Effects of Grazing Management on Selected Stream Bank Characteristics and Stream Bank Erosion

A.S. Leaflet R2325

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Summary and Implications

Six 30-acre cool-season grass pastures, containing predominantly smooth bromegrass and bisected by a 642-foot stream segment, were grouped into 2 blocks and assigned one of three treatments: continuous stocking - unrestricted stream access (CSU), continuous stocking - restricted stream access (CSR), and rotational stocking (RS). Stream bank condition and surface roughness and stream morphology were evaluated pre-, mid-, and post-grazing from 2005 to 2007. Stream bank erosion was monitored monthly from May through November over the same three years. Stream banks in CSU pastures had greater vegetative cover, stability, and condition scores than did the CSR or RS pastures implying that the stream banks in pastures in which cattle had unrestricted access were more susceptible to erosion than stream banks in pastures in which cattle access to stream banks was restricted or controlled. However, no effect of grazing management on the rate of change of stream cross sectional area, net stream bank erosion, or erosion deposition activity was observed in any of the three years.

Introduction

Improper management of beef cattle grazing may have negative impacts on the quality of surface waters in the Midwest. These concerns are partially related to the potential for grazing animals to elevate concentrations of sediment and phosphorus (P) in surface water. Grazing animals may remove protective vegetation from the soil surface and trample stream banks, thereby increasing the potential delivery of sediment and nutrients bound to sediment particles to pasture streams. Improved grazing management practices should preserve protective vegetation and limit cattle trampling on stream banks reducing negative impacts of grazing livestock on surface waters.

The objectives of this project were to determine the effects of grazing management practices on stream bank condition, stream morphology, stream bank surface roughness, and stream bank erosion.

Materials and Methods

Six 30-acre cool-season grass pastures, each bisected by a 642-foot stream segment, were grouped into 2 blocks and assigned one of three grazing management treatments. Treatments included: continuous stocking with unrestricted stream access (CSU), continuous stocking with stream access restricted to a 16-foot wide crossing (CSR), and 5-paddock rotational stocking with one paddock in the riparian zone (RS). Riparian paddocks in the RS treatment were stocked for a maximum of 4 days or until forage sward height decreased to a minimum of 4 inches. Riparian buffers on either side of the crossing in the CSR treatment were not grazed. Each pasture was stocked with 15 fall-calving Angus cows from mid-May through mid-October in 2005, 2006, and 2007 (initial mean BW = 1428, 1271, and 1369 lbs., respectively).

Pre-, mid-, and post-grazing in each year, stream banks were visually scored and measured for stream morphology and stream bank roughness. Stream banks within each pasture were visually evaluated and assigned a score for slope (1(flat) to 3(steep)), vegetative cover (1 (heavy) to 4 (bare)), and stability (1 (stable) to 5 (very unstable)). An overall bank condition score was calculated as the product of these values weighted for their percentage of stream length. Stream bank condition scores ranged from 1 to 60 with a greater value indicating greater potential for erosion to occur.

Digital photographs were taken of the channel cross-sections at 10 transects placed at equal distances in the stream across each pasture. Photographs were analyzed by image analysis to measure stream morphology characteristics (channel cross sectional area, stream width, and width between the tops of the banks).

Surface roughness was measured using a 41-pin meter with a length of 2 m from the stream's edge on banks on each side of the stream at each of the 10 transects. Surface roughness was calculated as the average standard deviation in pin length.

Stream bank erosion was measured using 5/8 x 30 inch fiberglass pins inserted perpendicularly into the bank to a depth of 28 inches at intervals of 36 inches from the stream surface to the top of both banks at the 10 equidistant transects in each pasture in November, 2004. Lengths of exposed pins were measured monthly May through November over three years. Net erosion and erosion/deposition activity (the absolute value of the change in exposed erosion pin length) were calculated as the net change in pin length within each transect and averaged by pasture.

Stream depths were measured with pressure transducers attached to data loggers in the stream where the stream entered and exited the research pastures. Rainfall was measured with rain gauges in the uplands on both sides of the stream.

Stream bank condition score and surface roughness were analyzes using the MIXED procedure of SAS with a model including treatment, period, and treatment × period and block as a random effect. Changes in stream cross sectional area were analyzed by regressing the cross sectional area versus date using the REG procedure of SAS. Stream bank erosion was analyzed by month using the MIXED procedure of SAS.

