Effect of stock density on ground cover on a southwest Montana foothills rangeland
by John Jesse Hansen

A Thesis submitted in partial fulfillment of Master of Science in Range Science
Montana State University

Abstract:
Stock density was a factor in the grazing process under which many of our native grasslands evolved. As such, stock density is worthy of investigation. Stock density has been little researched until recently and information concerning this factor is limited.

In 1986 a study was initiated at MSU's Red Bluff Research Ranch in southwest Montana to investigate the effect of stock density on ground cover of a native foothills grassland. Three levels of stock density were utilized: 0, 37, and 74 cow-calf pairs/ha, at two periods in the grazing season, spring and mid-summer. Grazing time per replicate pasture was 24 hours.

Cover responses of total dense clubmoss, live dense clubmoss, and bare ground, as estimated by line intercept, did not change significantly in response to the treatments. Lack of change in these cover classes may be attributed to insufficient time for animal-site interaction.

Cover of other vegetation and litter changed significantly in response to grazing but not in response to stock density. Dung cover yielded a significant change for the mid-summer, 74 cow-calf pairs/ha treatment. This change in dung cover was attributed to random dung deposition.

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APPROVAL

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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TABLE OF CONTENTS

TABLE OF CONTENTS-Continued

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES-Continued

ABSTRACT

Stock density was a factor in the grazing process under which many of our native grasslands evolved. As such, stock density is worthy of investigation. Stock density has been little researched until recently and information concerning this factor is limited.

In 1986 a study was initiated at MSU's Red Bluff Research Ranch in southwest Montana to investigate the effect of stock density on ground cover of a native foothills grassland. Three levels of stock density were utilized: 0, 37, and 74 cow-calf pairs/ha, at two periods in the grazing season, spring and mid-summer. Grazing time per replicate pasture was 24 hours.

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INTRODUCTION

Grasslands of the northern Great Plains and mountain foothills evolved under herbivory from large ungulates and other herbivores. Through this coevolution, plants present on these grasslands evolved adaptive traits and processes in response to the type of herbivory present (Coughenour, 1985). Historically, the large herbivores had been the American bison (Bison bison), pronghorn antelope (Antilocapra americana), wapiti (Cervus elaphus), mule deer (Odocoileus hemionus), and to a limited extent, bighorn sheep (Ovis canadensis). Due to European man's influence in North America, these native herbivores have decreased in number and have been replaced by domestic livestock including cattle (Bos taurus), sheep (Ovis orientalis), horses (Equus caballus), and goats (Capra aegagrus).

The bison was the major large herbivore present in very large numbers on the grasslands between the Appalachian and Rocky Mountains. Early descriptions of bison grazing behavior were made by explorers and travelers during the 1800's (Koch in Brown and Felton, 1955; Lewis and Clark, 1806; and Reighard in Sellers, 1982). Descriptions by these observers indicate that bison were present on the northern Great Plains in large numbers and tended to herd in small, closely associated groups of about 100 individuals. Large animal numbers per unit area (stock density) during grazing activity is a trait common among large, wild ungulates (McNaughton, 1984). The high stock density present under natural grazing was a factor present during coevolution of grasslands and herbivores and formation of many of the native grasslands.

It may be assumed that the native wildlife impacted the ecosystem with three basic mechanisms: 1. herbivory, 2. physical activity, and 3. deposition of feces and urine. Interaction and timing of these mechanisms were part of the processes responsible for formation and maintenance of the grasslands of western North America.

Following the introduction of domestic livestock, importance of native large herbivores in the grassland ecosystems declined. The grasslands necessarily changed to reflect the changes in herbivores and their different interactions with plants. Plant communities apparently changed in terms of species dominance. Plant species formerly relegated to secondary roles became dominant.

Observations of plant species composition changes lead to initiation of grazing research and consideration of grazing management as a tool in agriculture. Early studies considered grazing methodology with deferment and rest as primary treatments and the concept of stocking rate as a factor in plant community responses (Smith, 1895). Many studies have dealt with the influence of stocking rate on vegetation (Sarvis, 1941; Clarke et al., 1943; Lewis et al., 1956; and Houston and Woodward, 1966). Influence of stocking rate on animal performance has also received much attention (Woolfolk and Knapp, 1949; Cook et al., 1953; Lewis et al., 1956; Cook et al., 1962; Houston and Woodward, 1966; and Houston and Urick, 1972). Grazing methodology has also received a considerable amount of research and speculative attention (Anderson, 1797 in Johnstone-Wallace and Kennedy, 1944; Smith, 1895; Heady, 1961; Hormay and Talbot, 1961; and Shiflet and Heady, 1971).

