Effects of Stocking Rate and Botanical Composition on the Physical Characteristics of the Riparian Zones of Pastures (A Progress Report)

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Summary and Implications

Grazing management practices that allow congregation of cattle near pasture streams may increase sediment, phosphorus, and pathogen loading of the streams by removing vegetation and causing manure accumulation near the streams. Forage sward height, bare and manure-covered soil, and forage species were measured along the banks of streams in 13 pastures on 12 cow-calf operations in southern Iowa. Forage sward height decreased as the proportion of tall fescue at the vegetated sites increased, as the stocking rate increased, and as the proportion of reed canarygrass at the vegetated sites decreased. The proportion of soil that was bare tended to increase as the proportion of reed canarygrass at vegetated sites decreased and the proportion of tall fescue at vegetated sites or the stocking rate increased. The proportion of soil that was manure-covered increased as the stocking rate and proportion of tall fescue at vegetated sites increased and the proportion of reed canarygrass at vegetated sites decreased. In stepwise multiple regressions, stocking rate was not selected to predict sward height and the proportion of bare soil. In contrast, stocking rate was the first factor selected to predict the proportion of soil that was covered with manure. Selection of tall fescue in the stepwise multiple regressions implied that the sward height decreased and manure cover increased as tall fescue as a proportion of vegetated sites increased. The presence of tall fescue and increasing stocking rate may increase cattle activity near streams reducing sward height and increasing manure cover. However, the effects of stocking rate and the botanical composition on the proportion of bare soil along stream banks were relatively small.

Introduction

Grazing management practices that allow cattle to congregate near pasture streams may result in the loss of vegetative cover and accumulation of manure near the streams. These conditions may cause loading of the streams with sediment, phosphorus, and pathogens carried in precipitation runoff. Furthermore, the loss of vegetation and increased compaction associated with concentrated cattle traffic may promote stream bank erosion causing further impairment of stream water quality.

Previous research has shown that management practices like rotational stocking with flash-grazing of riparian paddocks or restricting stream access to stabilized crossings increased the proportion of vegetative cover and sward height of forage while reducing the proportion of ground covered with manure near streams in smooth bromegrass pastures. Therefore, nonpoint source pollution of these streams should be reduced by these practices. However, the efficacy of grazing management practices on sward height, vegetative cover, and concentration of manure are likely related to stocking rate and other factors such as the botanical composition or shade distribution in pastures that influence congregation of cattle near streams.

The objective of this project was to evaluate the effects of stocking rate of pastures and the botanical composition of the pastures' riparian zone on the forage sward height and the proportions of bare and manure-covered ground along the banks of pasture streams.

Materials and Methods

Thirteen pastures on 12 cooperating farms in the Rathbun Lake watershed were identified as appropriate for the project in the fall of 2006. Pastures ranged in size from 7 to 265 acres and had stream reaches of 948 to 5,511 feet and that drained watersheds of 624 to 13,986 acres. At the initiation of the experiment, two of the pastures were ungrazed vegetative buffers. However, grazing of one of these pastures was initiated in October, 2007. Owners of these operations recorded the number of cows, heifers, and bulls stocked in these pastures as they entered or left the pasture from November, 2006 to November, 2007.

Bi-monthly, from May through November, 2007, proportions of bare and manure-covered ground and the forage sward height and vegetation species were measured on both sides of the stream at up to 30 locations at 100-foot intervals along the stream in each pasture. Proportions of bare and manure-covered ground were measured perpendicular to the stream by the line transect method over

50 feet, beginning approximately 3 feet from the stream. Sward height was measured with a falling plane meter (8.8 lb/yd^2) and vegetation species was identified at the mid-point of the transect line. Sward height was not measured at sites in which brush was the major vegetative species. Vegetation species observed included tall fescue, reed canarygrass, Kentucky bluegrass, smooth bromegrass, orchardgrass, timothy, legumes (primarily white clover), sedge, weed grasses (primarily foxtail), broadleaf weeds (largely nettles and wild parsnips), and brush (primarily multiflora rose). Botanical composition was calculated as a proportion of the major vegetative species located at each vegetated site.

Cow-days for each pasture were calculated for each sampling interval as:
Cow-days = (Number of cows x days stocked) + (Number of heifers x .86 x days stocked) + (Number of bulls x 1.2 x days stocked)

For equivalent comparison to other sampling intervals, cow-days for the May sampling period were calculated for the preceding 62 days. Stocking rates were calculated on area and distance bases by dividing by the pasture acres and stream reach length and expressed either for the interval between each sampling period or the total year.

Differences in the proportions of bare and manure-covered ground, forage sward height, and the proportion of each vegetative species between farms were analyzed by analysis of variance using months as replicates. Similarly, differences in these variables between months were analyzed by analysis of variance using farms as replicates. Differences between means of variable with significant treatment effects in both of these analyses were tested by t-tests.

Regression equations were calculated to quantify the relationship between the dependent variables of sward height and proportion of ground that was bare or manure-covered with independent variables of stocking rates per pasture acre or foot of stream reach or the proportion of each vegetative species. Stepwise multiple regressions were also calculated with dependent variables of sward height and the proportion of ground that was bare or manure-covered and independent variables of stocking rate per pasture acre or foot of stream reach on either a sampling period or annual basis and the proportion of each vegetative species.

