Characteristics of Riparian Plant Communities and Streambanks with Respect To Grazing in Northeastern Utah

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Abstract.—Streambanks and associated riparian vegetation were studied in grazed and ungrazed pastures along Big Creek, Rich County, Utah, to determine whether differences in streamside community type composition and condition were related to differences in streambank morphology. Considerable structural difference was observed between grazed sites and sites where grazing has been suspended or greatly reduced for nearly two decades. In the ungrazed sites, structures that had been installed to improve fish habitat had apparently raised water tables and thus were associated with changes in riparian vegetation. Similar trends seem to be starting in unimproved sites that have been protected from grazing for only 4 years. Streambank morphology varied widely among the various community types. Certain riparian community types (e.g., those characterized by *Carex* spp.) were able to maintain bank structure under grazing use, but others (e.g., those characterized by *Poa pratensis*) appeared to be highly unstable when grazed. Higher order classification revealed groups of streamside community types that, in the absence of grazing, could be expected to confer similar streambank characteristics. An apparently distinct, successional sequence from sandbar-dominated communities through *Juncus balticus*-dominated communities to *Poa pratensis*-dominated communities or sedge-dominated communities was evident. Where sedges can become dominant, they clearly create the most optimal streambank structure. Even under grazed conditions, some of the optimum bank characteristics were associated with this community type. Moderate grazing pressure after viable sedge communities have become reestablished may be acceptable, but the managers responsible must ensure that CAREX community types do not revert to less favorable communities like POPR.

Dispersed throughout the vast rangelands of western North America are numerous ephemeral, intermittent, and perennial streams and wetlands. While of small areas themselves, these streams and wetlands constitute habitats where water is less of a limiting resource than on the surrounding uplands; wet islands in an arid sea, where plants requiring free or unbound water flourish. The mesic to hydric vegetation associated with these streams and wetlands defines a narrow riparian ecosystem, often referred to as a "corridor" when associated with streams, within the larger surrounding rangeland ecosystem. Such riparian ecosystems often support a higher diversity of terrestrial plant and animal species than the surrounding uplands and provide critical habitat components for diverse forms of aquatic life. They also attract livestock, which may congregate in riparian areas to take advantage of the relatively lush vegetation, readily available drinking water, soft soil, and shade; livestock may therefore spend a disproportionate amount of their time foraging within these fertile streamside corridors.

Growing recognition of these two important factors, that riparian areas provide critical resource values for fish and wildlife and that livestock are attracted to them and may use them more heavily than adjacent upland range areas, has led to increased study of riparian conditions and their relationship to grazing management. Several studies (Bryant 1982; Roath and Kruegar 1982; Platts and Nelson 1985b, 1985d) have shown the preference of cattle for riparian areas; others have focused on the differences in riparian physical (Crispin 1981; Platts et al. 1983b; Platts and Nelson 1985c) and biologic (Winegar 1977; Szaro and Pase 1983) conditions under a variety of cattle grazing strategies ranging from complete rest to season-long continuous grazing.

A serious shortcoming of early attempts to evaluate the relationship between grazing and riparian area conditions and to develop useful management guidelines was a lack of adequate integration of the physical and biological interactions occurring in riparian ecosystems. This shortcoming has been ameliorated somewhat by the application of habitat typing techniques, which were first developed for forest communities by Daubenmire (1952), to riparian plant communities. In contrast to the habitat type classification concept, which considers successional development of the observed stands and attempts to determine the potential climax type, the community typing concept as applied to riparian vegetation is restricted to existing species composition because succession in the riparian context is poorly understood (Youngblood et al. 1985).

Extensive riparian community type classifications have been developed for some Rocky Mountain areas (Tuhy and Jensen 1982; Youngblood et al. 1985) and are currently being developed in Great Basin watersheds in Utah (Platts and Nelson 1987) and Nevada. With these classifications, streambank and channel morphology and vegetal form of the various plant communities can be compared under different grazing treatments.

This report takes a first look at the vegetal composition and morphology of riparian plant communities and streambanks under grazed and ungrazed situations on Big Creek in Rich County, northeastern Utah. Fencing of a large portion of Big Creek in the late 1970s has led to extensive vegetal changes that can now be comprehensively examined. Fencing of another section of Big Creek in the early 1980s also permits evaluation of the rate at which these changes take place, providing insight into potential rehabilitative pathways[1] as riparian vegetation is released from grazing. As we expand such knowledge, a more thorough framework in which to develop grazing management strategies that promote realization of multiple-use values on western rangelands may develop.

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[1] Most riparian classifications devote a good deal of discussion to successional relationships of the types despite a stated lack of understanding of such sequences. Because of this lack of understanding, we have elected to use such terms as "progression" and "regression" in place of "succession" and "retrogression", respectively.

Study Areas

Two study areas were established in the Big Creek drainage west of Randolph, Utah. Big Creek is a perennial tributary of the Bear River on the eastern flank of the Bear River Range, a northward extension of Utah's Wasatch Mountains. Physiographically, Big Creek is within the Middle Rocky Mountain Province at the western edge of the Wyoming Basin (Fenneman 1931), but the Bear River drainage connects it with Great Salt Lake and the Great Basin (Basin and Range Province) opposite the Wasatch crest to the west.