Despite all the research on plant and animal responses to grazing and grazing management, one variable that has been little considered or investigated is stock density. Increased use of short duration grazing methods and their resultant higher stock densities has caused stock density to receive more attention as a factor in grassland response to grazing (Kothmann, 1984). But only four studies (Walker and Heitschmidt, 1986; Warren et al., 1986; Heitschmidt et al., 1987; and Pierson and Scarnecchia, 1987) were encountered in the literature to date that consider stock density as the research variable when investigating grazing response of North American grasslands.

Stock density is a unique variable in that it is not described by any other defined variable, and as such lends itself to investigation. As a factor in the evolution of some of our native grasslands, it is worthy of investigation. It may be an important factor when considering the response of native grasslands to grazing domestic livestock.

To better understand effects of stock density on native grasslands, a study was initiated in 1986 to investigate the effect of stock density on ground cover on a mountain foothills grassland. The study site was located in an area containing plant species which had coevolved with large herbivores. The study was sponsored by the Montana State University Animal and Range Sciences Department and the Montana Agricultural Experiment Station.

The purpose of this study was to investigate stock density as a factor in grazing influences of domestic livestock on a native grassland. Objectives of the study were to investigate the effect of stock density on ground cover and how specific animal impact mechanisms influence ground cover.

LITERATURE REVIEW

Historical Grazing Characteristics

In much of Montana the bison was the major large herbivore prior to settlement by European man. By better understanding the nature of the herbivory of these animals we may gain a better understanding of the response of present rangelands to herbivory by domestic livestock.

The bison is the native large herbivore that most resembles domestic cattle both in size and forage preference and so deserves much of the attention in this review. Records and observations of early bison numbers and behavior are not as plentiful as would be desired. Most of the observations are by trappers, hunters, travelers, and explorers.

An early traveler, Peter Koch (in Brown and Felton, 1955), related the following account:

> "In March 1870, I traveled from Muscleshell to Fort Browning on Milk River, and for a distance of forty miles I do not think we were out of easy rifle shot of buffalo. . . we could see many miles on either side; but . . . the eye only met herd after herd of grazing and slowly moving buffalo. . . . Three days later I passed over the same trail on my return trip, and the vast herds had disappeared as if by magic. Only two or three old bulls were still wandering over the prairie."

Lewis and Clark (1806) encountered large numbers of bison during the exploration of the Missouri and Yellowstone Rivers. Nearly every daily journal entry described large herds of bison. Upon arriving at the Great Falls of the Missouri, they encountered large numbers of bison. In reading their journals it is apparent that these animals did not remain in an area for a great length of time. Approximately three weeks after their arrival at the Great Falls the herds had moved to another area, except for a few scattered individuals.

Large herds of bison generally associated themselves into numerous small herds with a resultant high stock density. George W. Reighard, an early buffalo hunter, gave the following account of his observations of bison in the Kansas City Star for November 30, 1930 (in Sellers, 1982):

> "I have read after many writers who described a herd as 'blackening the plains.' They never herded that closely together. A grazing herd, undisturbed, would be divided into small groups, each group close together, and there would be ordinarily, about twenty-five or thirty buffaloes to the acre. They drifted along, about as closely together as cattle cluster when grazing loosely on the range. But looking at a buffalo herd from a knoll or hill, it seemed to be almost a solid mass, with the green sod showing only here and there, between groups."

The roaming and herding behavior of bison is supported by recent observations of bison grazing behavior. Norland (1984) investigated bison distribution and habitat use in Theodore Roosevelt National Park. His observations indicate that the bison in the park associated in small herds and changed grazing areas often.

From the previous descriptions of bison grazing behavior it is evident that high stock density was a variable in the natural grazing process on some grasslands. The influence and function of stock density, under conditions of free-ranging bison use, on development, maintainence, and productivity of the grasslands is unknown.

Stock Density

Stock density is defined by the Society of Range Management (1974) as "the relationship between number of animals and area of land at any instant of time". As a research variable, stock density has received little study. Literature pertaining to grazing studies is generally focused on stocking rate, seldom reporting stock density and often failing to supply sufficient information to derive stock density. Those studies not designed to investigate stock density, but with sufficient information to derive stock density, are complicated by variable stocking rate or grazing method. Recently several investigators have recognized stock density as a research variable in grazing trials. However, literature pertaining to this variable is scarce.

The following four articles are the only ones encountered that have stock density as the research variable. Three studies were done by splitting a paddock in an existing short duration grazing cell in Texas. The other study was conducted in central Washington on seeded pasture.

Walker and Heitschmidt (1986) reported an increase in cattle trail density with increased stock density on a Texas grassland. The grazing strategy utilized for this study was a short duration grazing system with stock densities of 4.2 and 12.5 AU/ha.

Warren et al. (1986) compared soil hydrologic response to three stock densities of 1.4, 2.0, and 3.0 AU/ha on a Texas grassland. They were unable to detect significant differences in sediment production and infiltration rate due to variable stock density.