Results and Discussion

Mean stocking rates of 26.0 cow-days/acre or 0.72 cow-days/foot of stream between sampling periods did differ ($P<0.05$) between farms (Table 1). While annual stocking rates could not be analyzed statistically because of lack of replication, means (ranges) were 123 (0-290) cow-days/acre and 3.66 (0-10.2) cow-days/foot of stream. The mean sward height (10.7 cm), bare soil (13.8%) and manure-covered soil (0.61%) over the sampling intervals had differences ($P<0.05$) between the 13 pastures. Variability between farms was particularly great for the sward height and the proportion of soil that was bare. Mean proportions of tall fescue (46.3%), reed canarygrass (20.8%), legume (0.75%), broadleaf weeds (15.4%), and brush (2.8%) over the four sampling periods differed ($P<0.05$) between farms. The mean proportion of sites with Kentucky bluegrass was 8.8%. But the variation between months on individual farms was so great that there were no differences between farms. The proportions of smooth bromegrass, orchardgrass, timothy, sedge, and weed grasses in the riparian areas of all farms were so low and variable that there were no differences between farms.

Stocking rates expressed on either an area or length of stream reach basis did not significantly differ between sampling intervals. Mean sward height across the 13 pastures was greater ($P<0.05$) in July (16.1 cm) than in September (9.6 cm) and November (3.7 cm; Table 2). Similarly, the mean sward height of the pastures in May (10.7 cm) was also greater than that in November. The low sward height of pastures in November seems to imply that the stream banks might be susceptible to erosion and sediment and nutrient losses in precipitation run-off over winter. However, the mean proportions of ground that were bare or manure-covered over the 13 pastures did not differ between months. In May, the mean proportions of Kentucky bluegrass, smooth bromegrass, and orchardgrass were greater ($P<0.05$) and the mean proportion of tall fescue was lower ($P<0.05$) in the 13 pastures than in the other months. The proportions of vegetated sites with broadleaf weeds were greater ($P<0.05$) in July and September than in May and November. The proportion of vegetated sites with brush was greater ($P<0.05$) in November than in May and July.

Of the methods for expressing stocking rate, the annual stocking rate per acre was most highly related to the forage sward height measured approximately 28 feet from the stream ($y=22.96-0.191x+0.0005x^2$; $r^2=0.35$). This equation would imply that in order to maintain 10 cm (4 inches) of forage on the banks, the annual stocking rate could not exceed 88 cow-days/acre in the area adjacent to a stream. Forage sward height also decreased as the proportion of tall fescue increased ($y = 20.4 - 0.21x$; $r^2 = 0.46$) and increased as the proportion of reed canarygrass ($y = 6.5 + 0.20x$; $r^2 = 0.35$), broadleaf weeds ($y = 6.8 + 0.25x$; $r^2 = 0.12$), sedge ($y = 9.2 + 1.64x$; $r^2 = 0.10$), and smooth bromegrass ($y = 9.2 + 0.56x$; $r^2 = 0.10$) increased. In stepwise multiple regression, only the proportions of tall fescue and Kentucky bluegrass were selected as significant variables (Table 3). Sward height decreased as the percentage of each of these species increased, explaining 57% of the variation in sward height in the riparian zone. This relationship might be expected as both of these species have relatively short growth habits compared to the other species observed in the pastures. However, the amount of variability in the proportions of reed canarygrass, smooth bromegrass, and broadleaf weeds was so great that they did not enter the equation. Similarly, stocking rate was not selected by stepwise multiple regression. Because variables are selected on the bases of linear relationships, stocking rate may have been not selected because of the relatively strong quadratic relationship that stocking rate had with sward height.

The proportion of bare soil along the stream banks was only weakly related to the annual stocking rate per acre ($y=4.55+0.150x-0.0004x^2$; $r^2=0.20$). The proportion of bare soil along stream banks also increased as the proportion of tall fescue in the pastures increased ($y = 6.5 + 0.16x$; $r^2 = 0.27$) and decreased as the proportion of reed canarygrass increased ($y = 18.3 - 0.21x$; $r^2 = 0.41$). In stepwise multiple regressions, the proportion of bare soil decreased as the proportions of both the reed canarygrass and broadleaf weeds increased. These variables accounted for 46% of the variation in the proportion of soil that was bare. Stocking rate either expressed on period or annual basis per unit of length or foot was not selected as a significant variable for predicting bare soil. Because the proportion of the bead line used for measurement of bare soil that went down the bank relative to that on top of the bank varied between pastures and sites within pastures depending on the depth of the channel and a high proportion of the sites without ground cover were down the banks, the small relationship of stocking rate to the proportion of bare soil may imply that natural factors like stream flow might have larger effects on bare soil than cattle traffic.

