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

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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 two 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 over a two-year period. Stream bank erosion was monitored monthly from May through November over the same two-year period. 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 unlimited 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 net stream bank erosion was observed for either grazing season.

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, which may increase 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 the quality of 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 two 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 four days or until forage sward height decreased to a minimum of four 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 both 2005 (mean cattle BW = 1428 lb) and 2006 (mean cattle BW = 1271 lb).

Stream banks were visually scored and measured for stream morphology and stream bank roughness pre-, mid-, and post-grazing in each year. 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 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. Lengths of exposed pins were measured monthly May through November of both 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. Erosion pins were measured monthly May through November of each year.

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.

Results and Discussion

Rainfall and Stream Stage

There were 25.0 and 18.9 inches of rainfall during the 2005 (Fig. 1) and 2006 (Fig. 2) grazing seasons, 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. 4) than in the 2005 (Fig. 3) grazing season.

Stream Bank Condition Score

Stream slope score tended to be greater (P=0.08) in pastures managed by CSR (Table 1) than by either CSU or RS. Stream banks in CSU pastures had greater (P<0.05) vegetative cover, stability, and condition scores than did the CSR or RS pastures implying that the stream banks in these pastures were more susceptible to erosion than the stream banks in the CSR or RS pastures. No effect of sampling period (pre-, mid-, or post-grazing), nor sampling period by grazing management practice interaction, were observed in either year. The lack of sampling period effects imply that treatment differences reflect inherent differences in stream characteristics that were not changed by grazing management.

Stream Bank Surface Roughness

Surface roughness was greater (P<0.05) on the stream bank in the RS pastures than in the CRS or CSU pastures (Table 1). There was no effect of sampling period or treatment by period interaction in either year.

Stream Morphology

Channel cross-sectional area was greater (P<0.05) in the RS pastures than in either the CSU or CSR pastures (Table 2). Similar to bank condition score and roughness, there were no grazing treatment by sampling period interactions for channel cross-sectional areas in either year. Stream cross-sectional area increased at a rate of 0.075 ft^2 per day with no difference between grazing management treatments.

Stream width was greater (P<0.05) in the CSR pastures than in either the CSU or RS pastures. Stream width varied with sampling period (Table 3), being greatest (P<0.05) during the 2005 and 2006 pre-grazing period and the 2005 mid-grazing period. Differences in stream width were likely related to differences in precipitation pattern. During the mid-grazing period of 2006, precipitation was below normal resulting in low stream flow and flow stopping for several days.

Bank width was greater (P<0.05) in the CSU and RS pastures than in the CSR pastures. Bank width increased at a rate of 0.008 ft per day and did not differ between grazing management treatments.

The lack of any sampling period by grazing treatment interactions indicate that any differences in stream morphology are likely related to pre-existing stream characteristics and cannot be attributed to any effect of treatment specifically.

Stream Bank Erosion

Net stream bank erosion over the entire grazing season was not affected by grazing management in either 2005 or 2006 (Table 4). Net erosion averaged -5.4 and 0.1 cm in 2005 and 2006, respectively. A negative value for net erosion indicates soil loss while positive numbers indicates deposition of sediment. A significant effect of grazing management on erosion was only observed during two months during the study period. In September 2005, erosion was greater (P<0.05) in CSU pastures than in either CSR or RS pastures. In October 2006, net erosion was slightly greater in the RS pastures than in the CSR pastures. Over the entire study period (May 2005 through November 2006), the rate of soil erosion from stream banks (Fig. 5) did not differ between grazing treatments, averaging 0.006 cm of soil loss per day.

Mean erosion/deposition activity also did not differ over the entire grazing season between management treatments in either 2005 or 2006 (Table 4). In 2005, erosion/deposition activity was greater (P<0.05) in the CSU pastures in September and October than in either the CSR or RS pastures in the respective month. There was no effect of grazing management on erosion/deposition activity in any month in 2006. Over the entire study period, soil erosion/deposition activity rate did not differ between grazing treatments (Fig. 6), averaging 0.213 cm per day.

Conclusion

Differences in susceptibility to erosion have been observed between treatments. However, because there have been no interactions between grazing management and sampling periods, these differences were apparently present at the initiation of the experiment. Thus, no differences have been observed in the rates of net erosion and erosion/deposition activity between treatments. Therefore, over two years, neither continuous grazing with full access to the stream nor rotational grazing with limited stream access has resulted in any more erosion than no grazing in a riparian buffer.

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Agriculture and by the Iowa Department of Natural Resources through a grant from the U.S. Environmental Protection Agency under the Federal Non-point Source Management Program (Section 319 of the Clean Water Act)."

Figure 1. Rainfall during 2005 grazing season.