Floristically, the unforested rangelands surrounding Big Creek are part of the Sagebrush-Wheatgrass Section of the Wyoming Basin Province (Bailey 1980). These uplands potentially comprise vast expanses of big sagebrush *Artemesia tridentata* accompanied by understory grasses, including bluebunch wheatgrass *Agropyron spicatum*. At the present time, the bunchgrass vegetation type represents only 9% of the upland range vegetation in the area and contains chiefly exotic crested wheatgrass *Agropyron cristatum*. Stands dominated by sagebrush and containing only about 5% grass comprise some 65% of the upland vegetation (USBLM 1979). Riparian vegetation, composed mainly of sedges *Carex* spp. and other graminoids, comprises less than 1% of the local vegetation but produces a disproportionately large amount of forage and thus has been an area of livestock concentration (USBLM 1979).

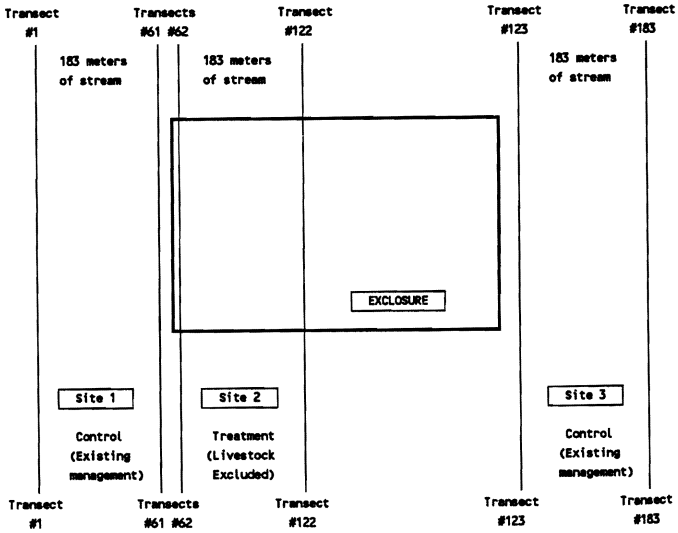
Water in Big Creek is moderately hard and bicarbonate buffered, with a mean annual flow of about 0.44 m^3/sec (D.A. Duff, U. S. Forest Service, personal communication). The stream supports populations of rainbow trout *Oncorhynchus mykiss*, cutthroat trout *O. clarki*, brown trout *Salmo trutta*, and Eastern brook trout *Salvelinus fontinalis*, as well as some non-game species, including mottled sculpin *Cottus bairdi* and suckers *Catastomus* spp. Aquatic habitat quality is generally poor for trout because the broad, shallow channel creates pools of low quality; fine sediments are abundant on the stream bottom, particularly in slow moving stretches; streambanks are poorly vegetated (Platts and Nelson 1985a, 1985c; Duff, personal communication); and stream canopy is sparse (Platts and Nelson 1985a). A livestock exclosure that released 0.8 km of Big Creek from regular annual grazing use was constructed in 1970, and about 40 instream repair[2] structures were installed in 1970 and 1971, both within and below the exclosure (USBLM 1979; Duff, personal communication). Despite occasional instances of unauthorized livestock entry, the exclosures have greatly improved riparian habitat conditions (USBLM 1979; Platts and Nelson 1985a, 1985c; Duff, Unpublished) and have led to channel and bank stabilization (Platts and Nelson 1985c; Platts et al. 1985). In 1983, construction was completed on a second livestock exclosure, somewhat larger than the first, approximately 2 stream-km upstream.

Livestock grazing on Big Creek has been largely for calf production. The grazing strategy of choice has been continuous (or season-long) grazing, with a season extending from mid-May to mid-September. A drift fence is located between the two exclosures to delay cattle from moving into the upper portion of the allotment, and a change to a deferred system[3] has been proposed (USBLM 1979) but has not been implemented. Livestock use of upland forage has been high, generally about 65% (USBLM 1979), but seems to have declined in the vicinity of the study areas since 1978 (Platts and Nelson 1983). Use of riparian vegetation has been much higher and has approached 90% where not protected (Platts and Nelson 1983, 1985a, 1985c).

Methods

Two study areas were established, one along 549 m of stream in conjunction with the first (downstream) exclosure (Lower Big Creek) (Figure 1) and one along 732 m of stream in conjunction with the newer (upstream) exclosure (Upper Big Creek) (Figure 2). Each study area was subdivided into treatment (rested) and control (grazed normally) sites of 183 m each. The lower study area comprised three sites: one control immediately below the exclosure, an adjacent treatment site immediately upstream and inside the exclosure, and one control about 0.6 km upstream and immediately above the exclosure. Treatments and controls had similar aquatic and riparian habitat conditions prior to construction of the exclosures (Platts and Nelson 1985a, 1985c). The upper study area comprised four study sites: a downstream pair of adjacent sites, with the control below the exclosure and the treatment site immediately above and within the exclosure, and an upstream pair, with the treatment site inside the fenced area and an adjacent control site outside and immediately above the exclosure.

Figure 1.—Schematic diagram of the Lower Big Creek study area.



