



Nutritional and developmental responses of three mountain bunchgrasses to summer cattle and winter elk grazing  
by William John Dragt

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

Elk-Livestock Studies in Montana was established to study elk-livestock interactions through cooperative research programs of various state and federal agencies. The objectives of Elk-Livestock Studies were: 1) to determine the influence of various cattle management practices on elk and their habitats, 2) to evaluate alternative management practices, and 3) to develop beneficial guidelines for dual use of the available resource. This research project fell within objective one, and its objectives were: 1) to quantify the effects of summer cattle grazing at various phenological stages on the winter nutritional values of three mountain bunchgrasses, and 2) to quantify the effects of winter elk grazing on the growth and development in the following spring of the same three species. Rough fescue (*Festuca scabrella*), Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Agropyron spicatum*) were the species studied. The study was conducted on the South Crow elk winter range in the Elkhorn Mountains of Montana.

For objective one a random experimental design of one factor with three levels and nine treatments was used. The grass species were the factor levels and the treatments consisted of the phenological stage when grazing had occurred plus an ungrazed stage. Winter chemical constituent values were the dependent variables. For objective two a randomized block design having one factor with three levels and two treatments in five blocks was used. Sites, species, grazing, and standing dead were the blocks, factor and two treatments, respectively. The dependent variables were plant height and phenological stage on six spring sampling dates.

None of the summer grazing treatments affected rough fescue or bluebunch wheatgrass winter nutritional values, and grazed plants were similar to ungrazed plants. Some phenological stages of summer grazing were reflected in Idaho fescue winter chemical constituent values, but no management significance could be attached to the differences. Winter grazing did not affect spring leaf lengths in rough fescue or bluebunch wheatgrass, and only occasionally affected Idaho fescue spring growth. The presence of standing dead in the spring resulted in longer Idaho fescue leaves in the next spring. Neither rough fescue nor bluebunch wheatgrass spring leaf lengths were affected by the presence of overwintering residual material. These results were discussed from the perspective of the winter physiological activity of each species of grass..

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June 18, 1985  
Date

Kuo J. J. Lin  
Chairperson, Graduate Committee

Approved for the Major Department

June 19, 1985  
Date

Arthur C. J. Lin  
Head, Major Department

Approved for the College of Graduate Studies

24 June 1985  
Date


W. S. Malone  
Graduate Dean

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## ABSTRACT

Elk-Livestock Studies in Montana was established to study elk-livestock interactions through cooperative research programs of various state and federal agencies. The objectives of Elk-Livestock Studies were: 1) to determine the influence of various cattle management practices on elk and their habitats, 2) to evaluate alternative management practices, and 3) to develop beneficial guidelines for dual use of the available resource. This research project fell within objective one, and its objectives were: 1) to quantify the effects of summer cattle grazing at various phenological stages on the winter nutritional values of three mountain bunchgrasses, and 2) to quantify the effects of winter elk grazing on the growth and development in the following spring of the same three species. Rough fescue (Festuca scabrella), Idaho fescue (Festuca idahoensis) and bluebunch wheatgrass (Agropyron spicatum) were the species studied. The study was conducted on the South Crow elk winter range in the Elkhorn Mountains of Montana.

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None of the summer grazing treatments affected rough fescue or bluebunch wheatgrass winter nutritional values, and grazed plants were similar to ungrazed plants. Some phenological stages of summer grazing were reflected in Idaho fescue winter chemical constituent values, but no management significance could be attached to the differences. Winter grazing did not affect spring leaf lengths in rough fescue or bluebunch wheatgrass, and only occasionally affected Idaho fescue spring growth. The presence of standing dead in the spring resulted in longer Idaho fescue leaves in the next spring. Neither rough fescue nor bluebunch wheatgrass spring leaf lengths were affected by the presence of overwintering residual material. These results were discussed from the perspective of the winter physiological activity of each species of grass.

## INTRODUCTION

Management and research groups have spent much effort investigating the various aspects and relationships of land, livestock and elk management. One current program is "Elk-Livestock Studies in Montana", an interagency effort to study elk-livestock interactions. "Elk-Livestock Studies" was initiated in 1982 to: 1) determine the influence of various cattle management practices on elk and their habitat, 2) to evaluate alternative management practices and 3) to develop beneficial guidelines for dual use of the available resource. In addition to Montana State University, the Intermountain Forest and Range Experiment Station in Missoula, MT, the Montana Department of Fish, Wildlife and Parks and the University of Montana are also involved in the program.