Heitschmidt et al. (1987), in comparing stock densities of 4.2 and 12.5 AU/ha, noted greater total aboveground net primary productivity (ANPP) for the 12.5 AU/ha treatment as compared to the 4.2 AU/ha treatment over two years. ANPP for sideoats grama (Bouteloua curtipendula) was also greater for the 12.5 AU/ha treatment compared to the 4.2 AU/ha treatment over two years. During this study, the amount of litter did not show a response to stock density, nor did annual harvest efficiency. In addition, the authors suggested that grazing preference on their study site was not affected by stock density.

Pierson and Scarnecchia (1987) investigated defoliation of intermediate wheatgrass (Agropyron intermedium) with stock densities of 2.6 and 5.2 AU/ha on a seeded pasture in central Washington. Stocking rate was similar for each treatment. Their results indicate that standing crop was reduced 64% for the 2.6 AU/ha treatment compared to 58% for the 5.2 AU/ha. Mean tiller heights decreased linearly over time for both treatments with the rate of decrease greater for the 5.2 AU/ha treatment. This difference in tiller height decrease was attributed to unequal grazing pressures between treatments. There was no difference in percent of tillers defoliated between treatments.

The following studies are those in which stock density could be derived from the reported methodology. These studies generally included a stock density that was greater than that found in grazing systems other than high intensity grazing systems. It should be noted that results may be confounded by differing stocking rates associated with differing stock densities.

While investigating distance traveled by cattle, Walker et al. (1985) compared a continuous grazing method with stock density of 0.17 AU/ha to a short duration grazing system with stock densities of 4.2 and 12.5 AU/ha. They reported that cattle walked farther and travel distance was more variable under the short duration grazing strategy than the continuous grazing strategy.

Kirby et al. (1986) reported differences in forage disappearance on North Dakota rangeland that may have been partially due to stock density. They compared a repeated seasonlong grazing strategy with a stock density of 0.15 AU/ha to a short duration grazing strategy (SDG) with a stock density of 2.1 AU/ha. Graminoid disappearance was similar for both treatments, but forb disappearance was increased three-fold in the SDG treatment for 1982 and more than two-fold for 1983. Grazing distribution did not seem to differ between treatments. Interpretation of these results may be complicated by the difference in stocking rates; 0.67 AUM/ha and 1.2 AUM/ha for the season-long grazing and short duration grazing, respectively.

Koerth et al. (1983) were unable to detect differences in trampling of simulated ground nests when comparing continuous grazing with a stock density of 0.12 steers/ha and short duration grazing with a stock density of 1.2 steers/ha.

Livestock Impact Mechanisms

Domestic livestock influence range and pasture lands in three basic ways: 1. herbivory, 2. physical activity, and 3. deposition of feces and urine (Balph and Malecheck, 1985).

Domestic livestock trampling has been shown to increase soil compaction in the upper portions of the soil profile in some soils (Bryant et al., 1972) and to disrupt and break soil and cryptogamic crusts (Anderson et al., 1982 and Brotherson et al., 1983). Trampling also has been shown to increase the mortality rate in some plant species. Trampling assists the deposition of standing dead plant material onto the soil surface and thus contributes to litter cover (Heitschmidt et al., 1987; Savory in Balph and Malecheck, 1985; Bement, 1969; and Tomanek, 1969).

Herbivory by domestic livestock influences many aspects of the grassland ecosystem. Many studies have demonstrated the influence of herbivory on plant species composition (Sarvis, 1941; Clarke et al., 1943; and Houston and Woodward, 1966). Studies involving amount, frequency, and seasonal timing of herbage removal have demonstrated the effect of herbivory on plant vigor and productivity (Weaver, 1950; Albertson et al., 1953; Lewis et al., 1956; Booysen et al., 1963; and Caldwell, 1984). Additional studies have shown the effect of herbivory on sward structure (Edwards and Hollis, 1982), soil moisture content (McCarty and Mazurak, 1976), surface water run-off (Hanson et al., 1970), and amount of soil erosion (Blackburn,1984).

Deposition of waste products in the form of feces and urine influences the concentration and redistribution of nutrients on range and pasture sites (Peterson et al., 1956a and b) and can influence pasture utilization patterns and sward structure (Edwards and Hollis, 1982). Deposition of feces and urine may also influence plant mortality and species composition, killing some species by urine burn (Marsh and Campling, 1970), transporting seed of plant species (Billings, 1978) and providing a suitable environment for germination and establishment of these seeds (Stoddart et al., 1975). Water quality of streams is influenced by feces and urine deposition by increasing coliform counts and suspended solids content of the stream (Kauffman and Krueger, 1984).

