Winter range resources : forage quality and cattle selection of microclimates
by Gregory Alan Houseal

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Range Science
Montana State University

Abstract:
Low forage quality and extreme cold and wind can stress cattle grazing northern latitude winter range. These conditions may contribute to loss of weight, body condition, and reproductive potential. The effects of low forage quality may be minimized if an adequate amount of high quality fall growth is present on range land. Diverse topography may provide natural shelter allowing cattle to maintain grazing time and forage intake in moderate microclimates when general weather conditions are extreme.

Our first objective was to assess the potential of the forage quality of live and dead components of two co-dominant cool-season bunchgrasses to meet the nutritional requirements of cattle throughout the year. Our second objective was to determine if cattle select moderate microclimates while foraging to minimize cold stress when environmental conditions are severe.

The study site was the Montana Agricultural Experiment Station Red Bluff Research Ranch (latitude 45°35'N, longitude 111°39'W) near Norris, Montana. Forage quality was assessed by determining crude protein (CP), acid detergent insoluble nitrogen (ADIN), neutral detergent fiber (NDF), and acid detergent fiber (ADF) contents of live and dead components of bluebunch wheatgrass (Pseudoroegneria spicata [Pursh] Scribn and Smith) and Idaho fescue (Festuca idahoensis (Elmer) sampled bi-monthly from October 1991 to April 1993. In addition, dry matter (DM) rate and extent of disappearance and CP extent of disappearance were determined in-situ using four mature ruminally cannulated beef cows.

Microclimates were quantified by measuring ambient temperature (Ta), black globe temperature (T), and wind speed (μ) at 12 fixed points placed along topographic gradients and at the concurrent location of pregnant range cattle grazing the pasture. Cow location was classified as protected (draw), moderately protected (lower slopes), and exposed (bench, upper slopes and ridgetops) relative to topography, prevailing wind direction, and reference climate.

Bluebunch wheatgrass and Idaho fescue were similar in chemical composition within forage type throughout the year. There were differences between species and stage of maturity ($P< 0.05$) in disappearance rates and extents. Fall growth was nearly equal in quality and digestibility to April growth, and maintained this quality throughout winter. Standing dead material was below NRC CP requirements (6 to 8%) year-round.

Cattle selected moderate microclimates for grazing and resting to avoid • high winds and cold temperatures. They tended to remain in microclimates above the assumed lower critical temperature (LCT) of -23°C, even though reference conditions often were below LCT. The availability of moderate microclimates may allow cows to continue grazing, thus maintaining forage intake, even when general conditions might otherwise cause them to defer grazing.

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Date

Chairperson, Graduate Committee

Approved for the Major Department

9/21/93
Date

Head, Major Department

Approved for the College of Graduate Studies

9/28/93
Date

Graduate Dean

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ABSTRACT

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Our first objective was to assess the potential of the forage quality of live and dead components of two co-dominant cool-season bunchgrasses to meet the nutritional requirements of cattle throughout the year. Our second objective was to determine if cattle select moderate microclimates while foraging to minimize cold stress when environmental conditions are severe.

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Bluebunch wheatgrass and Idaho fescue were similar in chemical composition within forage type throughout the year. There were differences between species and stage of maturity ($P < 0.05$) in disappearance rates and extents. Fall growth was nearly equal in quality and digestibility to April growth, and maintained this quality throughout winter. Standing dead material was below NRC CP requirements (6 to 8%) year-round.

Cattle selected moderate microclimates for grazing and resting to avoid high winds and cold temperatures. They tended to remain in microclimates above the assumed lower critical temperature (LCT) of -23°C, even though reference conditions often were below LCT. The availability of moderate microclimates may allow cows to continue grazing, thus maintaining forage intake, even when general conditions might otherwise cause them to defer grazing.

CHAPTER 1

INTRODUCTION

Wintering cattle in northern latitudes is the most costly aspect for livestock producers. Producing and feeding hay requires high inputs of time, labor, and capital. Grazing native range in winter, where possible, may help to reduce these costs. The major challenges to winter grazing in range livestock production systems in the northern latitudes are the generally low quality of forages and environmental stressors such as snow, cold temperatures, and wind.

For cattle, maintaining body condition through winter is difficult. The goal of management is to have a range cow in moderate to good condition at the beginning of winter and to try to either maintain that condition or minimize loss of condition so that calving is successful and rebreeding can occur without delay. The low quality of forage in general does not mature pregnant beef cow requirements. Energy and protein supplements are often fed to compensate for these deficiencies. Managing for adequate forage reserves on winter pastures would reduce the need for hay, except when snow cover limits forage availability. In years when fall growth is available in quantity, it could provide a source of high protein forage and may minimize the need for additional protein supplements.

