Effects of Late Season Cattle Grazing on Riparian Plant Communities

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Abstract

Livestock impacts on riparian plant community composition, structure, and productivity were evaluated. After 3 years of comparison between fall grazed and exclosed (nongrazed) areas, 4 plant communities out of 10 sampled displayed some significant species composition and productivity differences. Two meadow types and the Douglas hawthorne *(Crataegus douglasii)* community type had significant differences in standing phytomass. These also were utilized more heavily than any other communities sampled. Shrub use was generally light except on willow (*Salix* spp.)-dominated gravel bars. On gravel bars, succession appeared to be retarded by livestock grazing. Few differences were recorded in other plant communities sampled, particularly those communities with a forest canopy.

Riparian ecosystems have been identified as important zones of management because of their values as wildlife habitat (Ames 1977, Patton 1977, Thomas 1979), as a modifier of the aquatic environment and fisheries habitat (Cummins 1974, Duff 1979, Meehan et al. 1977), as a major constituent in maintenance of water quality and quantity (Horton and Campbell 1974), and as a valuable forage resource for livestock (Cook 1966, Reid and Pickford 1946). Johnson et al. (1977) stated that riparian habitat is the most productive and possibly the most sensitive of North American habitats and should be managed accordingly. However, these areas may also be among the more resilient of ecosystems following disturbance.

Grazing management strategies discussed for riparian zone rehabilitation and/or maintenance include exclusion of livestock, alternative grazing strategies, changes in the kind and class of animals, managing riparian zones as special use pastures, and several basic range practices (e.g. salting, artificial reestablishment of riparian vegetation, upland water developments, and herders). Recently many riparian ecosystems in the western United States have been fenced and managed as special use pastures. Rather than indefinite exclusion of grazing, several grazing strategies have been suggested to utilize the riparian forage resource while preserving the integrity of the riparian/stream ecosystem (Claire and Storch in press, Platts 1978). One such system is a late season grazing strategy.

Objectives of this study were to compare differences in succession, composition, productivity, and structure between riparian

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plant communities that were ungrazed and riparian plant communities that were grazed under a late season grazing strategy (late August- mid September).

Study Area

The study area is located on the Eastern Oregon Agriculture Research Center near the town of Union, Ore., in the southwest foothills of the Wallowa Mountains. The study area is roughly a 50-m by 3-km strip of riparian vegetation adjacent to Catherine Creek. The study area was part of a 49-ha pasture which was comprised wholly of plant communities within the riparian zone associated with Catherine Creek. Adjacent uplands are dominated by mixed conifer and ponderosa pine *(Pinus ponderosa)* habitat types. Elevation along the creek is approximately 1,030 m. Mean annual precipitation for the study area was 60 cm. Precipitation for 1979 was lower than average and mean precipitation for 1978 and 1980 was higher than average.

Methods

Five livestock exclosures were constructed alternating with grazed portions of the study area. Exclosures were constructed in such a manner as to minimize alterations in normal livestock movements. Approximately one-half of the streambank and riparian vegetation within 50 m of the stream was excluded from grazing. Exclosed and grazed areas contained an adequate number of similar vegetation stands for meaningful comparisons to be made. Grazing began about August 25 and continued for 3 to 4 weeks depending on the amount of forage produced and livestock numbers grazing. The stocking rate on the riparian study area was approximately 1.3–1.7 ha/AUM.

The 10 most prevalent and widely occurring communities in the riparian zone were intensively sampled using species frequency, standing phytomass and, where appropriate, shrub density, and height measurements. The 10 communities sampled were dry meadow (*Poa pratensis*-mixed forbs); moist meadow (*Poa pratensis-Phleum pratense-Carex* spp. and forbs); Kentucky bluegrass-cheatgrass *(Poa pratensis-Bromus tectorum);* cheatgrass *(Bromus tectorum),* Douglas hawthorne/Kentucky bluegrass *(Crataegus douglasii/Poa pratensis);* snowberry-Wood's rose *(Symphoricarpos albus-Rosa woodsii);* gravel bars (*Salix* spp.-*Populus trichocarpa* sapling-mixed graminoids-mixed forbs); thin leaf alder/Kentucky bluegrass *(Alnus incana/Poa pratensis);* ponderosa pine/Kentucky bluegrass *(Pinus ponderosa/Poa pratensis);* and black cottonwood-mixed conifer (*Populus trichocarpa*-mixed conifer).