Results and Discussion

Rainfall and Stream Stage

Rainfall during the 2005 (Fig. 1), 2006 (Fig. 2), and 2007 (Fig. 3) grazing seasons were 25.0, 18.9, and 27.0 inches, respectively. Mean, 30-year average rainfall during this time period (May 15 through October 15) is 28.7 inches. Lower rainfall during the 2006 grazing season resulted in fewer and smaller spikes in stream flow during 2006 (Fig. 5) than in the 2005 (Fig. 4) grazing season. Rainfall during 2007 was more evenly distributed than during the previous years, with the exception of a dry period during July. This precipitation pattern resulted in a relatively flat hydrograph (Fig. 6).

Stream Bank Condition Score

Stream bank slope score did not differ between grazing management treatment or sampling period (pre-, mid-, or post-grazing) in any year (Table 1). Stream bank vegetative cover score was greater ($P<.05$) in CSU pastures than in either CSR or RS pastures in 2006 and 2007 (Table 2). A greater vegetative cover score indicates a greater amount of bare ground along the stream banks, reflecting the greater amount of time which cattle in CSU pastures spend along stream banks than do cattle in other grazing management practices. Stream bank stability score was greater ($P<.05$) in CSU pastures than in either CSR or RS pastures during all study years (Table 3). A greater stability score indicates a greater instability of the stream banks. Given that CSU pastures had greater stability scores pre-grazing in 2005, differences in stability score at later periods may not be a result of grazing management but may reflect natural variability in the stream banks. Stream bank condition score tended to be greater ($P=.06$) in 2005 and was greater ($P<.05$) in 2006 and 2007 in CSU pastures than in either CSR or RS pastures (Table 4). The greater condition score indicates that stream banks in CSU pastures have a greater potential for erosion to occur than do stream banks in CSR or RS pastures.

Stream Bank Surface Roughness

Stream bank surface roughness was not affected by grazing management in any year (Table 5).

Stream Morphology

Stream channel cross sectional areas changed only slightly over the three years of the study (Fig. 7). There was no effect of grazing management on the rate of change of stream channel cross sectional area over the three years of the study.

Stream Bank Erosion

There were 2.1, 1.1, and 3.2 inches of net stream bank erosion from CSU, CSR, and RS pastures, respectively, during 2005. In 2006, there were 0.2 inches of net stream bank erosion from CSU pastures and 0.2, and 0.1 inches of net stream bank deposition in CSR and RS pastures, respectively. In 2007, net erosion was 2.5, 3.7, and 1.5 inches in CSU, CSR, and RS pastures, respectively (Table 6). During 2007, July was the only month in which there was a significant difference in net erosion between grazing treatments, with slightly greater erosion in CSU pastures than pastures with other treatments. Across all grazing treatments in 2007, the majority (nearly 90%) of net erosion occurred between November 2006 and May 2007. Net erosion did not differ between grazing management treatments in any year.

Erosion-deposition activities were 5.8, 3.2, and 4.7 inches for CSU, CSR, and RS pastures, respectively, in 2005. Erosion- deposition activities were 4.5, 3.2, and 3.3 inches for CSU, CSR, and RS pastures, respectively, in 2006. In 2007, erosion-deposition activities were 8.7, 7.1, and 6.7 inches for CSU, CSR, and RS pastures, respectively (Table 7). As with net erosion, July was the only month in which there was a significant effect of grazing management on erosion-deposition activity with CSU greater ($P<0.05$) than CSR, which was greater ($P<0.05$) than RS. In no year was there a significant difference between grazing management on erosion deposition activity of stream banks.

Conclusions

Differences in stream bank condition score and morphological factors have been observed between grazing management treatments, however, no differences in net stream bank erosion or erosion deposition activity have been observed between grazing management treatments.

Acknowledgements

The authors would like to thank the undergraduate and graduate students who assisted with data collection and analysis. The publication of this document has been funded in part by the Iowa Department of Natural Resources through a grant from the U.S. Environmental Protection Agency under the Federal Nonpoint Source Management Program (Section 319 of the Clean Water Act) and the Leopold Center for Sustainable Agriculture. This material is also based upon work supported by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under Award No.

2006-51130-03700. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the U.S. Department of Agriculture.

Figure 1. Rainfall during 2005 grazing season.