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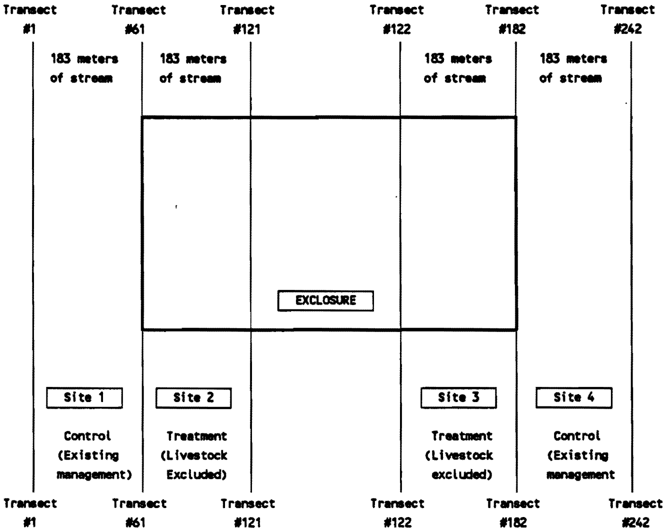
[2] Terms such as "repair structures" and "stream repair" have been used in place of the more commonly encountered terms, such as "habitat improvement structures" and "habitat enhancement" in order to distinguish attempts to rehabilitate degraded stream-riparian systems from simple attempts to enhance fishery productivity.

[3] A typical deferred grazing stategy is one in which the area to be grazed is divided into two pastures. Each season, one pasture is grazed early (i.e., for the first half of the grazing season), with use of the second pasture deferred until sometime near the middle of the grazing season, when the manager has decided that the vegetation will have become "ready". Range readiness often coincides with the time that particular range grasses ("key species") set seed ("seed ripe"). During successive grazing seasons, the pastures serve alternately for early and late use. The drift fence on Big Creek has typically been used merely to retard the entry of cattle into the upper portions of the allotment.

Figure 2.—Schematic diagram of the Upper Big Creek study area.



Riparian community type and streambank morphology data were collected using the transect method described in Platts et al. (1983b). Transects were established at 3-m intervals along the left streambank (downstream orientation) and perpendicular to the streamflow; thus, Lower Big Creek had 183 transects, and Upper Big Creek had 244 in pairs of 122 transects each. Riparian communities were classified (typed) along each transect line on each streambank, from the water's edge to at least 3 m back on the streambank. The length of each community type encountered along the transect was measured, but just those community types bordering the water's edge were considered in this report. Classification procedures are fully described in Platts and Nelson (1987) and were similar to techniques described elsewhere (Tuhy and Jensen 1982; Youngblood et al. 1985).

Classification of riparian vegetation is a new field of study and had not been attempted previously in the Big Creek area; pending more thorough investigation of riparian vegetation outside these study areas, the classification used for this study may ultimately be revised. Standard plant species acronyms used to name the community types, were based upon the dominant overstory and understory species. Where specific identification could not be accomplished, generic names or habitat descriptors were used (e.g., SALIX/DWM for a willow and downed woody material community type). Nonvegetated or sparsely vegetated areas were assigned names based on physical and biological characteristics. Consequently, and in contrast to the usual riparian community type classifications, we have referred to such community types as being mineral-dominated types in order to include the full range of ecosystem conditions. Precise descriptions of the individual community types that have been described for the Big Creek area can be found in Platts and Nelson (1987) and are described only briefly in this report.

Sixteen edge-of-water riparian community types were described (Platts and Nelson 1987) in the two Big Creek study areas (Table 1). Most community types occurred in both areas, but three (ROCK, HERB/SB, and RIBES/MH) were observed only in the lower study area and four (HERB/GB, AGST/SB, AGST/GB, and SALIX/MH) were found only in the upper study area. Although stream stage could conceivably influence what community type was present at water's edge, we consider this potential bias to be irrelevant for the purposes of this analysis because the average extent of the edge-of-water community types was 3.5 m.

Physical riparian habitat conditions were measured by using techniques described in Platts et al. (1983a, 1987). Variables evaluated included three morphological or structural variables (streambank angle, streambank undercut, and streamshore depth), three variables relating to vegetation form or condition (vegetation overhang, streambank stability, and forage production), and two vegetation variables that were directly related to livestock influence (vegetation use and streambank alteration). These measurements were sorted by community type and descriptive statistics (means, variances, and frequencies) were computed to evaluate relative characteristics of the individual community types. This reduced statistical reliability in many cases because of the attendant reduction in sample size, an effect that is considered, where necessary, in the following analysis. All structural variables were measured at as nearly the same time as practicable to minimize temporal variability.

Table 1.—Riparian community types described at water's edge along Big Creek, Utah (Platts and Nelson 1987).

Community type	Acronym
Mineral-dominated types[a]	
Sand bar	SB
Gravel bar	GB
Eroded bank	EB
Rock	ROCK
Herbaceous-mineral types	
Herbaceous sand bar	HERB/SB
Herbaceous gravel gar	HERB/GB
Agrostis stolonifera/sand bar	AGST/SB
Agrostis stolonifera/gravel bar	AGST/GB
Herbaceous types	
Mesic herbaceous	MH
Carex rostrata	CARO[b]
Carex nebraskensis	CANE[b]
Juncus balticus	JUBA
Poa pratensis	POPR
Riparian shrub-dominated types	
Ribes inerme/mesic herbaceous	RIIN/MH
Salix sp./mesic herbaceous	SALIX/MH
Salix sp./down woody material	SALIX/DWM
Upland shrub-dominated types	
Artemesia tridentata/Poa pratensis	ARTR/POPR
Artemesia tridentata/upland	ARTR/UP

[a] May contain some plant cover.