This project fell within the first objective of "Elk-Livestock Studies". Its objectives were: 1) to quantify the effects of summer cattle grazing at various phenological stages on the resulting winter nutritional values of three mountain bunchgrasses, and 2) to quantify the effects of elk winter grazing on growth and development of the same grasses in the following spring.

Two decisions were made which had important influences on the project. First, it was decided that this project would describe one annual cycle of growth and utilization from an individual plant perspective. As a result fieldwork was designed to minimize the impact of the project. Some effects of this decision were the use of line transects instead of cages and animals for defoliation

treatments. This approach resulted in reduced treatment control and sacrifice of experimental design integrity. Some treatment combinations were missing or had small sample sizes. The statistical analysis was less rigorous than could have been achieved from a more controlled experiment.

The other important decision was the selection of key species. Rough fescue (Festuca scabrella Torr.), Idaho fescue (Festuca idahoensis Elmer.) and bluebunch wheatgrass (Agropyron spicatum (Pursh) Scribn. and Smith) were chosen, because they are both important habitat components and major constituents of winter elk diets in Montana. Of the three species Idaho fescue was the most abundant and rough fescue the least. Sites with both rough fescue and bluebunch wheatgrass appeared to be ecotones between patches of rough fescue and the generally occurring bluebunch wheatgrass. Selection of these key species reduced the potential sampling sites from the entire available area to specific sites where all three species occurred.

## LITERATURE REVIEW

Elk diet selection studies from the mountainous regions of Montana are presented to support the choice of rough fescue, Idaho fescue and bluebunch wheatgrass as the studied species. Grass carbohydrate allocation strategies and growth responses to grazing are summarized. Phenological development, grazing responses and nutrient concentration patterns for rough fescue and bluebunch wheatgrass are presented. Only seasonal progression of nutrient concentrations are presented for Idaho fescue. The literature on bluebunch wheatgrass was much more extensive and complete than for either fescue.

ELK DIETS

Elk food habit studies in the Rocky Mountain region have been extensively reviewed by Kufeld (1973). From these studies it could be concluded that elk selected the greenest forage available. During the seasons of plant dormancy their diets were composed predominantly of graminoids. This general pattern has also been observed in Montana studies (table 1). Additionally, in Montana, a large proportion of the species selected were the dominant available bunchgrasses. In the Elkhorn Mountains of central Montana up to 62% of elk winter diets were composed of Idaho fescue, rough fescue and bluebunch wheatgrass, the most abundant and available bunchgrasses on the winter range (DeSimone et al. 1984). Other studies from Montana also reported that rough fescue, Idaho fescue and bluebunch wheatgrass were important elk winter diet components (table 1).

Table 1. Rough fescue (Fesc), Idaho fescue (Feid) and bluebunch wheatgrass (Agsp) in seasonal elk diets in Montana, selected studies.

SPECIES			SEASON	LOCATION	TECHNIQUE	CITATION
FESC	FEID	AGSP				
% OF DIET						
48	10	6	WINTER	ELKHORNS MT	MICROHISTOLOGICAL	DESIMONE ET AL. 1984
1	27	21	WINTER	ELKHORNS MT	FEEDING SITE EXAM	GORDON 1968
48	49	8	SPRING			
5	55	5	SPRING	ELKHORNS MT	FEEDING SITE EXAM	STEVENS 1965
39	24		APRIL	SUN RIVER MT	FEEDING SITE EXAM	KNIGHT 1961
1	6		MAY			
88% GRASS <sup>1</sup>	2	3	SPRING	LITTLE BELTS MT	FEEDING SITE EXAM	KIRSCH 1963
84% GRASS			WINTER		RUMEN ANALYSIS	
			SPRING			
100% GRASS-LIKE <sup>2</sup>			WINTER	NAT'L BISON RANGE MT	RUMEN ANALYSIS	MORRIS & SCHWARTZ 1957
100% GRASS-LIKE			SPRING			
4	3	48	WINTER	SUN RIVER MT	FEEDING SITE EXAM	CASAGRANDA & JANSON 1957
13	16	13	WINTER	SUN RIVER CANYON MT	FEEDING SITE EXAM	SCHALLENBERGER 1966
	71	5	WINTER	GRAVELLY MTNS MT	FEEDING SITE EXAM	EUSTACE 1967
	31	37	WINTER		CLIPPING	
90% GRASS <sup>1</sup>			WINTER	GRAVELLY MTNS MT	RUMEN ANALYSIS	ROUSE 1957
90% GRASS			SPRING			
67% GRASS <sup>1</sup>	18	35	WINTER	GALLATIN CANYON MT	FEEDING SITE EXAM	CONSTAN 1967
			MARCH			
31 <sup>3</sup>		25	WINTER	ROCKY MTN FRONT MT	MICROHISTOLOGICAL	KASWORM ET AL. 1984
20		21	SPRING			
43	27	11	SPRING	SUN RIVER MT	FEEDING SITE EXAM	KNIGHT 1970

