Mesic meadow response to varying levels of grazing utilization in south central Idaho

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INTRODUCTION

Livestock grazing in riparian and mesic meadow habitats is one of the most prevalent issues in rangeland management because of the need to balance agricultural and ecological values. Riparian zones in the Pacific northwest United States constitute a small proportion of total rangeland area (1% to 2%) but may provide up to 20% of summer range forage (Kauffman and Krueger, 1984). Historic land use practices have led to increased discussion around livestock grazing in mesic areas and the need to develop strategies that provide forage and water for livestock, but maintain healthy and functioning ecosystems (Kauffman and Krueger, 1984). Mesic vegetation response to livestock grazing is highly variable and dependent on several factors, including timing and intensity of grazing (Roath and Krueger, 1982) and plant community diversity (Green and Kauffman, 1995). High grazing pressure or excessive defoliation may have detrimental effects on mesic plants; however, defoliation during certain stages encourages plant regrowth.

Although riparian grazing management has been extensively studied, site-specific responses have contributed to the difficulty in developing general standards. There is still a need for better understanding how livestock grazing is associated with plant phenology and nutrient levels in mesic meadows. The objectives of this research were to determine whether and how livestock grazing utilization influences vegetative biomass and nutrient values in mesic meadow pastures. We hypothesized that higher grazing utilization would produce greater forage quality but less biomass than moderate grazing utilization after a period of regrowth, and that the level of grazing utilization would have no effect on cattle performance.

MATERIALS AND METHODS

Site Description

This research took place at Rinker Rock Creek Ranch (RRCR) in Blaine County, ID. Historically, the experimental mesic meadows were planted in pasture grass and grazed during late summer and fall. Grazing had not taken place in the experimental pastures for 2 yr prior to this trial. All animal procedures were approved by the University of Idaho Institutional Animal Care and Use Committee (Protocol no. 2017-39).

Experimental Design

In yr 1 (2017), an experimental gradient of increasing grazing utilization was created in

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pastures ($n = 6$), where stocking rates of 0, 5, 10, 15, 20, or 25 cattle were randomly assigned to a pasture. Because a clear grazing utilization gradient was not achieved in yr 1, and to increase replications in yr 2 (2018), four additional grazing utilization pastures of similar size and location were added to the original pastures ($n = 10$ total). The modified design included four moderate grazing utilization pastures (MOD; 30% to 50% utilization), four high grazing utilization pastures (HIGH; 60% to 80% utilization), and two ungrazed (CONT) pastures. All pastures, including CONT, were approximately 2.23 ha each and fenced with a two-strand hot wire. Stockwater was provided by either irrigation ditches or a free-flowing stream adjacent to pastures.

Animals

In both years, pregnant heifers ($n = 75$; 457 ± 4.0 kg initial body weight [BW] 2017, 416 ± 3.84 kg initial BW 2018) were shipped from the University of Idaho Nancy M. Cummings Research, Extension and Education Center (NMCREEC) to RRCR in early July. In 2018, yearling steers ($n = 62$; 349 ± 4.5 kg initial BW) from a local ranch were included. The grazing trial was conducted for 25 d (7/5–7/30) in 2017 and for 21 d (7/3–7/24) in 2018. The number of cattle were randomly allotted to pastures in 2017, and in 2018, pastures were grazed at the same utilization levels as in 2017. Cattle BW were collected on d 0 and 1 of the trial and on the final trial date and subsequent day each year. Cattle were stratified by BW into pastures, and the number of cattle in each pasture was adjusted to meet target utilization rates in 2018.