[b] CARO and CANE have been lumped into a combined CAREX community type for this study; however, some differences in occurrence are discussed where relevant.

Streambank Structure

Streambank angle is the angle formed between the streambank and the channel bottom.[4] The angle was measured directly from a clinometer that displays the degrees of arc of a surface. Angles of less than 90° are insloped and undercut, but those of more than 90° are outsloped and of little value in providing fish cover. Streambank undercut is the actual undercut of the bank along the transect line and measures the amount of overhanging bank cover available to fish. Undercut banks can be more stable than banks that are not undercut, because a large amount of plant root mass is required to hold the surface soil together while allowing subsurface soil to erode away beneath it to form the undercut. Streamshore water depth is the depth of the stream at the point where the streambank and water column meet. This depth is also a form of fish cover because it is associated principally with low-angle banks and indirectly indicates the resistance of the bank to erosion and trampling. Streambank undercut and streamshore water depth were measured directly with a measuring rod.

Vegetation Form

Vegetation overhang is the distance living vegetation from 0 to 30 cm above the stream surface overhangs the water column. This overhang provides fish cover and is related to the species of plants in the riparian corridor. Vegetation overhang was measured directly with a measuring rod. Streambank stability is a measure of relative cover, in percent, that was determined by visually estimating the amount of vigorous vegetal cover (basal area) or composition of large, stabilizing inorganic particles on the bank. This variable can further describe the vigor of the vegetation and its ability to protect the streambank from erosion.

Livestock Influence

Vegetation use was estimated visually near the end of the grazing season along each transect line to determine the amount of forage removed by livestock during the preceding grazing season. This estimate incorporated an estimate of the amount of vegetative productivity lost through past grazing (e.g., in trailing and watering areas). Thus, an area released from grazing may continue to show use if substantial bare ground remains as a result of heavy past grazing. Streambank alteration evaluated the amount, in percent, that streambanks have diverged from their optimal natural condition. Estimating alteration is inherently subjective and imprecise but provides insight into the mechanics of changes in channel structure induced by external forces, that, on Big Creek, include livestock.

Statistical Treatment

Basic statistical analysis was performed using SAS for Personal Computers, Version 6 (SAS Institute 1985a, 1985b, 1985c)[5]. Raw data from each transect were sorted by stream edge community type and mean values for each environmental variable by community type were computed. Frequency of each community type, which was also the sample size from which each mean was calculated, was also determined. Due to the consequent reduction in sample sizes from the sorting process, differences between means were not tested for statistical significance. Higher level grouping of streamside structure was accomplished by using the cluster analysis module in SYSTAT (Wilkinson 1986). Average structural and vegetal form characteristics by community type were arranged in a matrix and clustered by single (nearest neighbor) and complete (farthest neighbor) linkages, and dendrograms reflecting their degree of structural similarity (based on Euclidean distance) were produced.

Results

Community Type Frequencies

Grazed sites generally contained about the same mix of community types as did their adjacent ungrazed sites, but proportions of each type differed (Table 2). This was particularly true in the Lower Big Creek study area, where the ungrazed site had had 15 years of protection from grazing.

Lower Big Creek Study Area.—The lower grazed site (site 1) contained fewer individual community types than either of the other two sites. Sites 2 (ungrazed) and 3 (grazed) each contained one unique community type; these discrepancies, however, involved only relatively infrequent types. Mineral-based community types dominated the two grazed sections (66.4 and 62.6%, respectively) but were infrequent (6.7%) within the ungrazed site (Figure 3). At least three of the occurrences of ROCK community types (2.5%) and two of the EB community types in the ungrazed site were attributable to the rock baskets anchoring the gabions that had been installed to improve trout habitat.

The decrease in mineral-dominated community types in the rested site (site 2) coincided with an increase in sedge-dominated types. Sedge-dominated community types accounted for only 3.3% of the community types in the lower grazed site and a minimal 1.6% of the waterside community types in the upper grazed site; however, they accounted for 32.5% of the community types in the ungrazed site. In the rested section of Lower Big Creek, which had been ungrazed for 15 years, sedge-dominated types were the second most abundant of the community types encountered at the water's edge. The ungrazed area included both the CARO and CANE community types, but only CANE was observed outside the exclosure.

Grassy herbaceous types, comprising chiefly POPR but including JUBA, were common in the grazed areas, where they constituted 25.4 and 30.9% of the community types in the upper and lower sites, respectively; in the rested area, however, they were codominants with CAREX and comprised 48.3% of the community types at the water's edge. Most of this increase in occurrence is attributable to the

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[4] A rigorous geomorphological definition of "streambank" has not been employed for the same reason that nonvegetated and vegetated CTs were not differentiated. Streambanks are technically the portion of the channel that restricts lateral movement of the stream. As these banks break down (i.e. increase in angle) they become less distinguishable from the channel bottom. The purpose of this paper is to evaluate these changes, especially at that point where the demarcation between channel and bank becomes blurred.

