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Impacts of Cattle Grazing Management on Sediment and Phosphorus Loads in Surface Waters

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Abstract
The amounts of sediment and phosphorus (P) in water runoff from agricultural lands are of concern because of the potential for siltation and eutrophication of surface waters. There is limited information about the total sediment and P loads in runoff from pastureland in the Midwest. Because vegetation limits soil disruption caused by the impact of raindrops and forage roots hold soil particles, pastures grazed using suitable management practices should maintain water infiltration and minimize sediment and P losses in water runoff. Once sediment and P have been dislodged from the landscape, vegetative buffers can be an effective tool for reducing the amounts that arrive in surface waters. The objectives of this experiment were to quantify the amounts of sediment and P in the runoff from pasturelands managed by different systems and to evaluate the effectiveness of vegetative buffers at controlling sediment and phosphorus loss in runoff from the different forage management systems.

Keywords
Animal Science, Agriculture and Biosystems Engineering, Natural Resource Ecology and Management

Disciplines
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Introduction

The amounts of sediment and phosphorus (P) in water runoff from agricultural lands are of concern because of the potential for siltation and eutrophication of surface waters. There is limited information about the total sediment and P loads in runoff from pastureland in the Midwest. Because vegetation limits soil disruption caused by the impact of raindrops and forage roots hold soil particles, pastures grazed using suitable management practices should maintain water infiltration and minimize sediment and P losses in water runoff. Once sediment and P have been dislodged from the landscape, vegetative buffers can be an effective tool for reducing the amounts that arrive in surface waters. The objectives of this experiment were to quantify the amounts of sediment and P in the runoff from pasturelands managed by different systems and to evaluate the effectiveness of vegetative buffers at controlling sediment and phosphorus loss in runoff from the different forage management systems.

Materials and Methods

General Description. For three years (2001–2003) three blocks of approximately 6.8 acres were subdivided into five, 1-acre paddocks with a 30-ft wide vegetative buffer area down slope. Paddocks were located on hills with slopes of up to 15°. The primary forage species was smooth bromegrass. Pastures were fertilized to be at an optimum or greater level of P and potassium (K) at the initiation of grazing in 2001.

Forage Management. Grazing treatments were randomly assigned to each of the five paddocks in each block. Treatments included an ungrazed control (U), summer hay harvest with winter stockpiled grazing (HS), continuous stocking to a residual sward height of 2 in. (2C), and rotational stocking to a residual sward height of either 2 in. (2R) or 4 in. (4R). Grazing was initiated in May of each year with three mature Angus cows in each grazed paddock. Cattle received no supplemental P while stocked on pastures. Hay was harvested from the HS treatment in June of each year and paddocks were stocked with three mature Angus cows in mid-November of each year.

Rainfall Simulations. Rainfall simulations were conducted four times per year; late spring, mid-summer, and autumn and early spring the following year. Six simulation sites were selected within each paddock (three within a low slope (1°–7°) range and three in a high slope (7°–15°) range. Six simulation sites were selected within the vegetative buffer below each paddock. Three of these sites were at the base of the paddock and three were 30 ft within the buffer strip. Runoff was collected during the simulation and analyzed for total sediment, total P, and total soluble P. During rainfall simulations, surface roughness, ground cover, forage mass and sward height, and penetration resistance were measured. Soil samples were taken for determination of Bray-1 P and soil moisture.

Results and Discussion

Summarized in table 1 are the impacts of the five forage management treatments on percentage runoff, sediment flow, total P flow, and soluble P flow averaged across all years. The proportion of rainfall lost as runoff was less (P<.05) in the U paddocks than in all other treatments. Sediment loss did not differ by treatment. Losses of total and soluble P were greater from the 2C and 2R treatments (P<.05).

Summarized in table 2 are the effects of slope on percentage runoff and sediment flow from the five forage management treatments. High slope areas produced 63% greater runoff (P<.05) and 43% greater sediment movement (P<.05) than did low slope areas. Slope did not affect total or soluble P movement.

Summarized in Table 3 are the flow of sediment, total P, and total soluble P from the paddocks, at the base of the paddocks, and at the 30-ft buffer strips. A greater flow of sediment and P was observed in the paddocks as compared with the base or the 30-ft buffer strip in the 2C and 2R treatments (P<.05). There was no difference in the amounts of sediment or total P and total soluble P between the base and the 30-ft buffer strip in any treatment.

In conclusion, sediment and P losses in pasture runoff may be reduced by managing rotational stocking to maintain adequate sward height and reduce bare ground.

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Table 1. Effect of forage management on percentage runoff and sediment, total P, and total soluble P flow averaged across all rainfall simulation periods.

	Runoff, %*	Sediment, lb/ac	Total P, lb/ac	Total soluble P, lb/ac
U	5.14[a]	1.48	0.008[a]	0.005[a]
HS	15.14[b]	4.80	0.032[b]	0.021[b]
2C	22.26[c]	21.56	0.099[c]	0.050[c]
2R	20.56[c]	11.27	0.074[c]	0.057[c]
4R	12.27[b]	6.96	0.033[b]	0.020[b]

* Different superscripts within the same column denote a difference (P<.05).

Table 2. Effect of forage management and slope on percentage runoff and sediment flow averaged across all rainfall simulation periods.

	Runoff, %*		Sediment, lb/ac*	
	High slope	Low slope	High slope	Low slope
U**	6.27	4.02	1.94	1.04
HS	17.04[a]	13.25[b]	5.88	3.73
2C	27.16[a]	17.35[b]	30.88[a]	12.23[b]
2R	25.7[a]	15.41[b]	14.20[a]	8.32[b]
4R	16.02[a]	8.52[b]	11.57[a]	2.34[b]
Average	18.43[a]	11.71[b]	12.89[a]	5.54[b]

* High slope (7–15°), Low slope (0–7°).
**Different superscripts within a variable (runoff and sediment) within the same row (high vs. low slope) denote a difference (P<.05).

Table 3. Sediment, total P, and total soluble P losses within the paddocks, at the base of the paddock, and 30 ft within the buffer averaged across all rainfall simulation periods.

	Sediment, lbs/ac			Total P, lbs/ac			Total Soluble P, lbs/ac		
	Paddock*	Base	Buffer	Paddock	Base	Buffer	Paddock	Base	Buffer
U**	1.47	2.73	5.47	0.0083	0.0083	0.0159	0.0048	0.0040	0.0068
HS	5.00	4.81	6.67	0.0324	0.0169	0.0206	0.0217	0.0094	0.0116
2C	21.70[a]	1.37[b]	2.68[b]	0.0998[a]	0.0081[b]	0.0163[b]	0.0499[a]	0.0061[b]	0.0110[b]
2R	11.34[a]	2.67[b]	4.29[b]	0.0743[a]	0.0112[b]	0.0138[b]	0.0563[a]	0.0063[b]	0.0062[b]
4R	6.88	3.30	4.89	0.0332	0.0091	0.0271	0.0207	0.0065	0.0074

* Paddock = Within a paddock, Base = At the base of the paddock, Buffer = Within the buffer strip, 30 ft down slope from the paddocks.
**Different superscripts within a variable (sediment, total P, and Soluble P) within the same row (paddock, base, buffer) denote a difference, (P<.05).