Vegetative Data

Data were collected in each pasture pre-grazing (<3 wk), post-grazing (<1 wk), and after a period of regrowth (6 to 8 wk post-grazing). Six transects per pasture were spatially balanced along pasture boundaries and marked for replication during each sampling period. Grazing utilization data were collected post-grazing (USDA and USDOI, 1999) at 25 points along each transect (length = 45.7 m) in a pasture. Height and percent utilization of each grass species within a 100 cm^2 plot was measured. Percent utilization of each grass species was weighted by species percent cover within the plot for a total percent utilization per plot. During each sampling period, one biomass plot (1,000 cm^2) was clipped along each transect in addition to six biomass plots at random locations per pasture ($n = 12$ biomass plots per pasture). Biomass wet weights were recorded, samples were forced-air dried at 60 °C, and dry weights were recorded to determine dry matter (DM) content. Biomass samples were ground in a cyclone mill to 1 mm and all samples within a pasture were pooled for forage quality analyses (Cumberland Valley Analytical Services, Inc., Waynesboro, PA).

Statistical Analysis

An analysis of variance (ANOVA) was used to assess grazing utilization treatments (CONT, MOD, and HIGH) and year on actual grazing utilization values determined by grass species height. A pooled analysis was carried out across both years assessing grazing utilization treatment, year, and the interaction.

An ANOVA was also used to assess cattle performance. In 2017, the model for average daily gain (ADG) included grazing utilization CONT, MOD, and HIGH, whereas the pooled analysis conducted across both years for ADG, pre-grazing BW, and post-grazing BW included only MOD and HIGH grazing utilization. The pooled analyses also assessed year and year interactions. In all models, grazing utilization was a fixed effect, whereas pasture and animal were random effects.

For biomass and nutrient analysis variables, including DM, crude protein (CP), total digestible nutrients (TDN), acid detergent fiber (ADF), neutral detergent fiber (NDF), values were averaged to one value per response, year, and pasture. A repeated measures model was used with treatments, period, year and their interactions as fixed effects, with pasture as a random effect. Sampling period was considered a repeated measures effect assuming a lag 1 autoregressive (AR(1)) correlation structure.

An ANOVA was used to determine the effects of year and grazing utilization on percent change in biomass between post-grazing and regrowth periods for all biomass data along transects and at random locations. Percent change in regrowth biomass data were log-transformed ($\log(x+1)$) to meet assumptions of normality. Statistical significance was evaluated at $P \leq 0.05$. Pair-wise comparisons were used to further evaluate significant effects. All analyses were conducted using PROC MIXED of SAS (SAS v 9.4 Institute Cary, NC).

RESULTS AND DISCUSSION

Actual grazing utilization levels differed among utilization treatments ($P < 0.0001$; CONT = 14.98 ± 4.2%; MOD = 47.74 ± 3.2%; HIGH = 69.47 ± 3.2%), but there was no effect of year ($P = 0.57$). This suggests that our experimental design, in fact, resulted in different grazing utilization treatments by stratifying cattle by BW into pastures, and adjusting the number of cattle in each pasture to meet target utilization rates.

Cattle performance data are presented in Table 1. For all response variables, there were no ($P > 0.05$) grazing utilization or grazing utilization × year effects. However, due to the addition of lighter BW steers (349 ± 4.5 kg) compared with heifers (416 ± 3.8 kg) in 2018, pre-grazing and post-grazing BW were greater ($P \leq 0.02$) in 2017 than 2018. Across years, there was no effect ($P > 0.05$) of grazing utilization or year on percent change in BW (data not shown) or ADG ($P = 0.74$; Table 1). ADGs of pregnant yearling heifers grazing in montane meadows did not show consistent patterns during late summer and fall and may be more dependent on yearly variation in cattle performance and location than grazing system (Holechek et al., 1982). Our results suggest that over short time periods (21 to 25 d), high stocking rates in mesic pastures may not affect cattle performance in midsummer, when compared to moderate stocking rates.