Extreme cold and wind may further stress animals. Reduced grazing time and forage intake have been correlated with extreme cold, which may lead to loss of condition. Shelter, either natural or manmade, can minimize the effects of these enviromental stressors. In the open grasslands of the west, topography influences and creates microclimates over the landscape. Grazing animals may take advantage of these features to avoid extreme wind and cold.

There were two main objectives of this study. Our first objective was to assess the potential forage quality of the live and dead components of two co-dominant cool-season bunchgrasses to meet the nutritional requirements of cattle throughout the year. Our second objective was to determine if cows select moderate microclimates while foraging to minimize cold stress when environmental conditions are severe.

CHAPTER 2

NUTRITIONAL VALUE OF LIVE AND DEAD COMPONENTS OF TWO BUNCHGRASS SPECIES

Introduction

Matching forage quantity and quality with demands of the grazing animal is a major challenge in rangeland production systems. Intake of metabolizable energy is potentially limiting in the early growing season, and intake of crude protein is potentially limiting during the dormant season (Senft et. al. 1987). In northern latitudes, severe winter weather can stress livestock (Webster 1970a, Christopherson et. al. 1979, Young 1985) grazing native range at a time when overall forage quality is low (Dragt 1985, Prescott 1990). Energy or protein supplements are fed to compensate for low forage quality, but at great cost, and with variable responses (Rittenhouse et. al. 1970, Kartchner 1981, Beverlin 1988, Sowell et. al. 1992). Potentially, fall growth when present in adequate amounts could provide an important source of high quality forage for winter grazing and thus minimize or even eliminate the need for additional protein supplements in some years.

The documented low quality of mature grasses in northern latitudes during winter is often based on analyses of the entire plant. Although herbivores are able to select diets higher in quality than can be mimicked by hand clipping (Hardison 1954, Van Dyne 1965, Hart 1983, Karn and Hoffman 1989), in part by avoiding stemmy growth (Ganskopp 1992), the live and dead components of native bunchgrasses are seldom considered separately. Generally, the quality of native cool-season bunchgrasses declines as living material senesces; this material then becomes part of the dead component of the plant (McCall 1939, Stoddart 1945, Blaisdell 1952, Daer and Willard 1981). The quality of over-wintering standing dead continues to decline as a result of weathering processes (Blaisdell 1952). Uresk and Cline (1976) found higher mineral concentrations in live tissue compared with standing dead in bluebunch wheatgrass during seed development. Total nonstructural carbohydrate concentrations of bluebunch wheatgrass increase from summer dormancy through fall until the onset of winter, but concentrations in fall growth were not as high as those in spring growth (Daer and Willard 1981).

Cool-season species have the ability to initiate growth in spring and fall when conditions are favorable. During wet autumns, several researchers have noted the presence of new growth in bluebunch wheatgrass (Pseudoroegneria spicata[Pursh] Scribn. and Smith) (Blaisdell 1952, Quinton and McLean 1982) and Idaho fescue (Festuca idahoensis(Elmer) (McCall 1939). This growth, when present, may be as nutritious and palatable as new spring growth.

We determined the chemical composition and in situ digestibility of live and dead components of bluebunch wheatgrass and Idaho fescue. Our objective was to assess the ability of these forage components to meet animal requirements throughout the year.

Methods

Study Site

The study site was a 150 hectare pasture on the Montana Agricultural Experiment Station Red Bluff Research Ranch (latitude 45°35', longitude 111°39') near Norris, Montana. The pasture has sandy and silty range sites typical of the foothills of southwestern Montana. Elevation ranges from approximately 1470-1740 m, with predominately southwest facing slopes. The prevailing southerly winds tend to blow the slopes free of snow during winter.

The pasture is dominated by a Festuca idahoensis/ Agropyron spicatum (currently classified as Pseudoroegneria spicata) habitat type with a Rhus trilobata/Festuca idahoensis habitat type limited to the lower southwest slopes of the major draws (Mueggler and Stewart 1980). Dominate forages of the pasture include bluebunch wheatgrass (Pseudoroegneria spicata), Idaho fescue (Festuca idahoensis), needle-and-thread grass (Stipa comata), and basin wildrye (Elymus cinereus). Scattered Rocky Mountain juniper (Juniperus scopulorum) occur on the lower slopes and limber pine (Pinus flexilus) occurs on the higher slopes. Annual precipitation averages 300 mm. Soils are Typic Argiborolls, sand and silt loams.

