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LIVESTOCK AND VEGETATION RESPONSES TO STOCKING RATE AND GRAZING SYSTEM

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INTRODUCTION

Vegetation and livestock responses from a 25 year (1982-2006) grazing system and stocking rate study in the northern mixed-grass prairie at the USDA-Agricultural Research Service, High Plains Grasslands Research Station near Cheyenne, Wyoming are presented here. This study was longest known grazing system X stocking rate study in North America and was one of the few studies to use the same stocking rates for grazing system comparisons. Results from this study have been used to further development of, and validate, rangeland models for tactical (within-year) and strategic (across years) decision support tools for producers.

BACKGROUND

Stocking rate is the primary management driving factor influencing livestock and vegetation responses in rangeland ecosystems (Manley et al. 1997; Rogers et al. 2005). Responses of livestock weight gains to stocking rates have been well-studied in rangelands with productivity per animal decreasing with increasing stocking rate, and productivity per unit area increasing until scarcity of forage reduces nutrient intake of livestock and productivity decreases (Bement 1969; Holechek et al. 1998). Responses of vegetation production to stocking rates show a clear and consistent decrease with increasing stocking rate (Ralphs et al. 1990; Milchunas et al. 1994; Rogers et al. 2005). Livestock weight gains and vegetation production have been evaluated in many studies comparing season-long continuous grazing and rotational grazing systems in numerous rangeland ecosystems (Holechek et al. 1998; Briske et al. 2008). Effects of grazing systems on livestock weight gains and vegetation are inconsistent. Studies have demonstrated advantages of season-long grazing, benefits of rotational grazing, or conclusions of no difference between grazing systems (Briske et al. 2008). A lack of consensus in the scientific literature on this topic is likely attributed to the confounding effect of stocking rate between the grazing systems studied. Often greater stocking density and stocking rates were employed with rotational grazing to reduce patch grazing (i.e., selectivity) of grazing animals that occurs with season-long grazing under low to moderate stocking rates (Teague and Dowhower 2003). Comparisons between grazing systems with the same stocking rates are largely lacking in the literature.

Here, I report on the final 16 years (1991-2006) of a study established in 1982 to evaluate effects of grazing systems (season-long and short-duration rotational grazing), stocking rates (moderate and heavy stocking), and their interaction on yearling beef cattle weight gains and vegetation production on northern mixed-grass prairie in southeastern Wyoming. Findings from earlier years of this study have previously been reported (Hart et al. 1988; Manley et al. 1997). Specific objectives are 1) to determine the influence of stocking rate and grazing system on livestock and vegetation production, and 2) to determine relationships between spring precipitation and livestock and vegetation production.

STUDY AND SITE DESCRIPTION

An experiment was initiated in 1982 on northern mixed-grass prairie at the USDA-Agricultural Research Service High Plains Grasslands Research Station, at Cheyenne, Wyoming (41°11' N, 104°53' W). Mean annual precipitation (132 yr) is 15 inches with a peak in May. Soils are coarse and well-drained, comprised mainly of Albinas, Ascalon and Altvan loams (mixed mesic Aridic Agriustolls). Vegetation is predominately cool- and warm-season grasses. Two grazing systems were evaluated using a randomized block design on the study area that had previously been grazed very lightly by livestock and wildlife: 1) season-long continuous grazing, and 2) short-duration rotational grazing having 8 paddocks with 4 grazing cycles of approximately 2, 3, 5 and 7-day grazing periods. Grazing periods were shorter in the early growing season to match timing of peak precipitation and resultant forage production, and lengthened as the growing season progressed. Pastures were targeted to be grazed from early-June to early-October with yearling steers having entry weights across the study years of 545 ± 53 pounds. Cattle did not graze pastures in 2000 and 2002 due to severe drought and very low forage production, and grazing seasons were shortened in 1994 and 2006 due to drought. Stocking rates applied were either moderate (7.5 acres per steer) or heavy (5.5 acres per steer).

In late July/early August each year, with the exception of 2000, vegetation production was determined inside 4-6, 9ft^2 exclosures for each pasture. Yearling steers, mostly Hereford with the remainder crossbred English breeds, were used throughout the study. Steers were weighed prior to and following the grazing season, after being held overnight without feed or water. Average daily gains determined by dividing seasonal gains (determined by subtracting starting from end weights) by the days of actual grazing, and beef production calculated by multiplying grazing season gains by the number of steers in the treatment and dividing the product by acres in the pasture.