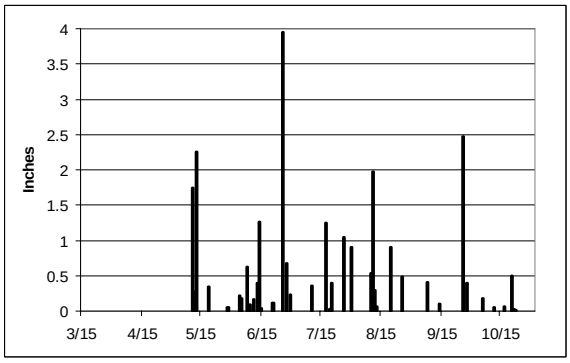

Figure 2. Rainfall during 2006 grazing season.

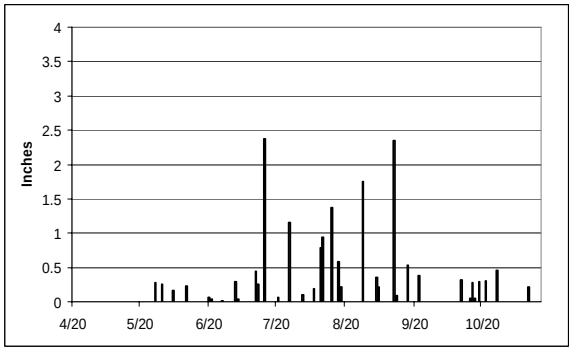

Figure 3. Rainfall during the 2007 Grazing Season.

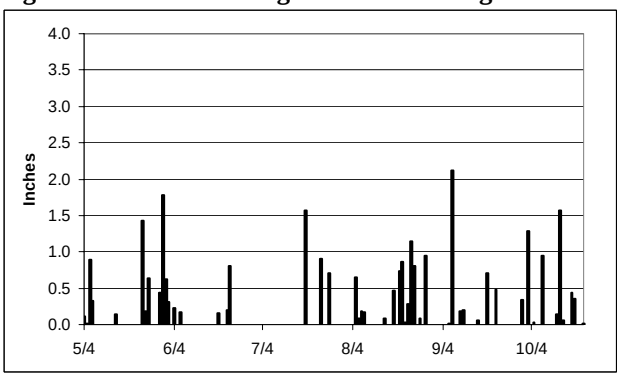

Figure 4. 2005 Willow Creek stream stage.

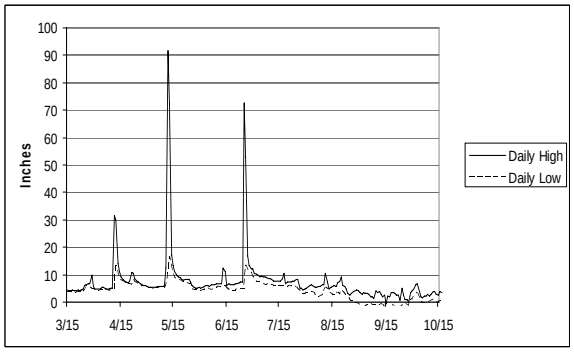

Figure 5. 2006 Willow Creek stream stage.

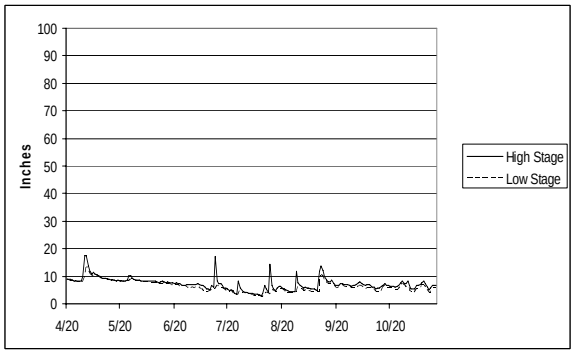

Figure 6. 2007 Willow Creek stream stage.

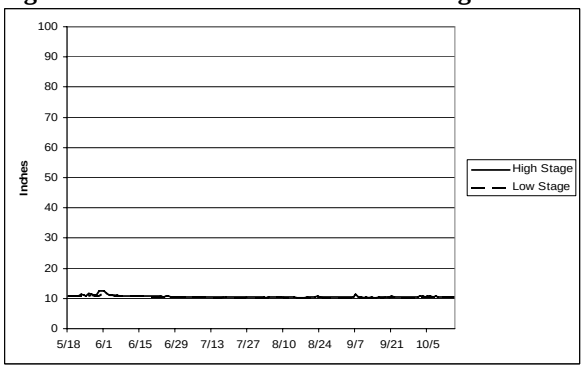

Table 1. Stream bank slope score[1] as affected by grazing management over three grazing seasons.