Average biomass (kg/ha) in the MOD and HIGH pastures was lower ($P = 0.002$) at post-grazing and regrowth periods compared with CONT and with all grazing utilization levels at pre-grazing (Table 2). However, average biomass was similar ($P > 0.05$) among MOD and HIGH grazing utilization levels at post-grazing and regrowth. Similarly, there were no effects of grazing utilization ($P = 0.70$) or year ($P = 0.08$) on percent change in biomass between post-grazing and regrowth (data not shown). Likely as a function of annual precipitation (475 mm, 2017 vs. 261 mm, 2018; USBR AgriMet Station, Picabo, ID), average biomass (kg/ha) was greater ($P = 0.007$) for each grazing utilization level in 2017 compared with 2018. In each year, average biomass was expectedly lower ($P \leq 0.007$) in MOD and HIGH pastures compared with CONT; however, it was of interest that MOD and HIGH did not differ ($P > 0.05$) within each year.

Previous research suggests that mesic plants can withstand grazing as long as root systems can be maintained or replenished (Swanson et al., 2015). Furthermore, short-duration grazing has been reported to have fewer negative impacts on riparian areas compared with longer duration grazing, when adequate rest or regrowth is

Table 1. Least squares means for ADG, pre-grazing BW, and post-grazing BW of cattle that grazed in mesic meadows for 25 and 21 d in 2017 and 2018, respectively, at varying levels of grazing utilization and year

	Grazing utilization[*]		Year			*P* value		
Item	Moderate	High	2017	2018	SEM	Grazing utilization	Year	Grazing utilization × year
ADG (kg)	0.69	0.59	0.59	0.69	0.2	0.762	0.741	0.783
[†]Pre-grazing BW, kg	418	424	456	386	10.1	0.706	0.004	0.991
[†]Post-grazing BW, kg	433	438	470	401	13.8	0.855	0.020	0.919

[*]Grazing utilization to moderate (30% to 50% utilization), high (60% to 80% utilization).

[†]Pre-grazing BW to average BW on d 0 and 1; post-grazing weight is average weight from the last day of the trial and following day.

Table 2. Least squares means for average biomass (kg/ha) collected in mesic meadow pastures that cattle grazed for 25 and 21 d in 2017 and 2018, respectively, at varying levels of grazing utilization, sampling period, and year

	Period[*]			Year			*P* value	
	Pre-grazing	Post-grazing	Regrowth	2017	2018	SEM	Grazing utilization × period	Grazing utilization × year
Control†	6,981.04[a]	6,082.57[a]	6,083.20[a]	6,996.33[a]	5,768.21[b]	301.1	0.002	0.007
Moderate	5,242.62[a]	2,299.67[b]	2,179.79[b]	4,256.93[c]	2,224.45[d]			
High	5,930.72[a]	2,057.30[b]	2,591.82[b]	5,450.45[b,c]	1,602.78[d]			

[*]Period to pre-grazing (<3 wk prior to grazing), post-grazing (< 1 wk after grazing), regrowth (6 to 8 wk after grazing).

[†]Grazing utilization to Control (ungrazed), Moderate (30% to 50% utilization), High (60% to 80% utilization).

[a to d]Means within grazing utilizations and years with different letters are significant ($P < 0.05$).

permitted (USDOI, 2006; Swanson et al., 2015). Mesic meadow plants responded to short-duration grazing similarly for both MOD and HIGH grazing utilization levels in this trial. These results suggest that over the short-term, mesic plant communities may be able to compensate for biomass removal when provided a regrowth period, regardless of whether they are removed at the HIGH or MOD utilization level. It is of interest whether long-term grazing at HIGH utilization levels would produce similar results.

As expected, due to precipitation patterns and vegetation maturity, DM was greater ($P \leq 0.05$) at regrowth compared with pre-grazing in both years (Table 3). In 2017, DM was similar ($P > 0.05$) between pre-grazing and post-grazing, but post-grazing and regrowth both had greater ($P \leq 0.05$) DM than pre-grazing in 2018. These results suggest that vegetation dried out more quickly in 2018, likely due to lower annual precipitation compared with 2017. Similarly, in 2018 CP decreased ($P < 0.05$) during post-grazing and regrowth from pre-grazing, when DM was greatest (Table 3). However, CP at post-grazing and at regrowth in 2017 was similar ($P > 0.05$) to pre-grazing in both 2017 and 2018. Within grazing utilization levels across years and periods, CP was lower ($P = 0.003$) in MOD pastures compared with CONT and HIGH pastures.