The proportion of manure-covered ground increased as the annual stocking rate per acre increased ($y=-0.038+0.0077x-0.00001x^2$; $r^2=0.47$). At the annual stocking rate of 88 cow-days/acre calculated to maintain a sward height of 10 cm, the proportion of ground covered with manure within 53 feet of a stream would be 0.56% The proportion of manure-covered ground also increased as the proportion of tall fescue in the pastures increased ($y = 0.22 + 0.008x$; $r^2 = 0.24$) and decreased as the proportions of reed canarygrass ($y = 0.79 - 0.008x$; $r^2 = 0.21$), broadleaf weeds ($y = 0.85 - 0.016x$; $r^2 = 0.15$), and sedge ($y = 0.70 - 0.10x$; $r^2 = 0.13$) increased. In stepwise multiple regressions, the proportion of manure-covered ground increased as the stocking rate per foot of stream reach by period and the proportions of tall fescue, Kentucky bluegrass, and reed canarygrass increased. These variables accounted for 61% of the variation in manure cover and may represent the effects of stocking rate of areas with the most commonly grazed species.

Results imply that increasing stocking rate will result in significant decreases in sward height and increases in manure cover in riparian zones. While increasing the stocking rate will also tend to increase the proportion of soil that was bare, this effect was relatively small. Increasing the amount of tall fescue in riparian zones in pastures reduces forage sward height, while increasing the proportions of soil that was either bare or covered with manure. Whether these relationships are caused by the growth characteristics of tall fescue compared to other vegetative species, the difference in the distribution of tall fescue in heavily grazed, lightly grazed or ungrazed pastures, or congregation of cattle near streams resulting from heat-stress related to grazing tall fescue near streams is unknown. However, other studies investigating the effects of grazing characteristics on the temporal spatial distribution of cattle may provide some evidence to explain the relationships.

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Table 1. Mean physical characteristics, botanical composition, and stocking rates measured bimonthly in 13 pastures in the Rathbun Lake watershed.

Variable	Mean	Range	Significance of difference between farms[a]
Sward height, cm	10.7	3.6-25.6	*
Bare ground, %	13.8	2.0-32.7	*
Manure-cover, %	0.61	0-1.16	*
Stocking rate,			
Cow-days/acre	26.0	0-68.8	*
Cow-days/ft stream	0.72	0-1.97	*
% of vegetated sites			
Tall fescue	46.3	7.9-71.0	*
Reed canarygrass	20.8	0.6-85.0	*
Kentucky bluegrass	8.8	0-24.9	NS
Smooth bromegrass	2.6	0.6-7.8	NS
Orchardgrass	0.9	0-3.6	NS
Timothy	0.1	0-1.7	*
Legume	0.8	0-3.3	*
Sedge	0.9	0-3.8	NS
Weed grasses	0.5	0-3.9	NS
Broadleaf weeds	15.4	1.3-31.0	*
Brush	2.8	0-7.9	*

[a]P<0.05

Table 2. Means of physical characteristics, botanical composition, and stocking rate in 13 pastures in the Rathbun Lake watershed by sampling interval.

	Month			
Variable	May	July	September	November
Sward height, cm	12.4[ab]	16.9[a]	9.6[bc]	3.7[c]
Bare ground, %	13.9	12.3	15.7	13.5
Manure-cover, %	0.64	0.68	0.37	0.75
Stocking rate,				
Cow-days/acre	9.9	29.4	31.0	33.6
Cow-days/ft stream	0.32	0.69	0.90	0.99
% of vegetated sites				
Tall fescue	21.6[a]	46.7[b]	50.3[b]	66.3[b]
Reed canarygrass	24.9	20.3	18.9	19.2
Kentucky bluegrass	28.5[a]	3.6[b]	1.0[b]	1.9[b]
Smooth bromegrass	7.6[a]	2.3[b]	0.2[b]	0.3[b]
Orchardgrass	3.2[a]	0.5[b]	0.1[b]	0[b]
Timothy	0.3	0.3	0	0
Legume	0.6	0.8	0.7	0.9
Sedge	0[a]	1.6[b]	1.9[b]	0[a]
Weed grasses	0	1.3	0.5	0.3
Broadleaf weeds	11.8[a]	20.6[b]	22.9[b]	6.3[a]
Brush	1.5[a]	1.8[a]	3.4[ab]	4.6[b]

[ab]Differences between means with different superscripts are significant, P<0.05.

Table 3. Stepwise multiple regressions predicting sward height, bare ground, and manure cover from stocking rate and botanical composition data

Dependent variable	Independent variables	Coefficients	Partial r^2
Sward height, cm	Intercept	23.80	
	Tall fescue, % of vegetation	-0.249	0.46
	Kentucky bluegrass, % of vegetation	-.186	0.11
		Total	0.57
Bare soil, %	Intercept	20.93	
	Reed canarygrass, % of vegetation	-0.223	0.41
	Broadleaf weeds, % of vegetation	-0.157	0.05
		Total	0.46
Manure cover, %	Intercept	-0.49	
	Stocking rate, cow-days/ft stream by period	0.262	0.37
	Kentucky bluegrass, % of vegetation	0.019	0.12
	Tall fescue, % of vegetation	0.013	0.08
	Reed canarygrass, % of vegetation	0.007	0.04
		Total	0.61