<sup>1</sup>GRASSES IN THE DIET WERE NOT DIVIDED BY SPECIES, BUT THE KEY SPECIES WERE THE DOMINANT GRASSES ON THE STUDY AREA.

<sup>2</sup>GRAMINOIDS IN THE DIET WERE NOT DIVIDED BY SPECIES, BUT THE KEY SPECIES WERE THE DOMINANT GRASSES ON THE STUDY AREA.

<sup>3</sup>ALL FESTUCA IN THE STUDY COMBINED.

CARBOHYDRATE ALLOCATION STRATEGIES

Carbohydrate allocation patterns on a seasonal basis and in response to defoliation and grazing treatments have been reviewed by Trlica (1977), White (1973) and Cook (1966). Some generalizations supported by all three authors included: 1) although it was seldom emphasized total plant soluble carbohydrates increased with maturity, 2) carbohydrate allocation patterns varied with phenological development and environmental conditions, and 3) the level of soluble carbohydrates located in a particular tissue at any given time was also a function of concurrent plant physiological activities and biotic and abiotic environmental influences.

Grazing, a biotic environmental influence, has modified the carbohydrate allocation pattern of all species studied to date. Studies using more sophisticated techniques have demonstrated that individual species responded differently to grazing (e.g. Caldwell et al. 1981). However some interspecific generalizations were apparent. If grazing ended before the initial growth period ended, injury from defoliation was reduced. Fall regrowth was much more important to plants grazed through the entire initial growth period than to plants grazed early in the initial growth period or ungrazed (McLean and Wikeem 1985a,b). Graminoids that were entirely dormant during the winter were more dependent on carbohydrate reserves for spring growth initiation than those with photosynthetically active overwintering leaves (Robertson and Woolhouse 1984b). Graminoids that depended on overwintering photosynthetically active leaves to fuel initial spring growth required some intact leaves in the spring (Robertson and



Woolhouse 1984b). There may also be additional carbohydrate allocation patterns not yet elucidated.

#### AGROPYRON SPICATUM

Quinton et al. (1982) studied bluebunch wheatgrass vegetative and reproductive growth in the absence of grazing from 1971 to 1973 in interior British Columbia. Vegetative growth initiation was determined by extrapolation of yield and leaf growth curves to zero. Growth initiation, estimated from yield curves, occurred from mid-March to May. Soil temperatures at 10 cm were 6°C and average air temperatures within 1°C. Soil moisture at 28 and 75 cm had been recharged by spring snow melt. Leaf growth estimates of growth initiation were earlier. Soil temperatures were still near 0°C at 10 cm and snow melt less than one week earlier. A 6°C soil temperature at growth initiation was supported by others (Harris 1967 and Anderson and McNaughton 1973).

Vegetative growth in British Columbia lasted two months with culms reaching a maximum height of 19 cm. Average culm length reached 38.2 cm in Washington (Rickard et al. 1975) and 16.4 cm at Dubois, ID (Blaisdell 1958). Leaf growth ceased in early summer. Associated soil moisture levels were variable, and air temperatures were still cooler than optimum growth temperatures (DePuit and Caldwell 1975).

Fall growth in British Columbia occurred only in the year with both the wettest and warmest September and October. Precipitation and temperature were 135% and 120% of average, respectively. Phenological development patterns from several areas are reported in table 2.

Table 2. The progression of bluebunch wheatgrass phenological development in the Northern Rockies.