At the onset of the study in 1978, representative stands were stratified by ocular reconnaissance with respect to species composition, standing phytomass, and structure. If a stand was found to be significantly different from the others sampled, it was omitted for further comparisons. Within each selected stand, transects were randomly established, and plots were measured at 1/2-m intervals.

A 1/4-m^2 quadrat was used for frequency measurements with a 1/16-m^2 nested plot used to determine frequency for the prominent species which would normally have a frequency of 100% in the larger plot. Frequency was based on 30 plots per vegetation stand with 6-18 stands of each community measured. Usually half of the stands for each community sampled were in grazed areas and half of the stands were in ungrazed areas. Frequency was determined during late June to early July, the time when most perennial species were in an identifiable phenological state and the highest seasonal species diversity for most plant communities was expressed.

Shrub density, height and composition was measured using transects of 10, 1-m^2 plots, permanently established in 30 vegetation stands. Density and height measurements were recorded for all shrub species with a rooting stem base occurring totally within the plot. Because of the rhizomatous nature of many of the woody species, density estimates were recorded as rooting stem density and not as individual plant density.

Standing phytomass was determined using a 1/4-m^2 plot. Three stands of each community in both grazed and exclosed areas were measured by clipping 10 plots in each stand for a total of 30 plots in each community for each treatment. Plots were clipped in late July to mid August just prior to the onset of grazing. All forbs and graminoids that had their stem base within the plot were clipped, oven dried, and then weighed to obtain individual species dry weight estimates.

Estimation of utilization after cattle were removed in the fall was accomplished by an ocular estimate of 10-15 plots in each stand that was sampled for standing phytomass. Stubble heights of key forage species in meadow and Douglas hawthorne communities were estimated by randomly measuring 1 grazed plant per plot.

Plant species diversity and equitability values were generated from frequency data. The Shannon-Weaver information theory formula was used to calculate diversity (H'), where $H' = \Sigma pi \log_e pi$ (Shannon 1948). Here, pi is the frequency of the ith species (i = 1,2,...S). S is the number of species in the community, or species richness. Equitability is expressed as $J' = H'/H'max$, where H'max is equal distribution of units between a given number of classes. H'max is calculated as $\log_e S$.

Changes in individual species frequency were tested with chi-square statistics. Standard analysis of variance and student-Newman-Keul's test were used to compare standing phytomass estimates of plant communities among both treatments and years. Changes in shrub density and heights between grazed and exclosed areas were tested using the Student's *t*-test (Steele and Torrie 1960).

Multivariate analysis of variance (MANOVA) was also used to test for differences in plant community composition (Morrison 1976). Population parameters used in the MANOVA were species diversity, species richness, community equitability, and standing phytomass. Wilk's lambda (λ) was the test statistic used to detect significant differences with the MANOVA (Neter and Wasserman 1974). When a significant λ was obtained, student-Neuman-Keul's test was used to determine where differences occurred. Fiducial limits for all statistical analyses were set at $p \leq 0.05$.

Results

Patterns of Utilization by Domestic Livestock

Utilization by livestock on the study area varied greatly, not only from community to community but often from stand to stand within particular communities. Dry meadows (Kentucky bluegrass-mixed forbs) and moist meadows (Kentucky bluegrass-timothy-mixed *Carex* spp.) were most preferred, and cattle utilized these communities more heavily than the other communities sampled. Greater than 60% of the forage produced in these communities was removed by livestock (Table 1).