At pre-grazing in 2017, TDN (Figure 1a) in HIGH was lower ($P = 0.003$) than in CONT and numerically lower than MOD, but was numerically greater than MOD and CONT at regrowth in 2017 and pre-grazing in 2018. Between pre-grazing and regrowth in 2017, TDN increased by 3.15% in HIGH, whereas a downward trend was observed in CONT and MOD pastures. At pre-grazing in 2018, both MOD and HIGH had greater ($P = 0.003$) TDN than CONT; however, a downward trend was observed for all grazing treatments from pre-grazing to regrowth in 2018. As expected, inverse relationships between TDN (Figure 1a) trends and both ADF (Figure 1b) and NDF (Figure 1c) trends were observed. Similar to the results from this study, Ball et al., (2001) observed that as DM and fiber concentrations increase, relative percentages of available nutrients, including CP decrease. Furthermore, greater CP and TDN observed in grazed pastures was associated with greater regrowth, higher leaf to stem ratios, and increased intake by livestock (Ball et al., 2001). Taken all together, these data suggest that nutrient composition of mesic vegetation may be improved through higher grazing utilization during years with greater annual precipitation.

Table 3. Least squares means for CP and DM collected in mesic meadow pastures that cattle grazed for 25 and 21 d in 2017 and 2018, respectively, at varying levels of grazing utilization, sampling period, and year

	Grazing utilization[†]			Period[*]							*P* value	
				Pre-grazing		Post-grazing		Regrowth				
	Control	Moderate	High	2017	2018	2017	2018	2017	2018	SEM	Grazing utilization	Year × period
DM, %	64.31	63.84	59.27	46.69[c]	48.94[c]	50.30[c]	80.86[a]	63.75[b]	84.29[a]	3.1	0.290	0.001
CP, %	6.83[a]	5.99[b]	6.99[a]	6.95[c]	7.94[a]	6.57[cd]	5.56[d]	7.20[c]	5.40[d]	0.3	0.033	0.003

Treatment × Period × Year ($P = 0.003$).

[*]Period to pre-grazing (<3 wk prior to grazing), post-grazing (<1 wk after grazing), regrowth (6 to 8 wk after grazing).

[†]Grazing utilization to Control (ungrazed), Moderate (30% to 50% utilization), High (60% to 80% utilization).

[a to d]Means within grazing utilizations and years with different letters are significant ($P < 0.05$).