PHENOLOGICAL STAGE	DATE			
snow free		Ap 1	Mr 30	
growth initiation	mid-Ap	Ap 11	Ap 4	late Ap
boot	Jn 1	Ma 16	Ma 22	Ma - early Jn
early head	early Jn	Ma 28		
full head	mid-Jn	Jn 6	Jn 14	
early flower	mid-late Jn			
full flower	late Jn-mid-Jl	Jn 18	Jn 25	
seed ripe	late Jl	Jn 28	Jl 19	
seed shatter	late Jl-early Ag	Jl 21	Jl 24	late Jl
growth cessation	early Jn-mid-Jl	Jn 7	Jl 8	late Jl
fall growth	last half Oc			Jl & Ag - Oc
Years	1971-73	1937-40	1941-47	
Location	Kamloops, B.C.	Dubois, ID	Dubois, ID	Missoula, MT
Citation	Quinton et al. 1982	Blaisdell et al. 1952	Blaisdell 1958	Daer and Willard 1981

Climatic patterns modified the rate of phenological progression (Quinton et al. 1982). Where low spring temperatures were limiting, early phenological stages were compressed in time. Where summer drought was limiting, later phenological stages were shorter. Blaisdell and Pechanec (1949) reported that clipping during spring growth did not affect the time or rate of phenological development. Spike numbers were not well correlated with tiller number or basal area of plants.

Several studies analyzing bluebunch wheatgrass chemical constituents have established seasonal variation in components associated with forage quality. Stoddart (1946) reported that total carbohydrates increased as vegetation matured. Nonstructural carbohydrates, presumably available for plant utilization or storage, increased in the spring (Caldwell et al. 1981). Daer and Willard (1981) found that minimum total nonstructural carbohydrates (TNC) levels corresponded to initial growth and early boot stages and that the maximum TNC occurred at the late boot stage. "Other carbohydrates" (total carbohydrates - cellulose) reached maximum concentrations in the fall and minimum levels in late winter (Stoddart 1946). Cellulose content ranged from 24% in early spring to 31% in late spring, 33% in late summer and 43% in late winter. Lignin increased from 4% in early spring growth to 14% in fall and 18% in late winter. Protein concentration declined from 26% in new spring growth to 13% when heads were emerging and 3% in the fall. Fall through spring nutrient contents are reported in table 3.

Table 3. Nutritional profiles of bluebunch wheatgrass from fall dormancy through spring growth.

STAGE OR SEASON	TOTAL <sup>1</sup> CRUDE			CRUDE				CITATION
	CH <sub>2</sub> O %	FIBER %	NFE %	CELLULOSE %	LIGNIN %	PROTEIN %	ASH %	
MATURE		37.8	49.4			5.0	5.2	KNIGHT ET AL. 1908
FALL		35.1	46.7			3.2	12.5	MCCREARY 1927
NOV		31.2	46.4			3.4	7.9	MCCREARY 1931
JAN		29.5	44.2			5.0	10.9	"
APR		28.5	43.7			4.2	13.4	"
OCT		30.7	48.4			3.0	8.2	"
POST SEED SHATTER		33.4	39.6			2.9	10.1	MCCALL 1940
NEW GROWTH		20.6	36.6			25.5		BLAISDELL ET AL. 1952
MATURE FOLIAGE		30.2	44.1			7.8		"
NOV		33.9	43.5			3.7		"
NEW GROWTH (4/20)	62.5			24.2	4.0	26.2	8.6	STODDART 1946
DRY MATURE (9/15)	86.6			32.9	12.9	2.9	7.5	"
OLD GROWTH (4/1)	88.6			43.2	17.7	2.5	6.5	"
NEW GROWTH (4/15)	63.8			24.8	5.6	23.4	9.0	"
DRY MATURE (9/15)	83.3			31.8	14.5	4.6	8.9	"

<sup>1</sup>TOTAL CARBOHYDRATES

Herbage removal affected bluebunch wheatgrass nutrient content in the same summer. Stoddart (1946) reported that one midspring clipping resulted in the best overall forage quality as reflected by higher protein and lower lignin contents. Subsequent clippings at one- or two-week intervals resulted in slight forage value declines, but all clipping treatments had higher forage values than unclipped control plants. Caldwell et al. (1981) reported that protein concentrations in regrowth leaves were similar to those of unclipped leaves one month earlier. Bolton and Brown (1980) associated higher nitrogen (N) concentrations with higher photosynthetic activity. Caldwell et al. (1981) measured higher photosynthetic activity in regrowth tissue compared to unclipped photosynthetic tissue. Nitrogen incorporated into regrowth was new assimilate, because root and crown N pools did not decline (Caldwell et al. 1981).