In the dry meadow community, Kentucky bluegrass was utilized from 55–79% (Table 1). Average stubble heights for Kentucky bluegrass were 3 to 4 cm. Utilization of forbs in the dry meadow community was moderate to light, with utilization estimates of 33% of 1979, and 15% in 1978 and 1980.

Kentucky bluegrass utilization in the moist meadow community was moderate to heavy, with an estimated utilization of 67-80% (Table 1). Mean stubble heights were measured at 4 to 7 cm (Table 2). In the grazed moist meadow stands, meadow timothy was utilized 60–76% and sedges were utilized 65–81% (Table 2). Mean stubble heights for meadow timothy were 9 cm to 14 cm (Table 2). The only forb utilization of any consequence in moist meadows was that of the northwest cinquefoil *(Potentilla gracilis)* and white clover *(Trifolium repens).* In many stands northwest cinquefoil utilization estimates were greater than 70%. White clover was generally utilized 60% or greater.

Another community that apparently was preferred by cattle as a forage source included the Douglas hawthorne community, particularly those stands with a relatively open canopy. Utilization in Douglas hawthorne stands ranged from 25–47% with the more open stands of Douglas hawthorne receiving the heaviest utilization. Stubble heights of Kentucky bluegrass in Douglas hawthorne communities were less than 8 cm (Table 2).

On gravel bars utilization was light to moderate with less than

Table 1. Standing phytomass and percent utilization for grazed and ungrazed plant communities along the Catherine Creek Study Area.

	1978		1979		1980		1978		1979		1980	
	Thin leaf alder *(Alnus incana/ Poa pratensis)*						Dry Meadow (*Poa pratensis*-Mixed forbs)					
	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed
Standing phytomass (kg/ha)	1080	1206	962	1193	1369+	1609	2620	3950*	2829	2463+	3371	4173*+
% Utilization	25	T	16	5	14	3	44	2	70	1	67	T
	Douglas hawthorne *(Crateagus douglasii/ Poa pratensis)*						Moist meadow (*Poa pratensis-Phleum pratense*-mixed grasslikes and forbs)					
	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed
Standing phytomass (kg/ha)	1784	1691	1462	1632	1813	2498*+%	7150	6990	6553	3497+*	8750+	9180*
% Utilization	25	2	47	1	37	3	66	T	73	2	59	T
	Black cottonwood (*Populus trichocarpa*-mixed conifer)						Cheatgrass (*Bromus tectorum*-mixed forbs)					
	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exlosed	Grazed	Exclosed	Grazed	Exlosed
Standing phytomass (kg/ha)	2668	2597	1291+	938+	2139+	1602+%	1920	2001	974	1093+	2020+	1702
% Utilization	23	1	11	1	9	T	11	T	2	T	1	T
	Ponderosa pine *(Pinus ponderosa/ Poa pratensis)*						Kentucky bluegrass-cheatgrass *(Poa pratensis-Bromus tectorum)*					
	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed
Standing phytomass (kg/ha)	1655	1632	1390	1553	1457	1962	2173	3275	2162	1990	—	—
% Utilization	27	T	17	T	10	T	37	T	57	T	—	—
	Gravel Bar Communities						Snowberry/ Wood's *(Symphoricarpos albus-Rosa woodsii)*					
	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed	Grazed	Exclosed
Standing phytomass (kg/ha)	1973	2345	1389	1016	2156	2779	3964	3643	3987	3213	—	—
% Utilization	18	8	19	2	40	T	15	4	15	2	—	—

*Significant difference among treatments within the same year ($p \geq .05$)
+Significant change of same treatment compared to previous year ($p \geq .05$).
%Significant difference between 1978-1980 within the same treatment ($p \geq .05$).

40% of the total available forage utilized (Table 1). A preference for willows, black cottonwood saplings, and white clover was observed.

