock exclosures as compared with grazed areas in Idaho.

Kentucky bluegrass appears to be favored by cattle grazing, whereas fowl bluegrass may be enhanced by protection. Costello (1944) stated that Kentucky bluegrass has replaced native plant species and is an indicator of moderately heavy grazing in wet meadows. Kauffman et al. (1983) stated that exotic grasses, which flourish in drier environments, are replaced by native sedges and forbs better adapted to wetter environments inside exclosures. Although fowl bluegrass is not a native species, it is adapted to more mesic environments than Kentucky bluegrass (Hansen et al. 1988).

Nebraska sedge cover was approximately equal in both grazed and rested areas. This sedge is commonly found in riparian areas and, while preferred, appears to be little affected by cattle grazing along Sheep Creek. These findings are consistent with Platts and Nelson (1989), who reported that Nebraska sedge was resistent to cattle grazing in a Utah riparian study. Ratliff and Westfall (1987) found that grazing did not affect the shoot frequency and density of Nebraska sedge. Beaked sedge also appears unaffected by livestock grazing along Sheep Creek. Cattle and sheep normally avoid this species when foraging in riparian areas (Winward 1986).

Tufted hairgrass has been shown to be preferred by livestock in wet meadows in Idaho (Leege et al. 1981). This study, however, showed no difference in cover of tufted hairgrass between grazed areas and exclosures.

Unexpected results, according to traditional increaser/decreaser

classification, were obtained in this study. Some "decreaser" species had similar cover values in grazed and ungrazed areas. For example, Nebraska sedge was the first plant grazed by cattle when brought onto the allotment, but it appeared to withstand grazing pressure quite well. This suggests that our data on grazing response of riparian species may need to be reexamined.

Fowl bluegrass had high cover values in the exclosures, while Kentucky bluegrass had high values in the grazed areas. The major difference between these species in plant keys is the presence of rhizomes. Could fowl bluegrass be present in other western riparian areas and be misidentified as Kentucky bluegrass? We hope this article will stimulate discussion on this issue.

Range and wildlife managers need to know how vegetation change progresses in riparian areas and the impacts caused by livestock grazing. This study indicated similar densities of willows in grazed areas and exclosures, but willows were not able to grow as tall on streambanks in grazed areas even though grazing pressure in the Sheep Creek Allotment had been reduced by 2/3 over levels of 50 years ago. The actual reduction in grazing pressure within the riparian zone was probably less, though, because cattle tend to concentrate in these areas. Other values, such as nongame wildlife and fisheries habitat, have changed as a result of cattle exclusion (Tucker 1987). Trout biomass and fishing opportunities are higher in the exclosures when compared to the grazed sections of Sheep Creek (Stuber 1985).

Some rest from cattle grazing may be needed to reestablish healthy stands of shrubs such as willows in degraded riparian areas. Skovlin (1984) recommended a 5-year rest followed by proper livestock management. Additional data from this area (unpublished data on file USDA Forest Service) and other sites (Duff 1979, Rickard and Cushing 1982) suggest that considerable recovery can take place after only 5 years of livestock exclusion from riparian zones. One way to achieve this goal might be through the use of low-maintenance, inexpensive, temporary fencing materials, such as solar-powered electric fences. These materials need to be examined for use in resting riparian areas. These fences could be established for several years during the growing season to allow shrubs to reestablish along degraded streambanks or set up during high soil moisture conditions to reduce streambank trampling. An additional advantage to this approach would be the ability to move livestock watering areas during the year, thereby reducing streambank concentration.

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