Total nonstructural carbohydrate pools in bluebunch wheatgrass, which were concentrated in stems and sheaths in intact plants, were diminished by clipping and remained low in regrowth compared to unclipped plants (Caldwell et al. 1981). "Other carbohydrates" also declined in clipped plants (Stoddart 1946). Carbohydrate pools in the roots declined rapidly with growth initiation, increased slightly during the active growth period, and were completely replenished following active vegetative growth (Daer and Willard 1981, McCarty and Price 1942 and McIlvaine 1942). Removal of photosynthetic tissue disrupted this pattern of allocation to the roots, reducing reserves available for growth initiation the following spring (Blaisdell and Pechanec 1949).

Bluebunch wheatgrass foliage removal by burning, grazing or clipping in any season reduced production in at least the following year (Stoddart 1946, Blaisdell and Pechanec 1949, Mueggler 1972, Sauer 1978, Wilms et al. 1980 and McLean and Wikeem 1985a). The clipped tillers rarely produced new tillers (Caldwell et al. 1981). Severe damage resulted from both spring and fall clippings (Stoddart 1946). A single clipping treatment during the most metabolically demanding growth periods, active reproductive stages or carbohydrate reserve replenishment periods, all reduced yield in the following year (McCarty and Price 1942, McIlvaine 1942, Blaisdell and Pechanec 1949 and Wilson et al 1966). If clipping killed a tiller it usually died immediately or with the onset of drought (Caldwell et al. 1981). When competition from surrounding vegetation was reduced, extreme clipping during critical growth stages was much less detrimental (Mueggler 1972).

The key factor mitigating defoliation damage appeared to be the time and amount of leaf growth remaining following defoliation (McLean and Wikeem 1985a). Plants defoliated early in the spring with several weeks of leaf growth following defoliation had higher survivability and vigor than plants defoliated near or past the end of the leaf growth period (McLean and Wikeem 1985a, Stoddart 1946 and Blaisdell and Pechanec 1949).

The effects of clipping fall regrowth were more variable and difficult to explain. Blaisdell and Pechanec (1949) reported that fall regrowth was very important to production in the next year. Clipped plants with regrowth yielded, in the next growing season, 270%

of plants with no regrowth. Plants with regrowth also produced 2.5 times as many flower stalks as plants without regrowth. McLean and Wikeem (1985a) reported that clipping plants with 5.1 g/plant of fall regrowth resulted in significantly higher percent kill in the following year than clipping plants with 2.7 or 1.6 g of fall regrowth, suggesting that some threshold level of fall regrowth production was required to have an impact.

Clipping bluebunch wheatgrass standing dead in January reduced production in the following spring, leaf and culm yield declined 28%, leaf length decreased 25% and loss of standing dead decreased 21%. Factors associated with reproduction were not significantly affected (Sauer 1978).

The caespitose growth form provides microsite modifications (Sauer 1978, Chapin et al. 1979, Caldwell et al. 1981 and Smith et al. 1983). By removing standing dead material some beneficial effects of the caespitose growth form were lost. Sauer (1978) hypothesized that freer air circulation increased moisture stress, causing stomate closure, reducing  $\text{CO}_2$  uptake and consequently production. Sauer (1978) also suggested photoinhibition of photosynthesis. However, bluebunch wheatgrass leaf display patterns and culm densities exposed most leaves to direct solar radiation in intact bunches (Caldwell et al. 1981). Bluebunch wheatgrass leaves had a relatively high photosynthetic rate per area (Caldwell et al. 1981). Competition from surrounding vegetation may have contributed to decreased production (Mueggler 1972). Other researchers (Blaisdell and Pechanec 1949 and

Wilson et al. 1966) have reported that overwintering fall regrowth became the first carbohydrate source in the spring, because carbohydrate reserves declined shortly after rather than concurrently with growth initiation (Caldwell et al. 1981). Absence of fall regrowth for earliest spring photosynthetic activity may also inhibit spring production. Fall regrowth has also been reported as a major source of new tillers (Daer and Willard 1981).