Utilization of those plant communities containing a dense canopy cover (black cottonwood, ponderosa pine, and thin leaf alder communities) was light, usually less than 20%, and always less than 30% (Table 1). It appeared that Kentucky bluegrass in forested communities was not as palatable as in meadow communities. Observations in forested communities indicated a lower plant density with fewer tillers per plant but greater leaf blade length compared to those found in meadow or open communities. Lodging was also a more common occurrence in communities possessing an overstory canopy. Utilization by cattle occurred almost exclusively on plants that were not lodged.

The cheatgrass community was the least preferred of all communities sampled. Autumn regrowth was the only detectable forage utilized in cheatgrass stands. Utilization in 1978 was 14% while less than 2% of the total available standing phytomass was utilized in 1979 or 1980 (Table 1).

Shrub utilization for the entire riparian ecosystem was neither constant from year to year nor from community to community. Shrub utilization by cattle was generally light except in the gravel bar community and on very palatable shrubs. In stands on gravel bars, livestock most preferred black cottonwood saplings with a mean utilization of 84, 31, and 50% in 1978, 1979, and 1980, respectively. Willow utilization (primarily *Salix rigida* and *Salix exigua)* ranged from 27–48%. Utilization on exclosed gravel bar communities, primarily by big game was always less than 5% for all shrub species. Cattle utilization of palatable shrubs such as blue elderberry *(Sambucus cerulua)* and goosecurrents (*Ribes* spp.) was heavy, and was often greater than 100% of the current year's growth. Douglas hawthorne shrubs with a height of less than 1-m were preferred by cattle, particularly in low density hawthorne stands or as solitary shrubs in meadow communities. Utilization often exceeded 50% of the current year's growth on many individuals. Douglas hawthorne shrubs exceeding 2m in height were rarely browsed as heavily as the smaller hawthorne shrubs. Snowberry was utilized 9 to 36% in ponderosa pine, snowberry-Wood's rose, and black cottonwood communities. Utilization of the other shrub species was less than 10%. Precipitation, and subsequently forage production, was lower in 1979 than 1978 or 1980 and shrub utilization for all shrub species was lower in 1979 than 1978 or 1980.

Impacts of Livestock on Species Composition

Species composition differences between the grazed and ungrazed treatments were evident after 3 years in the moist meadow community. In addition, phenological and temporal differences in the growing season have occurred. In some stands the onset of the growing season, anthesis, and dormancy in exclosed areas occurred as much as 2 weeks later in the year compared to grazed areas. Significant increases in mesic/ hydric species such as lineleaf indianlettuce *(Montia linearis)*, willowweeds (*Epilobium* spp.), and sedges have occurred in some exclosed stands of moist meadows. In 1980, lineleaf indianlettuce had a mean frequency of 3% in grazed stands compared to a mean frequency of 16% in exclosures,

Table 2. Mean stubble heights (cm) of selected graminoids in the 3 plant communities most preferred by livestock and estimated utilization percent of that species.

Communities	1978		1979				1980			
	Grazed	Exclosed	Grazed		Exclosed		Grazed		Exclosed	
	Util. %	Util. %	Stubble Ht. (cm)	Util. Ht. (cm)	Stubble (%)	Util. Ht. (cm)	Stubble Ht. (cm)	Util. (%)	Stubble	Util.
Dry meadows (*Poa pratensis*-Mixed forbs)										
Poa pratensis	55	2	3	79	29	1	4	77	34	0
Juncus balticus	26	—	12	50	—	—	10	40	—	—
Carex sp.	40	—	4	90	—	—	—	0	—	—
Phleum pratense	T	0	—	—	23	10	—	—	74	0
Bromus carinatus	T	—	—	T	23	14	—	—	20	0
Agropyron repens	—	—	4	90	—	—	—	—	—	
Moist meadows (*Poa pratensis-Phleum pratense*-Mixed grasslikes)										
Poa pratensis	67	T	4	80	29	2	7	68	48	T
Phleum pratense	76	15	9	76	37	3	14	60	66	2
Carex sp.	65	0	8	81	34	3	20	65	66	T
Juncus balticus	55	0	12	43	29	T	—	0	—	0
Douglas hawthorne (*Crataegus douglasii*/ *Poa pratensis*-Mixed forbs)										
Poa pratensis	40	2	6	59	33	10	8	48	33	3
Juncus balticus	—	—	14	17	—	—	4	85	—	—
Phleum pratense	—	—	—	—	—	—	9	38	51	T