Field Sampling

Individual bunchgrasses of each species were clipped bi-monthly from mid-

October 1991 to mid-April 1993 one week prior to in situ trials. Plants were clipped approximately 2 cm above soil surface which represents the portion of the plant readily available to ungulates. These samples were separated into live and dead material based on color, and allowed to air-dry.

In situ Trials

The rate and extent of forage disappearance of the live, when present, and dead components were measured in situ using 4 mature, ruminally cannulated beef cows grazing the study pasture. Live and dead forage samples were separately ground through a Wiley Mill using a 2mm screen. For the in situ trials, 3 g samples of prepared material were placed in 15 x 20 cm bags made of 40 um mesh monofilament nylon. Only 2.5 g of Idaho fescue fall growth and spring growth were used in February and April 1993, respectively, because of limited availability. Ten bags of each forage type were placed in a mesh bag and suspended in the rumen of each cow. Animals were then allowed to forage on the study pasture. After intervals of 8, 24, 48, 72, and 96 hours, duplicate bags of each forage type were removed from each animal.

All bags were rinsed by hand with cold water until rinse water squeezed out of the bag was clear, then dried in a forced-air oven 48 hrs at 60 ^{O}C, and weighed. Bag residues from disappearance trials were analyzed for total Kjeldahl nitrogen (AOAC 1980) to determine extent of CP disappearance.

The dry matter (DM), crude protein (CP) (AOAC 1980), neutral detergent fiber (NDF), and acid detergent insoluble nitrogen (ADIN) (VanSoest and

Robertson 1980) contents of original samples for each forage type were determined and used as measures of forage quality.

Rate Calculation and Analysis

Mertens and Loften's (1980) model was used to estimate in situ rate of dry matter (DM) disappearance:

$$R = D_o e^{-k(t-L)} + U, \text{ when } t > L; \qquad (1)$$

and

$$R = D_o + U, \text{ when } 0 < t < L \qquad (2)$$

where R = percentage of DM remaining at time = t, D_o = potentially digested DM fraction, k = disappearance rate constant, t = time of incubation, L = discrete lag time, and U = indigestible DM fraction.

A non-linear least squares regression equation was used to estimate disappearance rate (Mertens and Loften 1980, Nocek and English 1986, SAS 1988). To obtain intitial estimates, the natural logarithm (ln) of the percentage of DM remaining was plotted as a function of incubation time.

Dry matter disappearance was adjusted for zero-hour disappearance (Nocek 1988). Duplicate nylon bags were prepared as above for each forage component and presoaked for 15 minutes in 39^{o}C water. Fall growth samples were composited within species. Bags were hand rinsed, oven dried, and weighed as above. The percent dry matter lost was calculated and subtracted from the dry matter disappearance values of the in situ trials.

Dry matter rates and DM and CP extents were analyzed using the general liner model of SAS (1988) least-square means procedure. The main effects of species and stage of maturity, and the interaction of species and stage were determined within periods. Differences were considered significant when $P<0.10$ (Gill 1981).

Live-to-Dead Ratio

Fifteen plants of each species were randomly clipped from north, east, and southwest aspects of the pasture. Plants were clipped bi-monthly from April 1992 through April 1993. These were sorted into live and dead components and oven dried for 48 hrs at $60^{O}C$. Each component of each plant was weighed separately and the percent live component of the total plant was calculated on a dry-weight basis. Means and standard errors were calculated for each species and plotted by period.

Results

Composition of Forage Components

The two species were similar in chemical composition within forage component type and period. In general, CP concentrations decreased in live material as it matured. Idaho fescue retained live leaves through October and into winter. Thus its live component retained higher CP and lower ADIN in August and October than bluebunch wheatgrass (Table 1). Spring growth CP levels averaged above 20% for bluebunch wheatgrass and above 18% for Idaho fescue (Table 1).

Table 1. Percent crude protein (CP) of forage components.