All of these studies used treatments which removed all tillers. Bluebunch wheatgrass responses to selective herbivory would be similar, but less severe, than those presented above. Some leaves would remain ungrazed and could continue photosynthetic activity. Stems and sheaths comprised major pools of nonstructural carbohydrates which could apparently contribute to regrowth production (Caldwell et al. 1981). Bluebunch wheatgrass stem and sheath photosynthesis was as productive and efficient as leaf photosynthesis (Caldwell et al. 1981). Therefore selective grazing of leaves would not eliminate all photosynthetically active tissue.

#### FESTUCA SCABRELLA

Rough fescue growth and phenological development were studied at two sites near Kamloops, British Columbia (Stout et al. 1981) and at Stavely and Lethbridge, Alberta (Johnston and McDonald 1967). Growth and phenological development varied between years and sites. Environmental factors seemed to control initiation of growth, but phenotypic adaptation resulted in different rates of phenological progress at different sites. For the three years studied in B.C.



(Stout et al. 1981) there were no more than three weeks variation in the timing of any phenological stage.

Stout et al. (1981) calculated from yield curves that growth initiated in mid-April with soil temperatures of 2-3°C at 10 cm. Johnston and McDonald (1967) reported new growth in early May with 20 cm soil temperatures of 2°C and calculated that leaf growth had been initiated two weeks earlier. Culm growth began six weeks after growth initiation. Growth initiation was correlated with soil temperature but not air temperature. Concurrent soil moisture had been completely recharged by snow melt (Bailey and Anderson 1978).

Cessation of vegetative growth was keyed to soil moisture (Stout et al. 1981) and modified by air temperature influences on plant water relations. Plant weight gain continued following leaf growth cessation, because photosynthesis could continue at vapor pressure levels which inhibited cell expansion (Hsiao 1973). Concurrent soil temperatures were not warm enough to inhibit growth (Smoliak and Johnston 1968). In Alberta foliage had entered winter dormancy by early October (Johnston and McDonald 1967). Patterns of phenological development from British Columbia and Alberta are reported in table 4.

Johnston and McDonald (1967) reported that rough fescue reproductive culm production ranged from 6.7 to 121.7 culms per plant. Seed production was erratic and difficult to relate to specific environmental cues (Johnston and McDonald 1967 and Stout et al. 1981). Abundant flower production years have included 1952, 1964, 1966 (Johnston and McDonald 1967) and 1972 (Stout et al. 1981). Floral primordia were initiated in the fall with seed production in the

Table 4. The progression of rough fescue phenological development in Alberta and British Columbia.

PHENOLOGICAL STAGE	DATE						
boot	Ma 27	-	Ma 1	Ma 12	Ma 10	Ap 30	
early head	Jn 3	Ma 18	Ma 8	Ma 19	Ma 17	Ma 7	late Jn
full head	Jn 10	Ma 25	Ma 30	Ma 22	Ma 24	Ma 14	mid Jl
early flower	Jn 17	Jn 1	Ma 30	Jn 2	Ma 31	Ma 28	
full flower	Jn 24	Jn 15	Jn 6	Jn 9	Jn 7	Jn 5	
end of flower	Jl 1	Jn 22	Jn 13	Jn 23	Jn 14	Jn 12	
seed in milk	-	-	Jn 29	Jn 30	-	Jn 19	
seed in dough	-	Jl 11	-	Jl 7	Jl 5	Jn 26	
seed ripe	Jl 22	-	Jl 5	Jl 14	-	Jl 3	early Au
seed shatter	-	Jl 24	Jl 5	-	Jl 17	Jl 3	
growth cessation	Jn 17	Jl 7	Jn 13	Jn 23	Jn 28	Ma 28	
fall growth	Se 3	none	Oc 16	Se 15	none	Oc 3	
Years	1971	1972	1973	1971	1972	1973	1964 -1966
Location	Hamilton, B.C.			East Mara, B.C.			Lethbrige, Al.
Elevation	1158 m			854 m			
Citations	Stout et al. 1981			Stout et al. 1981			Johnston and McDonald 1967

following summer (Johnston and McDonald 1967), a trait shared with some other northern grasses including Idaho fescue (Hodgson in Johnston and McDonald 1967). Within this time span a variety of potentially influential environmental events could occur. Initiated primordia were cold tolerant (Johnston and McDonald 1967). Of 3,780 primordia examined from 1963 through 1967, only one percent suffered frost killing. Minimum temperatures during this period were  $-40^{\circ}\text{C}$  air temperature and  $-11$  and  $-9^{\circ}\text{C}$  soil temperatures at 10 and 20 cm depths, respectively. Still only about 35% of initiated floral primordia successfully developed into seedheads, and spring management did not appear to affect seedhead production. Seed germination ranged from 86 to 97% (Johnston and McDonald 1967).