— Indicates particular species was not measured in the analysis.
T Indicates a trace of utilization was detected (usually less than 2%).

with a frequency of up to 47% in some exclosed stands. Conversely in exclosures, significant decreases were apparent in meadow timothy and in some forbs such as leafy-bract aster *(Aster foliaceus),* and northwest cinquefoil. In grazed stands, frequency of meadow timothy ranged from 73-89% for the 3 years of the study while in exclosures it significantly declined from 91% in 1978 to 40% in 1980.

Those areas which are susceptible to trampling damage have also experienced changes in species composition with cessation of grazing (Table 3). In areas with gravelly, loosely structured soils, cheatgrass dominates the portions of the stand utilized by livestock while quackgrass *(Agropyron repens)* now dominates the area within an exclosure. In the exclosure, perennial and biennial forbs are invading and colonizing the area while outside the exclosure the stands are basically dominated by annuals. A well-developed litter layer is forming in the exclosed area.

On gravel bar communities, density of cottonwood saplings significantly increased in exclosures after 2 years rest. Twenty-four rooting stems per meter^2 were measured in exclosed stands, compared to 13 rooting stems per meter^2 in grazed stands. In ungrazed stands, the mean height of black cottonwoods significantly increased from 19 cm in 1978 to 30 cm in 1979. Mean height of black cottonwoods in grazed areas was not significantly different between years where they remained 10–12 cm high. In addition, 1979 density of McKenzie willow *(Salix rigida)* was significantly greater in exclosures with a density of 3.8 per meter^2 compared to 1.0 per meter^2 in grazed areas. On gravel bar communities, observed changes in shrub composition included increased density and height of willows and black cottonwood in the ungrazed area while the grazed area remained dominated by a low cover of black cottonwoods.

Impacts of Livestock on Standing Phytomass and Productivity

Though small species composition changes have occurred, multivariate analysis indicated no significant differences in total species diversity (H′), species richness (S), or equitability (J′), between grazing treatments for all communities sampled. However, significant differences using MANOVA were detected in the standing phytomass component of some plant communities. In general, the communities with the greatest amount of standing phytomass in the field layer were the communities exhibiting the greatest response to cessation of grazing. These communities (primarily meadow and Douglas hawthorne communities) were also the areas most heavily utilized by cattle as a forage source. Vegetation stands with a low standing phytomass in the field layer generally displayed little response to cessation of grazing after 3 years rest.

Significant differences in the total standing phytomass estimate for moist meadow communities as well as for standing phytomass estimates for many individual species within moist meadows were noted. Pretreatment standing phytomass estimates were approximately 7,000 kg/ha for both grazed and exclosed areas (Table 1). During 1979 moist meadow stands that were grazed changed very little with a mean standing phytomass of 6,550 kg/ha. In exclosures, the standing phytomass estimate significantly decreased to 3,500 kg/ha in 1979. This decline in standing phytomass did not continue into 1980. In 1980 standing phytomass of moist meadows in exclosures increased to 9,180 kg/ha. This was a significant increase over the phytomass estimate for 1979 phytomass estimates. There was no significant difference in total standing phyto-

Table 3. Average percent frequency of major plant species on a grazed and ungrazed cheatgrass plant community on gravelly soils after 3 years.

