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Vegetation response to seven grazing treatments in the Northern Great Plains

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Abstract

Grazing systems may alter botanical composition and productivity of grasslands through differential use in time, space, or intensity. Seven simulated grazing treatments were applied six years in eastern Montana, USA to determine effects on plant community composition and standing crop. Treatments were moderate stocking (28.8 AUD ha^{-1} $year^{-1}$) of cattle using 3-pasture summer rotation, season-long, high-intensity low-frequency, short-duration, 3-pasture winter rotation, and spring calving systems. The final treatment was severe growing-season grazing (108.2 AUD ha^{-1} $year^{-1}$). Treatments were randomly assigned to 14, 6.1-ha pastures. Post-treatment grass and total standing crops were 54 and 58% of their pre-treatment measures because of extended drought. No single grazing system affected standing crop of any herbage component. Standing crops of *Pascopyrum smithii* Rydb. (Love) (674 ± 186 kg ha^{-1}; $P > 0.69$), other perennial C_3 grasses (102 ± 156 kg ha^{-1}; $P > 0.77$), perennial C_4 grasses (178 ± 111 kg ha^{-1}; $P > 0.22$), and shrubs (13 ± 34 kg ha^{-1}; $P > 0.57$) were similar across grazing treatments. Severe grazing produced more forbs (142 ± 16 kg ha^{-1}; $P < 0.01$) than moderate stocking (67 ± 16 kg ha^{-1}). Annual C_3 grasses increased ($P < 0.01$) from 131 ± 55 kg ha^{-1} on pastures grazed after May to 362 ± 55 kg ha^{-1} on pastures grazed before June. Cacti also increased ($P < 0.03$) from 47 to 187 ± 52 kg ha^{-1} on early-grazed pastures. Greater total standing crop on pastures grazed before June ($P < 0.03$) was accounted for by increases in annual C_3 grasses and cacti. Rotational and continuous grazing strategies produced similar effects on all vegetation components. Grazing systems were not effective in altering standing crop or functional group composition one year after six years of treatment. Standing crop changes over time and limited shifts in forbs, cacti, and annual C_3 grasses indicate northern mixed prairie is most responsive to weather, with stocking rate and timing of grazing contributing minor influences.
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Keywords: *Bromus*; Grassland; Rotational grazing; Mixed prairie; Rangeland; Standing crop; Stocking rate

1. Introduction

Plant species composition and associated biomass of natural plant communities are controlled by a multitude of factors of which climate, soils, and herbivory are primary. Among these, herbivory is the single factor that management controls directly on grasslands. This control is achieved by managing forage demand through the manipulation of number and kind of animals over both time and space (Heitschmidt and Taylor, 1991). Number of animals is most often considered to be the primary factor because it is highly correlated with the frequency and severity of individual plant defoliation (Heitschmidt and Walker, 1996). Grazing systems, on the other hand, are strategically designed to control time of grazing (Vallentine, 1990).

Individual grazing systems are often promoted as a cure for perceived grassland management problems. However, studies of grazing systems over long periods are limited and those directly comparing more than a few grazing systems at a time are quite limited (Hart et al., 1988; Manley et al., 1997).

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Among the grazing systems most commonly compared are year-long or growing-season-long continuous grazing, high-intensity low-frequency grazing, short-duration grazing, and various deferred-rotation systems. Previous research comparing two or three of these systems at similar stocking rates has generally shown that all grazing systems impact herbaceous standing crop and species composition in a similar manner (e.g., Hart et al., 1988; Thurow et al., 1988; Manley et al., 1997; Gillen et al., 1998) although some exceptions have been documented (Owensby et al., 1973; Taylor et al., 1993).

A fifth type of grazing commonly employed is repeated seasonal use, in which the same pasture is grazed annually at the same time of the year. Such use is often applied in conjunction with calving or lambing events. Although repeated seasonal use is often done to simplify animal management, such use may be expected to alter productivity and species composition because of seasonal differences in plant response to herbivory and subsequent effects on competitive plant interactions (Briske and Richards, 1994; Pieper, 1994). This is particularly so if use is severe, which is often the case.