	P. spicata			*F. idahoensis*		
Period	dead	live	fall	dead	live	fall
10/91	3.2	4.2	-	-	-	-
12/91	3.1	2.6[a]	-	-	-	-
02/92	2.8	-	-	2.6	-	-
04/92	2.4	20.7	-	4.0	18.3	-
06/92	2.2	8.3	-	4.1	6.3	-
08/92	3.1	4.7	-	2.7	8.0	-
10/92	2.2	4.5	26.2	1.4	8.8	17.1
12/92	2.6	-	20.8	2.6	-	14.1
02/93	2.6	-	20.8	2.6	-	16.3
04/93	2.4	25.2	-	2.0	21.3	-

[a] This material was not truely live material, but current year's standing dead.
- Forage component not sampled

The composition of fall growth was similar to spring growth throughout winter. Fall growth CP levels remained high through winter ranging from 20.8 to 26.2% for bluebunch wheatgrass and 14.1 to 17.1% for Idaho fescue (Table 1). Crude protein of the standing dead of both species averaged 2.7% and varied little during the study.

The NDF and ADF values tended to increase in live material from April to June, and then drop slightly in August and again in October (Tables 2 and 3). In June, most reproductive culms (high cell wall and lignin content) were still part of the live component of the forage. In August and October, more of these culms had senesced and became part of the dead component. The remaining live material was composed mostly of leaves and vegetative tillers, and thus had slightly less fiber content. The NDF and ADF content of fall growth were similar to levels in spring growth of both species. Standing dead NDF and ADF values were slightly lower on average for Idaho fescue than for bluebunch wheatgrass. Values were highest in October samples of dead components for both species. By October all culms were considered dead, increasing the fiber content of the dead component.

Acid detergent insoluble nitrogen increased in live material from spring through fall in bluebunch wheatgrass. There was an increase in ADIN from April to June in Idaho fescue, and a slight decrease through August and October, probably caused by the proportion of reproductive culms in live material as described previously. The ADIN content was higher in fall growth than in April

Table 2. Percent neutral detergent fiber (NDF) of forage components.

	P. spicata			*F. idahoensis*		
Period	dead	live	fall	dead	live	fall
10/91	76.2	70.7	-	-	-	-
12/91	78.2	78.2	-	-	-	-
02/92	79.7	-	-	72.1	-	-
04/92	78.2	56.8	-	76.8	54.2	-
06/92	80.8	73.8	-	76.7	69.8	-
08/92	74.8	68.8	-	76.8	63.6	-
10/92	82.4	67.8	57.5	83.0	62.9	57.7
12/92	79.4	-	52.0	76.9	-	50.7
02/93	77.6	-	55.0	76.0	-	51.5
04/93	75.8	54.0	-	80.0	56.7	-

- Forage component not sampled

Table 3. Percent acid detergent fiber (ADF) of forage components.

	P. spicata			*F. idahoensis*		
Period	dead	live	fall	dead	live	fall
10/91	54.1	44.5	-	-	-	-
12/91	54.8	50.3	-	-	-	-
02/92	53.8	-	-	46.3	-	-
04/92	52.8	25.7	-	50.2	26.6	-
06/92	57.7	42.1	-	52.6	40.7	-
08/92	53.1	41.6	-	50.6	39.8	-
10/92	57.2	45.7	23.3	52.9	36.8	29.1
12/92	52.8	-	22.0	47.6	-	25.9
02/93	50.8	-	20.8	48.8	-	24.5
04/93	51.1	22.3	-	49.2	24.9	-

- Forage component not sampled

growth (Table 4). Standing dead ADIN was lower for Idaho fescue than for bluebunch wheatgrass on average, but varied considerably across periods, and no trends were evident.

Table 4. Acid detergent insoluble nitrogen (ADIN) as a percent of total kjeldahl nitrogen.

	P. spicata			F. idahoensis		
Period	dead	live	fall	dead	live	fall
10/91	38.1	16.3	-	-	-	-
12/91	31.2	24.6	-	-	-	-
02/92	30.0	-	-	17.6	-	-
04/92	29.7	2.9	-	14.4	2.4	-
06/92	35.3	7.5	-	18.2	7.5	-
08/92	27.2	16.2	-	27.0	7.4	-
10/92	41.7	16.9	4.4	46.5	6.9	5.2
12/92	34.2	-	3.7	23.1	-	3.5
02/93	29.9	-	3.2	24.4	-	3.5
04/93	32.6	2.8	-	29.0	3.5	-

- Forage component not sampled

Rates and Extents

Generally DM rate constants were highest for April growth, and next highest for fall growth (Table 5). There was a main effect of stage of maturity ($P<0.05$) on DM rates during most periods (Table 6). Dry matter rate constants of live material tended to be higher than rates for dead components within sampling periods (Table 5). There were no differences between species except in October 1992 when rate constants were lower for Idaho fescue than for bluebunch