[5] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

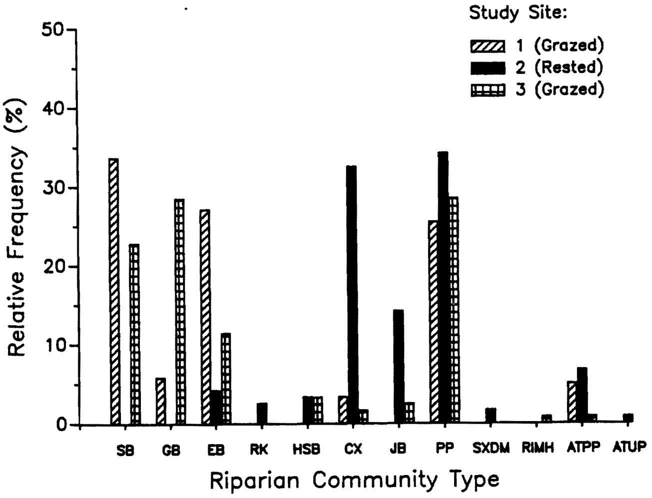
Table 2.—Distribution of observed riparian community types at water's edge in the Lower and Upper Big Creek study areas, Utah, in relation to grazing; N is the frequency of occurrence of each community type.

	Lower Big Creek						Upper Big Creek							
Community type[a]	Rested site		Lower site		Upper site		Grazed		Rested		Grazed		Rested	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
SB	0	0.0	41	33.6	28	22.8	15	12.3	13	10.8	1	0.8	9	7.4
GB	0	0.0	7	5.7	35	28.5	21	17.2	15	12.5	24	20.0	22	18.0
EB	5	4.2	33	27.1	14	11.4	37	30.3	15	12.5	6	5.0	7	5.7
ROCK	3[b]	2.5	0	0.0	0	0.0	—	—	—	—	—	—	—	—
HERB/SB	4	3.3	0	0.0	4	3.3	—	—	—	—	—	—	—	—
HERB/GB	—	—	—	—	—	—	0	0.0	0	0.0	6	5.0	5	4.1
AGST/SB	—	—	—	—	—	—	2	1.6	5	4.2	4	3.3	6	4.9
AGST/GB	—	—	—	—	—	—	0	0.0	1	0.8	0	0.0	3	2.5
CAREX	39	32.5	4	3.3	2	1.6	0	0.0	14	11.7	14	11.7	16	13.1
JUBA	17	14.2	0	0.0	3	2.4	0	0.0	0	0.0	2	1.7	11	9.0
MH	—	—	—	—	—	—	3	2.5	0	0.0	4	3.3	2	1.6
POPR	41	34.2	31	25.4	35	28.5	42	34.4	43	35.8	54	45.0	33	27.0
SALIX/DWM	2	1.7	0	0.0	0	0.0	0	0.0	0	0.0	2	1.7	3	2.5
SALIX/MH	—	—	—	—	—	—	0	0.0	0	0.0	3	2.5	5	4.1
RIBES/MH	0	0.0	0	0.0	1	0.8	—	—	—	—	—	—	—	—
ARTR/POPR	8	6.7	6	4.9	1	0.8	0	0.0	14	11.7	0	0.0	0	0.0
ARTR/UP	1	0.8	0	0.0	0	0.0	2	1.6	0	0.0	0	0.0	0	0.0
TOTAL	120	100.1	122	100.0	123	100.1	122	99.9	120	100.0	120	100.0	122	99.9

[a] Acronyms defined in Table 1.

[b] Rock baskets anchoring gabions.

Figure 3.—Distributions of riparian community types by study site, Lower Big Creek study area (acronyms shortened to fit on horizontal axis).



increased frequency of the JUBA community type in the ungrazed site; however, POPR was also more prevalent. Riparian shrub types were infrequent, and willow-dominated community types occurred only in the rested site. One occurrence of a community type defined by the presence of *Ribes inerme* (RIIN/MH) was recorded in the upper grazed site only.

Upper Big Creek Study Area.—Riparian community type differences between grazed and rested (4 years rest only) study sites were far less dramatic in the Upper Big Creek study area, but some progressive changes, paralleling those that were evident on Lower Big Creek, were noted nonetheless (Table 2, Figure 4). Mineral-dominated community types were somewhat less evident at water's edge in the ungrazed sites, and herbaceous mineral types, which may represent the initial phase of vegetal colonization of mineral bars, were more frequent. Sedge-dominated community types, here exclusively CANE, were not observed in the lower grazed site but were common in the lower rested site; they were slightly more abundant in the upper rested site than in the upper grazed site. Rush-dominated community types (i.e., JUBA) were not observed in the lower pair of sites but occurred in both upper sites. The POPR community type dominated the water's edge vegetation throughout but was least abundant in the upper rested site and most frequent in the upper grazed site. Riparian shrub community types were observed only in the upper study site pair, and upland types were noted only in the lower pair.