To determine the influence of stocking rate, grazing system and grazing system X stocking rate interactions on livestock and vegetation production, we used a 2-factor Analysis of Variance (ANOVA). To further investigate the influence of stocking rate and grazing system, we classified years as average if precipitation during April-June was within the mean ± 1 standard deviation (SD) of the study period, dry if less than the mean minus 1SD, and wet if greater than the mean plus 1SD. Relationships between livestock and vegetation production and April, May, and June monthly precipitation, and all possible combinations of these months, were fit with linear, power and hyperbolic functions.

RESULTS

Grazing system and stocking rate, but not their interaction, affected average daily gain (ADG). Gains were reduced by 6% with short-duration rotation compared to season-long grazing over the study period, with differences between systems observed in years with average, but not dry or wet, spring precipitation (Figure 1). Heavy stocking rates consistently reduced ADG by 10-16% compared to moderate stocking across all years and for each spring precipitation classification.

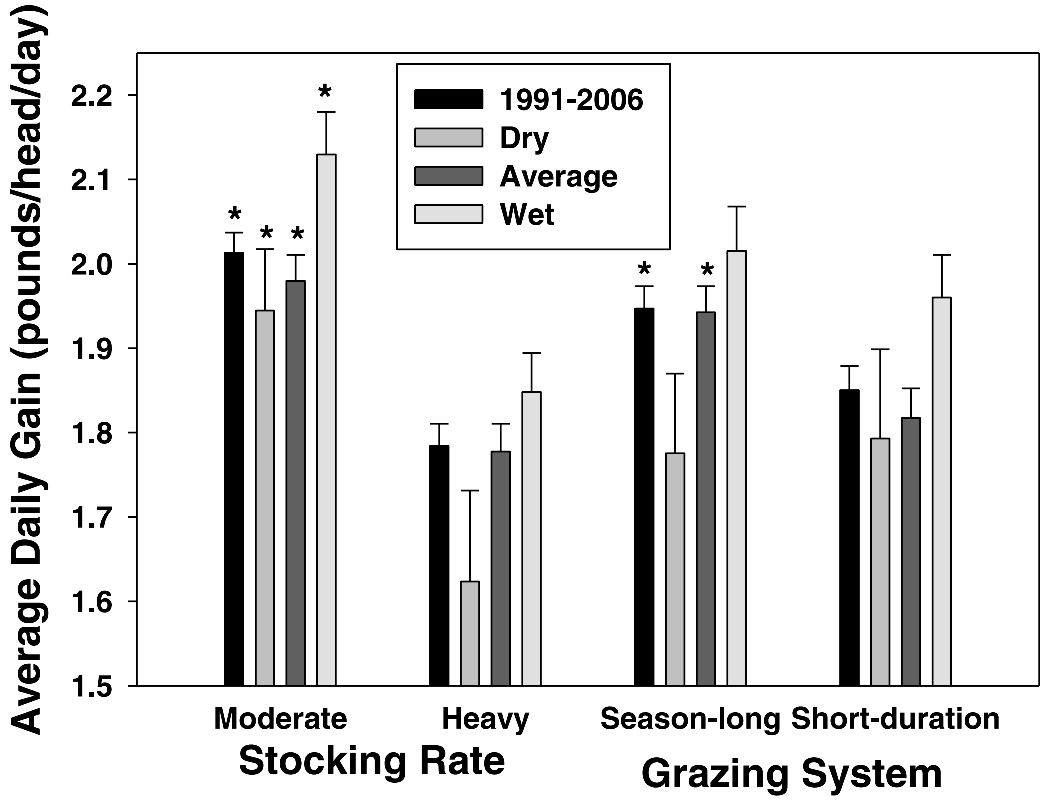

Figure 1. Average daily gains (pounds/head/day, mean±1standard error) for moderate and heavy stocking rates across season-long (mid- June to mid-October) and short-duration rotational grazing, and for season-long and short-duration rotational grazing across stocking rates on northern mixed-grass prairie at the USDA-Agricultural Research Service, High Plains Grasslands Research Station, near Cheyenne, WY, USA, for the 1991-2006 study years, and for dry, average and wet springs during this period. Asterisks indicate significant ($p<0.05$) differences between stocking rates, and between grazing systems for each classification (modified from Derner et al. 2008).

Grazing system and stocking rate did not interact to influence vegetation production across all years, or dry, average or wet springs (Figure 2). Neither stocking rate nor grazing system affected vegetation production either for all years, or dry, average and wet springs.