Species	Percent frequency Exclosure	Percent frequency Grazed
Grasses		
Bromus tectorum	5	100
Agropyron repens	100	—
Poa pratensis	20	25
Bromus racemosus	—	20
Forbs		
Epilobium paniculatum	50	40
Veronica arvensis	15	5
Microsteris gracilis	55	70
Taraxacum officinale	5	—
Collomia linearis	50	5
Lactuca serriola	35	—
Rumex acetosella	10	10
Achillea millefolium	10	—
Collinsia parviflora	10	—
Erodium cicutarium	5	10
Polygonum douglasii	—	15
Fragaria virginiana	—	5
chickweeds (*Caryophyllaceae* sp.)	—	25
unknowns	10	—

mass between treatments during 1980. Standing phytomass in grazed areas during 1980 was 8,750 kg/ha.

Individual species within moist meadows had different reactions to cessation of grazing. Standing phytomass for meadow timothy in grazed areas was estimated at 2,310 kg/ha in 1978, 1,420 kg/ha in 1979, and 2,040 kg/ha in 1980. In exclosures standing phytomass estimates for meadow timothy were 1,860 kg/ha in 1978, 170 kg/ha in 1979, and 720 kg/ha in 1980. When comparing grazed and ungrazed treatments, significant differences in standing phytomass estimates for meadow timothy occurred in 1979 and 1980. It was apparent that the decreased abundance of meadow timothy in exclosed moist meadows was related to cessation of grazing. Large carex spp. *(Carex aquatillis, Carex stipata* and *Carex rostrata)* responded in exclosed moist meadows with a significant increase in standing phytomass from 810 kg/ha in 1979 to 2,960 kg/ha in 1980. There was no significant difference between years in standing phytomass of the sedges in grazed areas. In moist meadow communities it appeared that without grazing, succession towards a more mesic/hydric plant community was occurring. In exclosures exotic grasses, such as meadow timothy, and forbs more attuned to drier environments decreased and were being replaced by native sedges and forbs more attuned to wetter environments.

Annual fluctuations in total standing phytomass in dry meadows were similar to those of moist meadows. In exclosed areas, 1979 phytomass was significantly less than phytomass measured in 1978 and 1980 in exclosures (Table 1). In contrast, grazed dry meadows had relatively stable phytomass estimates for all years of the study. A significant difference in standing phytomass between treatments was measured in 1978 and 1980, where there was no significant difference in standing phytomass in 1979, the year of low production in exclosures.

Phytomass for the forb component of dry meadows excluded from grazing was significantly less than that for dry meadows that were grazed. In exclosures, the forb component of dry meadows steadily declined each year of the study. Phytomass of forbs in exclosures was 300, 140, and 110 kg/ha for 1978, 1979, and 1980, respectively. Phytomass of forbs in grazed areas was 590, 430, and 470 kg/ha successively for the 3 years of the study.

After 3 years of no livestock grazing, the Douglas hawthorne/Kentucky bluegrass communities in exclosed areas had significantly higher phytomass than grazed areas (Table 1). Standing phytomass was not different in the previous years between treatments. This increase in standing phytomass was attributed exclusively to an increase in phytomass of Kentucky bluegrass. Estimates for Kentucky bluegrass in exclosures increased from 1,380 kg/ha and 1,300 kg/ha for the first 2 years of the study, respectively, to 2,176 kg/ha in 1980.

In the forested communities (black cottonwood-mixed conifer, ponderosa pine, and thin leaf alder communities), few changes in standing phytomass occurred after 3 years of cessation from grazing. No significant differences in standing phytomass between treatments were encountered in these communities (Table 1), nor were there significant differences in total standing phytomass on gravel bars dominated by willows and black cottonwood saplings.

Cheatgrass communities showed little response to the different grazing treatments after 3 years and no significant differences have been noted due to treatment effects in phytomass estimates of either the graminoid or forb component in the stands sampled, except as related to areas with extreme trampling. There were no significant differences in snowberry-Wood's rose communities or Kentucky bluegrass-cheatgrass communities in 1979 after 1 year of treatment effects. These communities were not sampled in 1980.