Community Type-Streambank Morphology Relationships

Streambank morphological characteristics by community type were evaluated only in the Lower Big Creek study area. Mean morphological attributes of the observed community types were quite different in the grazed sections than in the ungrazed site (Table 3). All morphological habitat characteristics except streamshore depth for the HERB/SB community type were clearly better for trout in the rested area. The cause of this apparent anomaly with

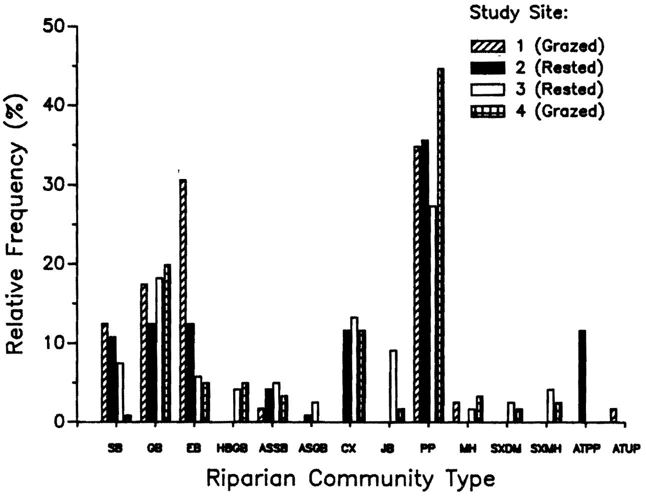


Figure 4.—Distributions of riparian community types by study site, Upper Big Creek study area (acronyms shortened to fit on horizontal axis).

HERB/SB may be attributable to the fact that few occurrences of this community type were observed and the potential for sampling error was therefore large.

Geomorphic Characteristics.—Average streamshore depth was typically much higher for each community type in the ungrazed portion of the Lower Big Creek study area than in the presence of grazing. Overall, streamshore depth was 133% greater under ungrazed conditions and achieved a maximum difference in the JUBA and ARTR/POPR communities, two community types that were relatively infrequent at the water's edge in the grazed sites. The POPR type, which was more evenly distributed over the entire study area and common in all three sites, had a 457% larger average shore depth in the ungrazed site.

Average streambank angle was lower within the rested site, and all community types that were common to Lower Big Creek sites had lower bank angles, on average, inside the exclosure. The differences in average bank angle between grazed and ungrazed sites ranged from 4% (HERB/SB) to 53% (EB and ARTR/POPR). The POPR communities, the most cosmopolitan of the community types encountered, had a 42% smaller average bank angle in the ungrazed site. In POPR community types, banks

Table 3.—Community type-specific comparison of mean streambank structural characteristics between grazing treatments, Lower Big Creek study area, Utah.

Community type[a]	Grazing treatment					
	Grazed			Rested		
	Extent (m)	Bank stability (%)	Stream-short depth (cm)	Extent (m)	Bank stability (%)	Stream-shore depth (cm)
SB	4.4	28.0	6.7	—	—	—
GB	9.1	46.4	16.6	—	—	—
EB[b]	1.3	29.4	4.0	1.0	89.0	14.6
ROCK	—	—	—	1.0	81.7	18.3
HERB/SB	4.6	60.0	16.2	3.0	100.0	14.6
CAREX	1.7	35.0	6.1	2.7	82.7	18.6
JUBA	1.5	32.5	0.0	1.6	85.3	16.2
POPR	3.1	29.6	2.1	2.8	93.8	11.9
SALIX/DWM	—	—	—	0.6	97.5	12.2
RIIN/MH	1.2	0.0	0.0	—	—	—
ARTR/POPR	3.0	17.1	0.0	3.0	88.8	13.7
ARTR/UP	—	—	—	3.0	90.0	8.2
Overall	4.1	32.0	6.4	2.5	88.5	14.9

Community type[a]	Grazed			Rested		
	Bank angle (°)	Undercut (cm)	Overhang (cm)	Bank angle (°)	Undercut (cm)	Overhang (cm)
SB	122	6.4	1.5	—	—	—
GB	95	13.7	2.1	—	—	—
EB	142	4.3	0.6	64	17.1	21.3
ROCK	—	—	—	62	25.3	25.3
HERB/SB	90	11.3	6.1	86	19.5	9.8
CAREX	116	10.7	2.1	74	17.7	14.9
JUBA	125	0.0	12.2	106	10.1	18.6
POPR	140	3.4	2.1	81	16.5	20.7
SALIX/DWM	—	—	—	50	24.4	25.9
RIIN/MH	170	0.0	0.0	—	—	—
ARTR/POPR	171	0.0	0.0	77	20.1	21.6
ARTR/UP	—	—	—	125	0.0	0.0
Overall	127	6.4	1.8	81	16.5	18.3

[a] Acronyms defined in Table 1.

[b] Rock baskets anchoring gabions.

were generally severely outsloped in the presence of grazing and insloped where protected from livestock. Even eroded banks (EB) exhibited small average bank angles in the rested site, but this was probably due largely to the fact that inside the exclosure they were mainly associated with the functioning artificial stream repair structures.

Because bank angles were much lower in the ungrazed site, average bank undercuts were much larger. The highest average angle was observed with ROCK, but the artificial nature of this community type in the Lower Big Creek study area (i.e., association with instream repair structures) trivializes its contribution. Similarly, large undercuts were observed in the rested site with EB communities, but their infrequency and association with artificial structures suggests that their apparently high quality is incidental. Of the major vegetative community types, POPR and CAREX provided the largest average undercuts, being 391% and 66% deeper, respectively, in the ungrazed site. The apparently large average streambank undercut for CAREX under grazing must be viewed with caution because of its relative infrequency but suggests that this community type is more resistant than POPR to shearing by grazing because of its sod-forming ability; however, the infrequency of CAREX in the grazed area suggests that once this community type begins to break down, it is readily lost from the system. The ARTR/POPR type, which appears to be transitional between riparian and upland vegetation (Platts and Nelson 1987) and may be a degraded riparian community type (B.L. Kovalchik, U. S. Forest Service, personal communication) exhibited dramatic differences in undercut; substantial undercuts occurred without grazing, but no undercut was noted with grazing.