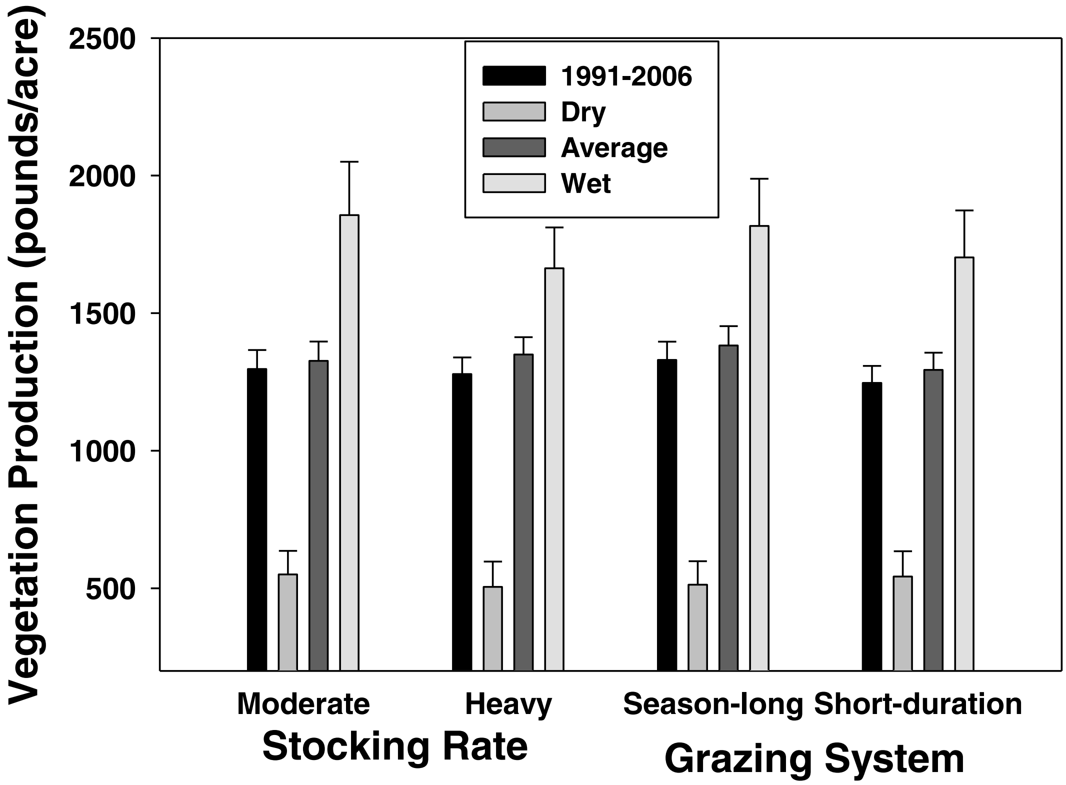

Figure 2. Vegetation production (pounds/acre, mean±1standard error) for moderate and heavy stocking rates across season-long (mid- June to mid-October) and short-duration rotational grazing, and for season-long and short-duration rotational grazing across stocking rates on northern mixed-grass prairie at the USDA-Agricultural Research Service, High Plains Grasslands Research Station, near Cheyenne, WY, USA, for the 1991-2006 study years, and for dry, average and wet springs during this period. Asterisks indicate significant ($p<0.05$) differences between stocking rates, and between grazing systems for each classification (modified from Derner and Hart 2007).

Beef production exhibited significant hyperbolic relationships with spring precipitation. Beef production increased with increasing spring precipitation for all stocking rate X grazing system combinations, with a substantial percentage of variation (68-83%) explained by spring precipitation (Figure 3).