Discussion

The effect of grazing on plant community composition and structure were apparent in the vegetation stands where a change in species composition in the exclosed areas occurred. Similar observations have been made in other riparian ecosystems (Hayes 1978, Dobson 1973). Dobson (1973) concluded the effect of grazing had been to open up the vegetation, creating more niches in which plants could establish themselves. Utilization on woody vegetation was light in all communities with the exception of use in the gravel bar community and on the highly palatable shrubs in other areas.

Carothers (1977), Crouch (1979), and Glinski (1977) have observed that grazing pressures on woody vegetation prevented the establishment of seedlings, thus producing an even-aged nonreproducing vegetation community. Few seedlings or saplings were found in shrub density transects for thin leaf alder and black cottonwood-mixed conifer communities indicating that there was little, if any, regeneration of either alders or cottonwoods. These communities appeared to succeed in an approximate seral order of black cottonwood sapling communities formed on gravel bars to willow-dominated communities, to thin leaf alder dominated-communities. Mature black cottonwood-mixed conifer communities appear to be succeeding thin leaf alder communities at many sites in the study area.

Examination of the woody species composition on willow-black cottonwood sapling-dominated gravel bars indicated that grazing was probably retarding the progression of this sere. This phenomenon was observed at several locations of willow-cottonwood dominated communities bisected by exclosure fences at the onset of the study. After 3 years, shrub density and height appeared to be greater in the exclosed portion of the stands and thin leaf alder and some species of willows that were not found in grazed areas were present. Conversely, the grazed portions of these stands of vegetation were dominated by stands of black cottonwood and willow species of lower stature and lower densities. Although it was too early to determine if a late season grazing strategy has a definite negative impact on succession to woody-dominated communities and hence the long-term structural diversity of this riparian ecosystem, early evidence and observations indicated that this was happening.

Though it could be argued that late season grazing would increase intensity of utilization of the shrub component in a riparian zone, this would probably not be as severe as the shrub utilization in upland (nonriparian) communities in this season. Late in the growing season, the herbaceous component was still succulent and palatable in the riparian zone whereas the herbaceous vegetation in uplands generally was not. In this riparian zone, observations indicated that shrub use by cattle was related to availability of herbaceous vegetation and the palatability of the particular shrub species. Discernable utilization of shrubs did not begin each year until the latter part of the grazing season. As long as herbaceous vegetation was available in the riparian zone, shrub utilization did not occur to greater extent due to late season grazing. This is similar to extensive observations by Hall (pers. comm.)[1] in the Blue Mountains of Oregon that little shrub utilization, except on highly palatable species occurs when a stubble height of 10 cm or greater is present. A definite shift in preference to less palatable species occurs at this point, which is increasingly apparent when stubble height is reduced below 5 cm.

Herbage removal by livestock appeared to be an important factor in altering seasonal phenology of the mesic/hydric meadow communities. In the ungrazed moist meadow communities, onset of the growing season occurred approximately 2 weeks after the grazed moist meadow communities in 1979 and 1980. Examination of phenology of individual plants in meadows indicated that at the time of anthesis for most grasses, sedges, and perennial forbs in grazed areas, most of the vegetation in exclosed areas was still in a vegetative form. The dense litter layer formed in exclosed meadows probably kept soil temperatures below levels for initiation of growth for longer periods of time than in grazed areas in which there was a smaller litter layer. Sharrow and Wright (1977) found similar soil temperature relationships between areas in which the litter layer had been removed by fire and unburned control plots containing a litter layer. They attributed increased soil temperatures to increased increased solar exposure of the soil surface due to litter removal.

[1]Frederick C. Hall, plant ecologist, USDA Forest Service, Pacific Northwest Region, Portland, Oregon 97208.