Vegetative Characteristics.—Streambank stability is principally a function of vegetal cover, although large substrate particles must also be regarded as providing resistance to erosion and, therefore, stability. Average stability was much higher (177%) within the rested portion of the Lower Big Creek study area, a situation that was dramatically illustrated by the POPR community types. Outside the protected area, POPR communities averaged a meager 30% bank stability rating; inside the exclosure they averaged 94% stable, a 217% increase. The ARTR/POPR community type, a transitional type between POPR and upland types, appeared to be destabilized under grazing but was stable under rested conditions. Community types that were less common in the grazed area, most importantly CAREX and JUBA, revealed similar, although smaller, stability differences between grazing and rest.

Removal of vegetation by cattle reduces the amount of vegetation overhang directly, so it is hardly surprising to find greater average overhangs in the ungrazed Lower Big Creek site for all community types that occurred in both grazed and rested sites. The smallest difference occurred in the CAREX communities, but their infrequency in the grazed sites cautions against overstating the importance of this situation. The POPR community type was heavily used by cattle in the grazed sites (Table 4) and was common in all three study sites. Average overhang for POPR was nearly nine times (867%) greater, however, in the ungrazed site than in the grazed areas. Some community types, such as JUBA, which was the most heavily grazed community type but was also relatively rare in the grazed sites, had no overhang where grazing occurred.

Table 4.—Community type-specific comparison of mean vegetation use and total alteration between grazing treatments, Lower Big Creek study area, Utah.

Community type[a]	Grazed		Rested	
	Grazing use (%)	Alteration (%)	Grazing use (%)	Alteration (%)
SB	67	74	—	—
GB	71	53	—	—
EB	62	78	0	26
ROCK	—	—	0	28
HERB/SB	45	33	6	9
CAREX	32	61	0	26
JUBA	85	73	4	24
POPR	62	78	0	11
SALIX/DWM	—	—	0	13
RIIN/MH	20	90	—	—
ARTR/POPR	17	90	0	12
ARTR/UP	—	—	0	40
Overall	63	72	1	19

[a]Acronyms defined in Table 1.

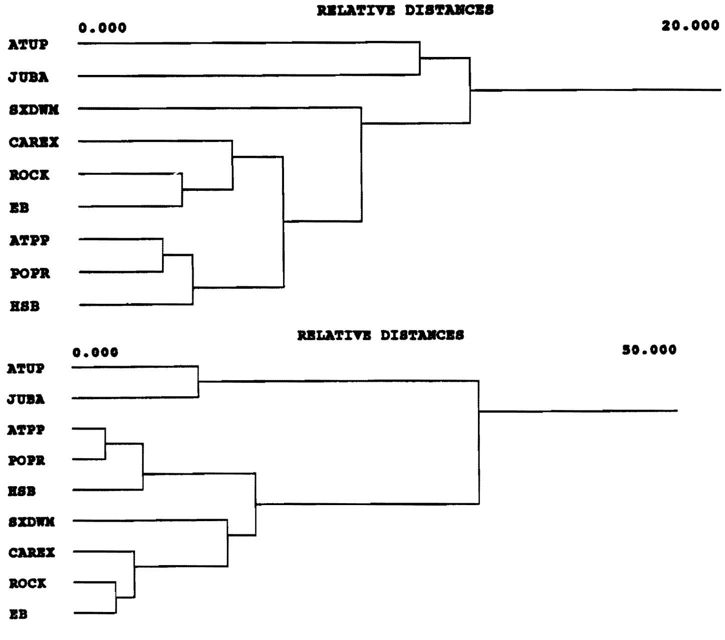
[b]Rock baskets anchoring gabions.

Higher Level Classification

Single linkage clustering, using all observed community types, produced only two distinct clusters, both joining at a relative similarity distance of about 5.0 (Figure 5a). The linkage suggests that the POPR, ARTR/POPR, and HSB community types function similarly with respect to maintaining bank quality, as do the CAREX, ROCK, and EB community types.

As is typical with complete linkage clustering, the apparent community type groupings discerned with this linkage technique are more compact than those discerned with single linkage clustering (Figure 5b). The overall pattern of the clustering is similar, but the SALIX/DWM type joins the CAREX-ROCK-EB cluster prior to linking with the POPR-ARTR/POPR-HSB group. The high bank quality of the SALIX/DWM type makes this an interesting linkage, although the rarity of this community type precludes drawing firm conclusions.

Figure 5.—Clustering of ungrazed community types based on bank characteristics: (a) single-linkage dendrogram, (b) complete linkage clustering.



Discussion

The ungrazed portion of the Lower Big Creek study area is vegetationally quite different from the nearby grazed areas, and a similar trend is becoming evident in the ungrazed treatments in the upper study area. The greatest differences concern the reappearance of *Carex*- and *Juncus*-dominated communities in conjunction with decreases in mineral-dominated communities within the ungrazed areas.