	2005			2006			2007		
	Pre[2]	Mid	Post	Pre	Mid	Post	Pre	Mid	Post
CSU[3]	2.47	2.40	2.13	2.43	2.41	2.48	2.47	2.42	2.20
CSR	2.59	2.58	2.47	2.72	2.71	2.67	2.64	2.68	2.58
RS	2.49	2.40	2.39	2.50	2.54	2.64	2.41	2.55	2.41
	trt NS			trt NS			trt NS		
	prd NS			prd NS			prd NS		
	trt×prd NS			trt×prd NS			trt×prd NS		

[1]Slope score (1 = Flat, 3 = Steep).
[2]Pre = pre-grazing (early May), Mid = mid-grazing (late July), Post = post-grazing (mid October).
[3]CSU = Continuous stocking with unrestricted stream access, CSR= Continuous stocking with restricted stream access, RS = Rotational stocking.

Table 2. Stream bank vegetative cover score[1] as affected by grazing management over three grazing seasons.

	2005			2006			2007		
	Pre[2]	Mid	Post	Pre	Mid	Post	Pre	Mid	Post
CSU[3]	2.80	2.84	2.86	3.03	2.73	2.58	3.22	2.94	2.83
CSR	2.43	2.15	2.08	2.26	1.72	1.64	2.49	1.88	1.71
RS	2.15	2.36	2.28	2.32	1.88	1.86	2.62	1.83	1.96
	trt NS			trt .05			trt .05		
	prd NS			prd NS			prd NS		
	trt×prd NS			trt×prd NS			trt×prd NS		

[1]Vegetative cover score (1 = Heavy, 4 = Bare).
[2]Pre = pre-grazing (early May), Mid = mid-grazing (late July), Post = post-grazing (mid October).
[3]CSU = Continuous stocking with unrestricted stream access, CSR= Continuous stocking with restricted stream access, RS = Rotational stocking.

Table 3. Stream bank stability score[1] as affected by grazing management over three grazing seasons.

	2005			2006			2007		
	Pre[2]	Mid	Post	Pre	Mid	Post	Pre	Mid	Post
CSU[3]	3.50	3.96	4.22	3.83	4.03	3.79	4.20	4.22	3.69
CSR	3.10	2.96	2.96	3.00	2.32	2.54	3.58	2.69	2.37
RS	2.70	2.66	3.36	3.22	2.81	2.98	3.85	2.76	2.70
	trt .05			trt .05			trt .05		
	prd NS			prd NS			prd .06		
	trt×prd NS			trt×prd NS			trt×prd NS		

[1]Stability score (1 = Stable, 5 = Unstable).
[2]Pre = pre-grazing (early May), Mid = mid-grazing (late July), Post = post-grazing (mid October).
[3]CSU = Continuous stocking with unrestricted stream access, CSR= Continuous stocking with restricted stream access, RS = Rotational stocking.

Table 4. Stream bank condition score[1] as affected by grazing management over three grazing seasons.

	2005			2006			2007		
	Pre[2]	Mid	Post	Pre	Mid	Post	Pre	Mid	Post
CSU[3]	29.67	28.42	26.05	31.34	27.49	26.19	37.94	31.16	23.70
CSR	21.42	19.08	17.14	21.53	13.49	14.00	25.22	16.22	12.42
RS	18.68	17.31	20.52	22.26	17.04	17.43	25.93	15.91	14.38
	trt .06			trt .05			trt .05		
	prd NS			prd NS			prd .05		
	trt×prd NS			trt×prd NS			trt×prd NS		

[1]Bank condition score (1 to 60 = Slope score × Veg. cover score × Stability score). A higher number indicates greater potential for erosion to occur.
[2]Pre = pre-grazing (early May), Mid = mid-grazing (late July), Post = post-grazing (mid October).
[3]CSU = Continuous stocking with unrestricted stream access, CSR= Continuous stocking with restricted stream access, RS = Rotational stocking.

Table 5. Stream bank surface roughness[1] as affected by grazing management over three grazing seasons.