The increased soil moisture due to litter layer accumulation could also be an important factor for the increased abundance of the more mesic/hydric species and the decreased abundance of species more attuned to drier environments in the exclosed moist meadows.

Impact of livestock trailing and trampling was localized primarily in those communities with moist or saturated soils susceptible to compaction by livestock and in those communities with very fragile, loosely consolidated gravelly soils susceptible to physical damage by the uprooting of established vegetation. Communities with saturated soils present for the entire summer were the only vegetation stands with a potential for severe compaction damage during the late season grazing period. In the majority of the vegetation stands, soil moisture was low enough to minimize potential physical damage to the soils. Some evidence of vegetation recovery due to cessation of grazing was noted on those areas with loosely consolidated unstructured gravelly soils (Table 3).

Management Implications

Ideally the results of proper management would be to perpetuate, rehabilitate, or improve the resources associated with riparian ecosystems. It must be recognized that no 2 streams or stream segments are the same and methods of management to restore disturbed streamsides to their former productive state will vary considerably (Claire and Storch in press). Even within a single segment of a riparian ecosystem the diversity of plant community types should be considered. Because of the great community diversity, and differing ecological tolerances of riparian plant communities, a management practice that may be beneficial for one community in a riparian zone may not be beneficial to another community in the same area. Herein lies what may be a fundamental problem in the future of riparian zone management: managing the riparian ecosystem in such a way as to be of the greatest benefit to the communities which are deemed most important for whatever use or uses are most preferred for that particular riparian ecosystem.

This study indicated that fall grazing had major influences on some communities and no discernable influence on others. If the impacts of fall cattle grazing on plant communities are perceived as acceptable, then consideration of other effects and consequences of this grazing strategy may be important, depending on management objectives. These effects and consequences of this grazing strategy include, among other things, utilization of the forage resource by livestock, maintenance of water quality, minimization of disturbance to avian communities, minimization of physical impacts on soils, increased calf gains, improved condition of mother cows, and improved utilization of upland plant communities (Claire and Storch in press, Kauffman 1982, Vavra and Phillips 1979). Conversely, the late season grazing strategy was found to significantly increase streambank erosion and cause a significant short-term decrease in small mammal densities, although the impact on mammals did not appear to affect carryover densities (Kauffman et al. 1982, Kauffman et al. 1983).

Late in the grazing season, vegetation growing in riparian zones generally is more palatable and of higher nutritive quality than vegetation in upland plant communities. Several sedges common to riparian zones of the Pacific Northwest outrank key upland forage species in late season protein and energy content (McLean et al. 1963, Paulsen 1969, Skovlin 1967). Vavra and Phillips (1979) found improved dry matter digestibility, improved protein levels, lowered acid detergent fiber, and lowered lignin contents in diets of fistulated heifers grazing this riparian study area during late August–early September, compared to what upland pastures provided up to 1 month preceding this period. Daily intake rates also were greater in the riparian zone than in upland pastures either before or after this period.

There are many economic, aesthetic, and management factors that must be considered before fence construction and implementation of a special use pasture grazing system. Riparian zones in many mountain grazing allotments provide up to 20% of the total forage produced (Reid and Pickford 1946, Roath and Krueger 1982). Often due to livestock distribution problems this fraction of total forage produced supplies up to 80% of the total forage consumed by livestock (Roath and Krueger 1982). Rather than fence pastures of equal size, fencing areas of similar ecological responses could be implemented. Fencing uplands in separate pastures from riparian types is a start in this direction, when areas are productive enough to be effectively managed as separate pastures.

Land and/or livestock management flexibility is easily attained when the riparian zone is fenced separately and used as a special use pasture for late season grazing. Utilization of upland forages could be achieved independently from management requirements of the riparian zone, thereby allowing for proper use of the uplands without overuse of the riparian zone. And, depending on environmental conditions for a given year, length of grazing in riparian areas could be optimized to achieve desired use levels for the key riparian species, whether they be woody or herbaceous species.

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