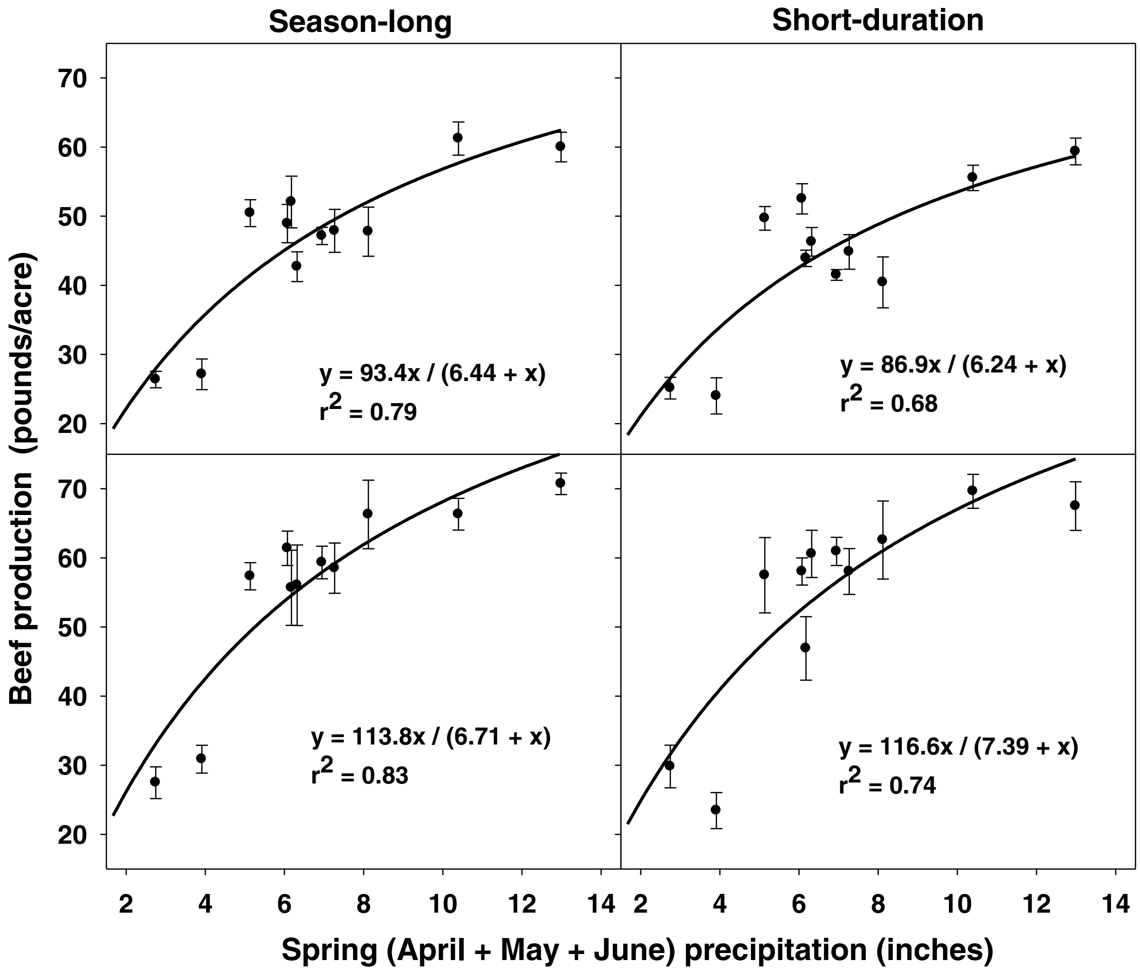

Figure 3. Hyperbolic relationships between beef production (pounds/acre, mean±1 standard error) and spring (April+May+June) precipitation (inches) for season-long and short-duration rotational grazing at moderate (top panels) and heavy (bottom panels) stocking rates on northern mixed-grass prairie at the USDA-Agricultural Research Service, High Plains Grasslands Research Station near Cheyenne, WY, USA for the 1991-2006 study years (modified from Derner et al. 2008).

Similarly, vegetation production exhibited significant hyperbolic relationships with spring precipitation. Vegetation production increased with increasing spring precipitation for all stocking rate X grazing system combinations, with a substantial percentage of variation (54-67%) explained by spring precipitation (see Derner and Hart 2007).

CONCLUSIONS

1) Long-term (1982-2006) grazing treatments of stocking rate and grazing system, but not their interaction, influenced livestock gain responses over the final sixteen years (1991-2006) of this study in northern mixed-grass prairie of the North American Great Plains; livestock gains were more responsive to stocking rate than to grazing system.

2) Livestock grazing did not induce modifications to vegetation production in this northern mixed-grass prairie through either stocking rate or grazing system.

3) Livestock gains and vegetation production exhibited hyperbolic increases with increasing amounts of spring (April-June) precipitation.

4) Rotational grazing is a viable management strategy for rangelands, but it is not superior to season-long grazing (Briske et al. 2008).

5) Relationships between spring precipitation and livestock gains and vegetation production can be used to extend the utility of existing plant-animal models. These relationships can be incorporated into current system models assessing production risks for land managers in these ecosystems with erratic precipitation (Andales et al. 2006). For example, combining predictions of forage production with expected livestock performance can provide land managers a viable tool to assist in enterprise decision-making.

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