Verifying the effectiveness of management strategies is crucial in achieving objectives and improving grassland resources. Although excellent reviews of grazing systems have been conducted (Vallentine, 1990), few have been able to directly compare a large number of grazing systems applied concurrently at the same stocking rate and on the same site. Grazing systems selected for study represented a continuum of high-utilization grazing and high-performance grazing tactics commonly applied, ranging from a multi-pasture, 1-herd, high-intensity, low-frequency grazing system (high-utilization tactics, HUG) to a 1-pasture, 1-herd continuous grazing system (high-performance tactics, HPG) (Booysen and Tainton, 1978). The primary objective of this study was to determine the impacts of six different grazing treatments, all stocked at the same moderate rate, on standing crop and functional group composition of a northern mixed prairie. Additional objectives were to contrast the impacts of severe grazing intensity and moderate stocking, and to assess the effects of season of grazing and pasture rotation on these grasslands to determine whether key general grazing management strategies could be identified across grazing systems. A very high stocking rate treatment was also included in the study to evaluate the stability of these grasslands as discussed by Archer and Smeins (1991). Perennial C_3 grasses dominate the region and are generally less tolerant of herbivory than the most common perennial C_4 grasses. Therefore, greatest potential for and magnitude of grazing effects are likely to exist within the perennial C_3 grasses. Our fundamental hypotheses were: (1) high-utilization systems would tend to impact plant biomass and functional group composition to a greater extent than high-performance systems; and (2) severe stocking would reduce herbaceous standing crop through the reduction of perennial C_3 grasses and exceed the effects of grazing system.

2. Materials and methods

2.1. Study area

Research was conducted in southeastern Montana, USA at the Fort Keogh Livestock and Range Research Laboratory, near Miles City (latitude 46°22′N, longitude 105°5′W, elev. 720 m). The region consists of rolling hills and broken badlands with broad river valleys. Vegetation is northern mixed prairie of the grama–needlegrass–wheatgrass potential vegetation type (Küchler, 1964). Long-term (1937–2004) mean annual precipitation is 340 mm, with about 65% occurring as rain during the mid-April to mid-September growing season (Western Regional Climate Center, 2004). Mean monthly temperatures range from −14 °C in January to 32 °C in July. Daily temperatures can exceed 38 °C during summer and be colder than −40 °C in winter.

Treatments were imposed across a contiguous 85-ha area with level to gently sloping (<2%) topography. Soils on the site were dominated by Sonnett loams (FOA: Calcic Luvisols; USDA: fine, smectitic, frigid Aridic Haplustalfs) and included a complex of Kobase silty clay loams (fine, smectitic, frigid Torrertic Haplustepts) and Gerdrum clay loams (fine, smectitic, frigid Torrertic Natrustalfs) on about 15% of the area. All soils were deep, well-drained, and formed from alluvium. The study site was used in the early 1980s as part of a rangeland improvement study. Original treatments were established in 1982 and consisted of: (1) soil tilling with a Range Improvement Machine (RIM); (2) drill seeding of alfalfa (*Medicago sativa* L.) after RIM tilling; (3) aerial seeding of alfalfa after RIM tilling; (4) contour furrowing; (5) nitrogen fertilization; and (6) mechanical brush shredding. Studies of the effects of these treatments on herbage standing crop and plant species composition between 1983 and 1990 revealed no treatment effects (Haferkamp et al., 1993).

During the eight years of this study (1996–2003), perennial grasses dominated the study pastures, with the most abundant being western wheatgrass (*Pascopyrum smithii* Rydb. [Love]) and blue grama (*Bouteloua gracilis* [H.B.K.] Lag. ex Griffiths). Sub-dominant perennial grasses were needle-and-thread (*Hesperostipa comata* [Trin. & Rupr.] Barkworth) and buffalograss (*Buchloe dactyloides* [Nutt.] Engelm.). The dominant annual grass was Japanese brome (*Bromus japonicus* Thunb.) with sub-dominants of cheatgrass (*Bromus tectorum* L.) and six-weeks fescue (*Vulpia octoflora* [Walt.] Rydb.). Needleleaf sedge (*Carex duriuscula* C.A. Mey.) and threadleaf sedge (*Carex filifolia* Nutt.) were the most abundant grass-like plants, but neither were large contributors to standing crop. Western salsify (*Tragopogon dubius* Scop.), dandelion (*Taraxacum officinale* Webber), and scarlet globemallow (*Sphaeralcea coccinea* [Pursh.] Rydb.) were the most common forbs, but all forbs combined were generally less than 6% of the herbaceous species composition by weight. The primary