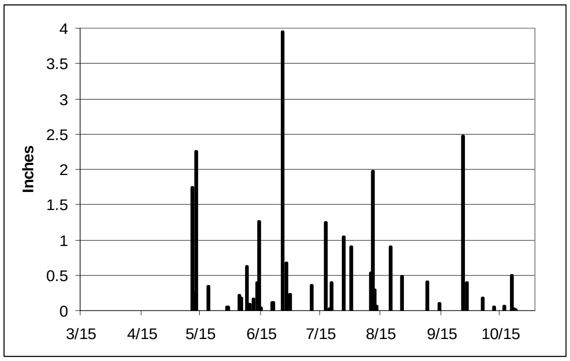


Figure 2. Rainfall during 2006 grazing season.

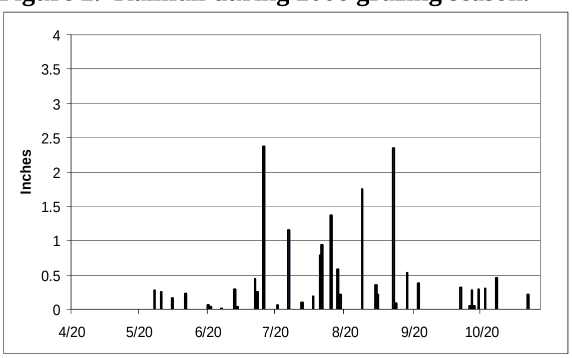


Figure 3. 2005 Willow Creek stream stage.

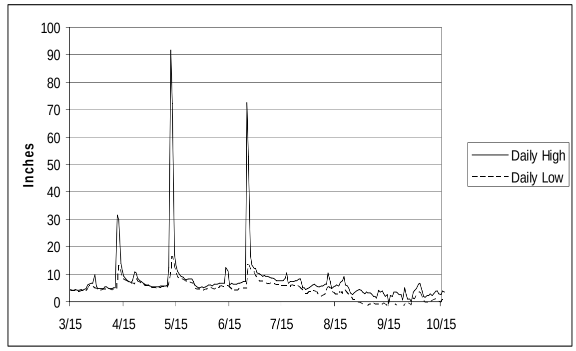


Figure 4. 2006 Willow Creek stream stage.

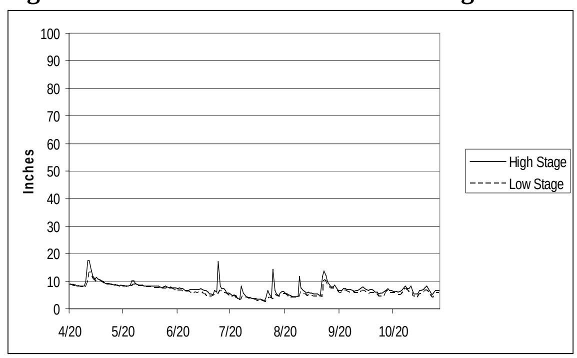


Table 1. Stream bank slope, vegetative cover, stability, and condition score as affected by grazing management in 2005 and 2006.

	CSU[a]	CSR	RS	SE	trt	prd	trt*prd
Slope Score[b]	2.38	2.62	2.49	0.13	0.08	NS	NS
Vegetative Cover Score[c]	2.81[i]	2.04[h]	2.14[h]	0.16	<0.05	NS	NS
Stability Score[d]	3.89[i]	2.81[h]	2.95[h]	0.13	<0.05	NS	NS
Bank Condition Score[e]	28.19[i]	17.78[h]	18.87[h]	1.51	<0.05	NS	NS
Surface Roughness, cm[f]	1.75[h]	1.72[h]	1.91[i]	0.04	<0.05	NS	NS

[a]CSU = Continuous stocking with unrestricted stream access, CSR= Continuous stocking with restricted stream access, RS = Rotational stocking.

[b]Slope score (1 = Flat, 3 = Steep).

[c]Vegetative cover score (1 = Heavy, 4 = Bare).

[d]Stability score (1 = Stable, 5 = Unstable).

[e]Bank condition score (1 to 60 = Slope score*Veg. cover score*Stability score). A higher number indicates greater potential for erosion to occur.

[f]Values are least squares means of the standard deviation (cm) of 41 pins on a pin meter taken at ten transects on both the north and south sides (20 locations per pasture) of the stream.

[g]SE = Standard error of the mean, trt = treatment, prd = period.

[hi]Values in the same row with different superscripts differ (P<0.05).

Table 2. Differences in stream morphological characteristics across pastures managed with different grazing treatments in 2005 and 2006.

	CSU[a]	CSR	RS	SE[b]
Channel Cross Sectional Area, ft^2	288[d]	251[d]	327[c]	17
Stream Width, ft	6.8[d]	9.1[c]	6.1[d]	1.0
Bank Width, ft	53.9[c]	43.7[d]	54.5[c]	1.3

[a]CSU = Continuous stocking with unrestricted stream access, CSR= Continuous stocking with restricted stream access, RS = Rotational stocking.
[b]SE = Standard error of the mean.
[cd]Values within a row with different superscripts differ (P<0.05).

Table 3. Changes in stream morphological characteristics over two grazing seasons.