STUDY SITE

The study site was located on Montana State University's Red Bluff Research Ranch at Norris, in southwest Montana, T.3S R.1W E1/2,SW1/4, section 23 (Figure 1). This site is a mountain foothills grassland (Figure 2) with the dominant forage species being bluebunch wheatgrass (<u>Agropyron spicatum</u>), needleandthread (<u>Stipa comata</u>), prairie junegrass (<u>Koleria pyramidata</u>) and standing milkvetch (<u>Astragalus adsurgens</u>) (Table 1). The soil surface is well covered with vegetation and litter (Figure 3). Bare ground estimates ranged from <1% to 22%.

Table 1. Study site species composition (%) by weight estimated from 10 one meter square clipping plots.

Species	% Composition
Stipa comata	34.8
Agropyron spicatum	18.5
Astragalus adsurgens	20.0
Festuca idahoensis	6.0
Koeleria pyramidata	5.5
Agropyron smithii	T
Lupine spp.	T
Increaser grasses	1.9
Increaser forbs	12.8
Shrubs	T

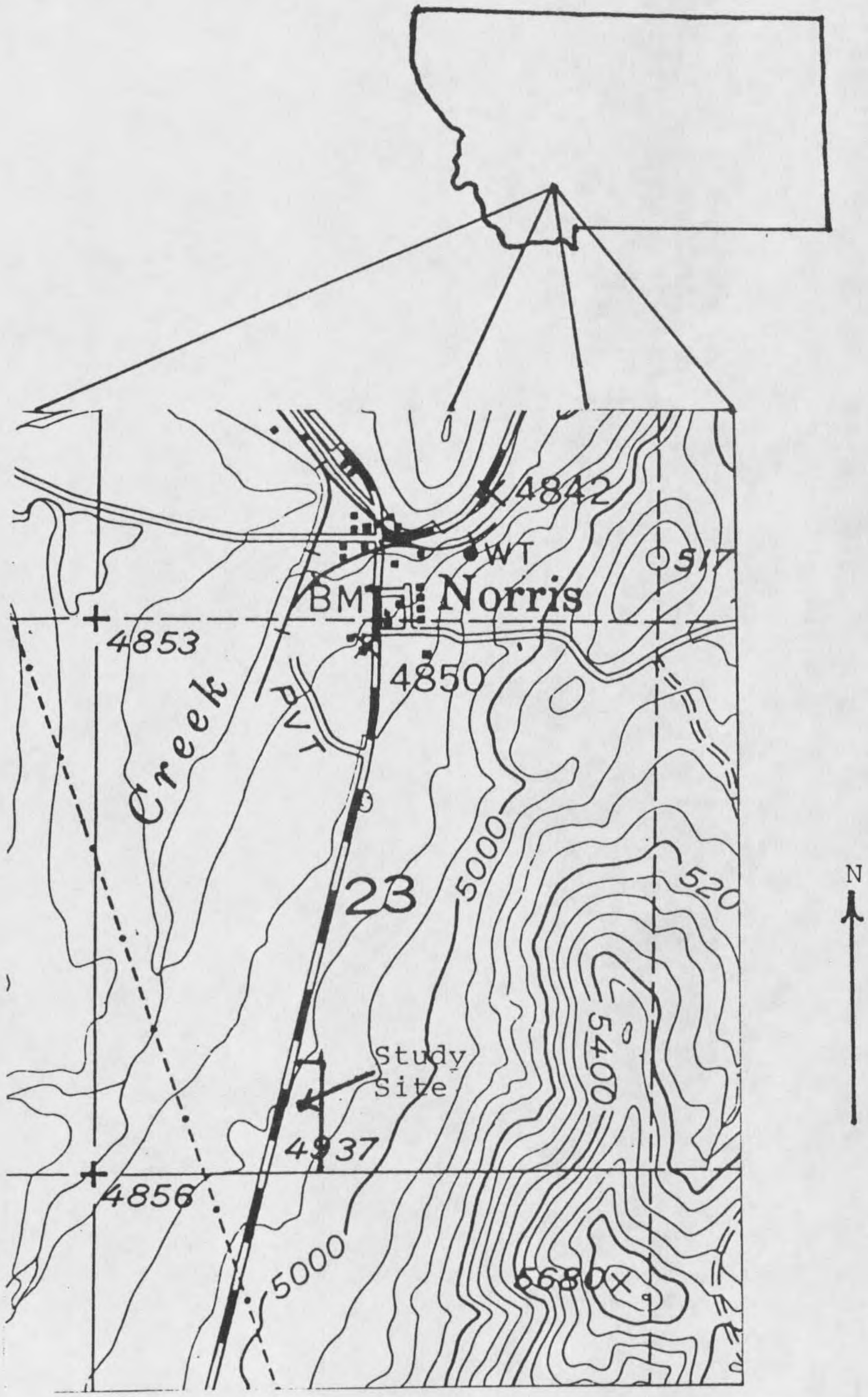

Figure 1. Map of study site location.