Although the soil wetness associated with sedge communities may discourage their use by cattle during certain parts of the grazing season and may account for their relatively low utilization in the grazed Lower Big Creek sites (32%), sedge-dominated community types are still far more abundant in the ungrazed portion of the Lower Big Creek study area and are apparently increasing in frequency in the ungrazed portions of the Upper Big Creek study area. In addition, there appeared to be an increase in width of streambank sedge community types and a shift from CANE to CARO (the latter being associated with more soil moisture) in parts of the lower exclosure, possibly indicating both increasing extent of sedge-dominated communities and a rising water table in certain areas. The presumed rise in water table within the exclosure is probably due to the reduction in water velocity, the increase in sediment deposition, and an increase in water level behind the instream repair structures. These structures remain functional within the ungrazed Lower Big Creek study site because they have been relatively undamaged by livestock. Outside the exclosure, however, where heavy grazing continues, most of the structures have been destroyed by livestock trampling and subsequent streambank erosion (Platts and Nelson 1985c).

Poa pratensis, a species that fares well under heavy grazing pressure, was common in all three Lower Big Creek study sites, but was slightly more abundant in the ungrazed site. Both *Juncus balticus* and *Poa pratensis* are generally considered "increaser"[6] species under grazed conditions. Our results do not refute this contention but suggest that both species may be less abundant under grazing than in areas that have been released from grazing (i.e. they continue to increase after grazing is removed), even after 20 years. In contrast to the sedge-dominated community types, the JUBA community type appears to be heavily used by livestock (85%) and is nearly absent from the grazed sites in both study areas. The low frequency of occurrence in the Lower Big Creek study area, where community type-specific use was measured, however, may mean that this apparently heavy level of use is strictly incidental. Our data suggest that removal of grazing leads to increase in JUBA at the water's edge; this community type is perhaps one of the first to appear on sandbars after livestock are removed.

The JUBA and POPR community types can be similar floristically; *P. pratensis* is frequently common in JUBA community types, and both bluegrass and rush are common in the SB community type (Platts and Nelson 1987). Thus, the reduction in SB with a corresponding increase in CAREX, POPR, and JUBA types within the ungrazed portion of the Lower Big Creek study area suggest a progressive change from SB through JUBA (and/or AGST/SB) to POPR on drier microsites, or to CAREX on wetter microsites (and possibly thence from CANE to CARO) during the first few years after release from grazing. The proposed mechanism behind this progressive or repair sequence is one of increasing soil moisture as increasing amounts of fine sediments are deposited and held on the developing bank, leading to narrowing of the stream channel and a corresponding rise in the water table. Conversely, the decrease in herbaceous mineral types in the upper rested site on Upper Big Creek and their absence from the ungrazed site on Lower Big Creek suggest that they may represent a regressive phase of the same sequence.

Another regressive/progressive sequence with POPR is also possible. Kovalchik (U. S. Forest Service, personal communication) suggests that the POPR/ARTR community type may represent degradation of POPR due to a lowered water table. As the channel widens and the banks recede, *P. pratensis* and *Artemesia tridentata* may form a transistional community type. If water tables and soil moisture increase, these two communities may return to POPR and from thence to other fully riparian types as determined by local factors. This is the process that seems to be occurring in the ungrazed sites.

Juncus balticus can produce thick, horizontal rhizomes (Cronquist et al. 1977). Youngblood et al. (1985) report that the JUBA community type in eastern Idaho and western Wyoming provides good sod- and bank-stabilizing properties, and POPR produces relatively unstable banks. The sod formed by JUBA adjacent to Big Creek appears to consist chiefly of vertically oriented root systems (Platts and Nelson 1987) that would intuitively seem to have little effect in counteracting bank shearing and sloughing forces imparted by cattle; however, this root structure may be typical only of early or degraded JUBA communities, with more vigorous root-systems possibly being produced later in the rehabilitative sequence. This study suggests that, in some cases, grazing may be relatively more injurious to POPR than to JUBA, the latter apparently maintaining better bank conditions under grazing, but that without grazing POPR provides superior streambank conditions.

Where sedges can become dominant, they clearly create the most optimal streambank structure. Even under grazed conditions, some of the optimum bank characteristics were associated with this community type. Thus, moderate grazing pressure after viable sedge communities have become reestablished may be acceptable, but the managers responsible must ensure that CAREX community types do not revert to less favorable communities like POPR. Both *Carex rostrata* and *C. nebraskensis* are capable of producing dense sod (Cronquist et al. 1977; Ratliff 1983), but our results suggest that only *C. nebraskensis* persists under the intensity with which Big Creek streambanks are grazed. Despite its resistence to grazing (Ratliff 1983; Ratliff and Westfall 1987), however, it appears that CANE community types are only poorly maintained under present grazing management. *Carex rostrata* may be less desirable to cattle than *C. nebraskensis* because of lower palatability and wetter habitat (Hermann 1970; Cronquist et al. 1977) and may therefore be additionally useful in deterring heavy grazing use in the riparian corridor if its requirements can be maintained or restored.

As these studies continue, we should be able to draw an increasingly clear picture of the general functioning of various community types in providing bank characteristics commensurate with riparian protection. We hope to be able to discern what community types produce optimum bank conditions and whether some types may be favored

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[6] An increaser species is one that is favored by grazing and thus tends to increase in abundance under grazed conditions.

by limited grazing and still provide bank conditions similar to those provided by other, less grazing-resistant types. As managers interested in promoting the needs of both the livestock industry and the general public, we may, for example, be willing to sacrifice communities that do not fare well under grazing for some that do, provided their value for other uses remains nearly equivalent.

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