	2005			2006				
	Pre[a]	Mid	Post	Pre	Mid	Post	SE[b]	
Channel Cross Sectional Area, ft^2	258	271	296	293	328	285	21	=0.06
Stream Width, ft	8.7[c]	8.7[c]	6.9[d]	8.8[c]	5.0[e]	5.8[de]	1.0	<0.05
Bank Width, ft	48.5	48.3	50.8	51.4	53.5	51.6	1.8	NS

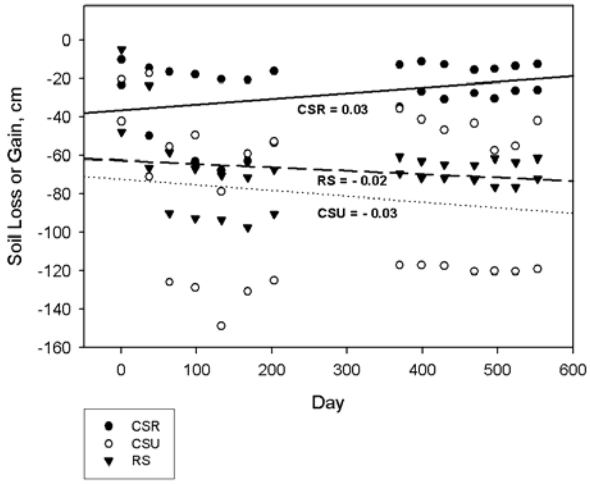
[a]Pre = pre-grazing season, Mid = mid-grazing season, Post = post-grazing season.
[b]SE = Standard error of the mean.
[cde]Values within a row with different superscripts differ (P<0.05).

Table 4. Least squares means of net erosion and erosion/deposition activity in pastures with different grazing management in 2005 and 2006.

	2005[a]							2006						
	Jun	Jul	Aug	Sept	Oct	Nov	*Season*	Jun	July	Aug	Sept	Oct	Nov	*Season*
	Net Erosion[c], cm							Net Erosion[c], cm						
CSU[b]	-1.0	-4.6	0.1	-2.5[e]	-2.2	0.6	*-5.2*	-0.3	-0.3	-0.01	-0.7	0.1[ef]	0.7	*-0.51*
CSR	-2.3	-0.8	-0.5	-0.5[f]	0.2	1.0	*-2.8*	0.6	-0.4	-0.2	-0.1	0.4[f]	0.1	*0.40*
RS	-3.1	-3.8	-0.8	-0.3[f]	0.7	0.6	*-8.1*	0.2	-0.1	-0.04	0.1	-0.1[e]	0.3	*0.36*
	Erosion/Deposition Activity[d], cm							Erosion/Deposition Activity[d], cm						
CSU	2.5	4.9	1.2	2.9[e]	2.5[e]	0.7[f]	*14.7*	2.6	1.7	1.8	1.9	2.0	1.3	*11.3*
CSR	2.3	2.2	0.8	0.8[f]	0.8[f]	1.1[e]	*8.0*	1.8	1.0	1.5	1.3	1.4	1.1	*8.1*
RS	3.5	4.8	0.9	0.6[f]	1.4[f]	0.7[f]	*11.8*	1.8	1.2	1.3	1.5	1.4	1.2	*8.4*

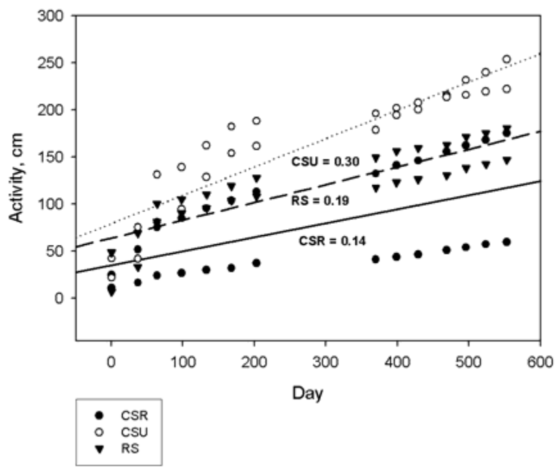
[a]Analyzed using the GLM procedure of SAS using the changes occurring during the preceding winter as a covariant.
[b]CSU = Continuous stocking with unrestricted stream access, CSR= Continuous stocking with restricted stream access, RS = Rotational stocking.
[c]Negative values represent soil erosion and positive values represent deposition.
[d]Determined from the absolute values of changes in erosion pin lengths.
[ef]Within a column, differences among means with different superscripts are significant (P < 0.05).

Figure 5. Erosion rate from stream banks in pastures managed with different grazing practices.



Positive slopes indicate soil deposition and negative slopes indicate soil erosion.
Day 0 is the initiation of grazing in May 2005.

Figure 6. Rate of soil erosion / deposition activity from stream banks in pastures managed with different grazing practices.



Day 0 is the initiation of grazing in May 2005.