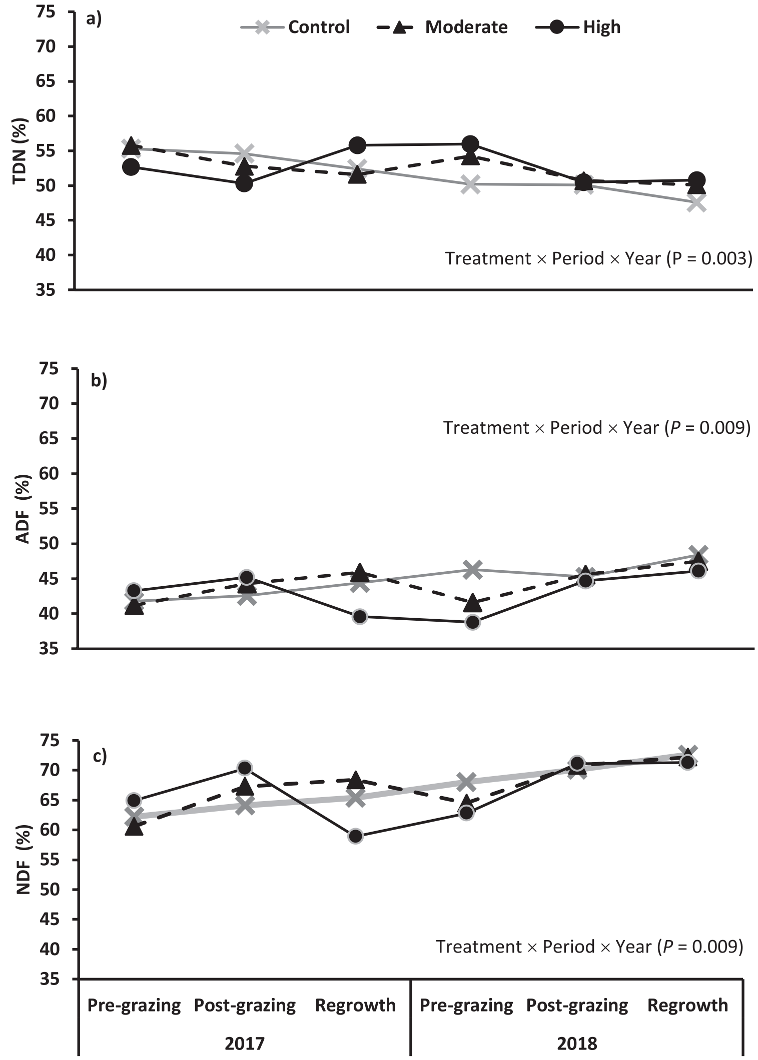

Figure 1. Least squares means for (a) TDN, (b) ADF, and (c) NDF collected in mesic meadow pastures that cattle grazed for 25 and 21 d in 2017 and 2018, respectively, for each sampling period (Pre-graze (<3 wk prior to grazing), Post-graze (<1 wk after grazing), Regrowth (6 to 8 wk after grazing) per year (2017 and 2018) for Control (ungrazed), Moderate (30% to 50%), and High (60% to 80%) grazing utilization treatments.

However, during years with lower annual precipitation, vegetation nutrient composition declines over the grazing season regardless of grazing utilization treatment.

IMPLICATIONS

Our results suggest that short-duration, high utilization (60% to 80%) grazing in mesic meadows in July, during normal or high annual precipitation years, with a subsequent regrowth period, may provide adequate forage and nutrient quality for fall grazing and/or wildlife habitat without affecting cattle performance.

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LITERATURE CITED

Ball, D. M., M. Collins, G. D. Lacefield, N. P. Martin, D. A. Mertens, K. E. Olson, D. H. Putnam, D. J. Undersander, and M. W. Wolf. 2001. Understanding forage quality. American Farm Bureau Federation Publication 1-01, Park Ridge, IL.

Green, D. M., and J. B. Kauffman. 1995. Succession and livestock grazing in a northeastern Oregon riparian ecosystem. J. Range Manag. 48(4):3017–313. doi:10.2307/4002482

Holechek, J. L., M. Vavra, and J. Skovlin. 1982. Cattle diet and daily gains on a mountain riparian meadow in northeast Oregon. J. Range Manag. 35(6):745–747. doi:10.2307/3898254

Kauffman, J. B., and W. C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications—A review. J. Range Manag. 37(5):430–438. *doi:*10.2307/3899631

Roath, L. R., and W. C. Krueger. 1982. Cattle grazing influence on a mountain riparian zone. J. Range Manag. 35(1):100–103. doi:10.2307/3898531

Swanson, S., S. Wyman, and C. Evans. 2015. Practical grazing management to maintain or restore riparian functions and values on rangelands. J. Rangel. Appl. 2:1–28.

U.S. Department of Agriculture and U.S. Department of the Interior (USDA and USDOI). 1999. Utilization studies and residual methods. Bureau of Land Management's National Applied Resource Sciences Center. Interagency Technical Reference 1734-3. Denver (CO): USDA, 1999.

U.S. Department of the Interior (USDOI). 2006. Riparian area management: grazing management processes and strategies for riparian-wetland areas. Denver (CO): Bureau of Land Management, National Science and Technology Center. p 105. Technical Reference 1737-20. BLM/ST/ST-06/002 + 1737.