	2005			2006			2007		
	Pre[2]	Mid	Post	Pre	Mid	Post	Pre	Mid	Post
CSU[3]	2.02	1.83	1.72	1.42	1.91	1.63	1.97	1.88	1.55
CSR	1.70	1.82	1.86	1.55	1.66	1.74	1.91	1.91	1.81
RS	1.93	1.88	1.92	1.74	1.95	2.05	2.13	2.00	1.75
	trt NS			trt NS			trt NS		
	prd NS			prd .11			prd .17		
	trt×prd NS			trt×prd NS			trt×prd NS		

[1]Surface roughness was determined as the average standard deviation of pins on a 41-pin min meter.
[2]Pre = pre-grazing (early May), Mid = mid-grazing (late July), Post = post-grazing (mid October).
[3]CSU = Continuous stocking with unrestricted stream access, CSR= Continuous stocking with restricted stream access, RS = Rotational stocking.

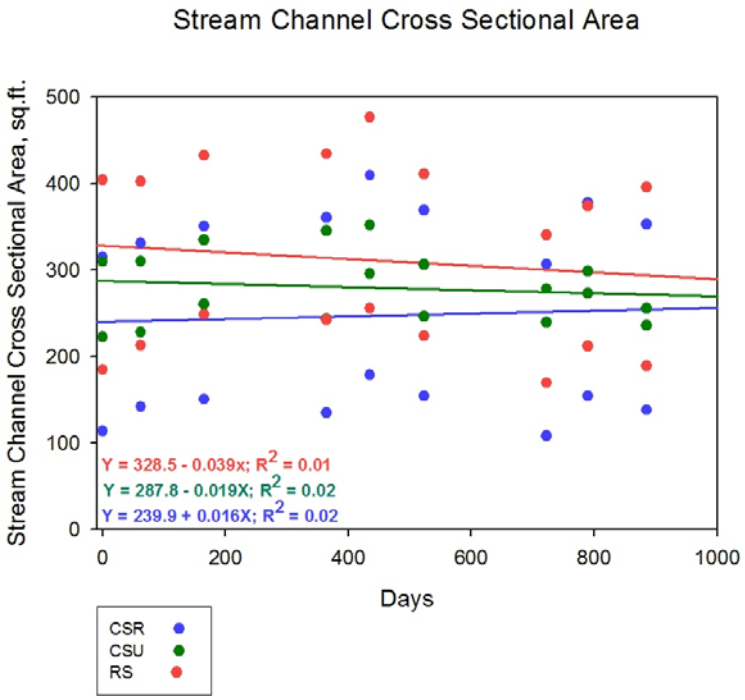

Figure 7. Effect of grazing management on stream channel cross sectional area.

Table 6. Effect of grazing management on net erosion during 2007.

	Net Erosion (in)[1]							
	May[2]	June	July	August	September	October	December	Annual
CSU[3]	-2.1	-0.2	-0.4[a]	0.1	-0.1	0.0	0.2	-2.5
CSR	-3.4	-0.1	-0.3[b]	0.2	-0.1	0.0	0.0	-3.7
RS	-1.3	-0.1	-0.1[b]	0.0	-0.1	0.2	0.0	-1.5

[1]Negative values represent soil erosion; positive values represent deposition.
[2]May value indicates change from previous November; all other values are from the previous month.
[3]CSU = Continuous stocking with unrestricted stream access, CSR= Continuous stocking with restricted stream access, RS = Rotational stocking.
[ab]Within a column, means with different superscripts differ (P<0.05).

Table 7. Effect of grazing management on stream bank activity during 2007.

	Erosion/Deposition Activity (in)[1]							
	May[2]	June	July	August	September	October	December	Annual
CSU[3]	4.3	1.0	0.8[a]	0.9	0.3	0.7	0.6	8.7
CSR	4.8	0.7	0.6[b]	0.6	0.2	0.1	0.1	7.1
RS	3.3	0.8	0.5[c]	0.9	0.4	0.6	0.1	6.7

[1]Determined from the absolute values of changes in erosion pin lengths.
[2]May value indicates change from previous November; all other values are from the previous month.
[3]CSU = Continuous stocking with unrestricted stream access, CSR= Continuous stocking with restricted stream access, RS = Rotational stocking.
[abc]Within a column, means with different superscripts differ (P<0.05).