Rough fescue had characteristics which were indicative of both grazing tolerance and susceptibility (Johnston and McDonald 1967). Meristems of vegetative culms were not elevated, and the range of reproductive to vegetative culm ratios, 0.299 to 0.001, was relatively low even in years of high seed production. Grazing susceptible traits included the erect caespitose growth form which made a high proportion of photosynthetic tissue available to herbivory. Tillering in rough fescue was neither vigorous nor stimulated by the removal of culms or elevated meristems. Under grazing management, such as rest-rotation and deferred grazing methods with moderate utilization, rough fescue has recovered and maintained itself (Anderson and Franzen 1983).

Rough fescue was damaged by consecutive years of heavy summer grazing (Johnston and McDonald 1967). But protection from even light grazing, 15% to 25% utilization for 12 years, increased the presence

of rough fescue in an enclosure (Johnston 1961). Spring burning produced varying results (Bailey and Anderson 1978). Burning with 10 cm of new growth resulted in reduced, but recovering canopy coverage for at least three years (39% of unburned in year one, 69% in year two and 90% in year three). When burned with 4 cm of new growth, canopy coverage declined less and production was not affected. Floral primordia were unaffected by burning until they had been elevated above the root crown in the spring, when seedhead density was greatly reduced (3% of unburned one year post burn) (Bailey and Anderson 1978).

Based on anecdotal evidence some rough fescue populations have had a long history of heavy winter grazing (Johnston and McDonald 1967). In areas of the northern Great Plains where Fescue grassland is the dominant vegetation type, such as the Cypress Hills in southeastern Alberta, buffalo summered on the open plains and wintered in the hills. In such areas rough fescue was subjected to severe winter grazing every year, but rested the remainder of the year.

Chemical analyses have found that, except for protein, nutritional components of rough fescue were relatively stable through the year (Johnston and Bezeau 1962 and Bezeau and Johnston 1962). Protein decreased from 13.7% in early vegetative growth to 4.7% in the fall and 4.2% by the end of winter. Overwinter protein decline was more variable than in other seasons. Crude fiber and cellulose increased through the growing season from 29.9 to 33.4% and 33.2 to 38.4%, respectively. Overwinter crude fiber increased to 34.8% and cellulose to 39.5%. In vitro dry matter disappearance dropped from

48.5% in early spring to 32.1% by fall and 24.0% at the end of winter. Rough fescue nutrient contents from dormancy through spring are reported in table 5.

#### FESTUCA IDAHOENSIS

For Idaho fescue only the seasonal progression of diet quality will be discussed. Growth and phenological development and grazing effects are not presented because this information was not found. McCall (1940) reported that the typical fall decline in grass nutritional values was less pronounced in Idaho fescue than in other bunchgrasses studied. In particular crude protein (CP) dropped to 4.6% in Idaho fescue and 2.9% in bluebunch wheatgrass while crude fiber increased to 27.2% in Idaho fescue and 33.4% in bluebunch wheatgrass. In digestion trials using lambs on mature forages, Idaho fescue had higher total digestible nutrients and positive crude protein digestion coefficients (% dietary CP - % fecal CP). Bluebunch wheatgrass had lower total digestible nutrients and negative crude protein digestion coefficients. Idaho fescue was more nutritious than bluebunch wheatgrass.

McCall (1939) determined biweekly chemical constituents of Idaho fescue over a four year period (table 6). Crude fiber rose slightly as Idaho fescue matured from "new growth" to "maturing" stages, changed little in the "fall" and rose again through the "winter." Only "new growth" and "winter" crude fiber levels were significantly different. Nitrogen free extract (NFE) in "winter" and "new growth" were significantly lower than in "maturing" and "fall" stages. Crude

Table 5. Nutritional profiles of rough fescue from fall dormancy through spring growth.

Stage or Season	Total <sup>1</sup> CH <sub>2</sub> O	Crude Fiber %	NFE %	Cellulose %	Crude Protein %	Ash %	IVDMD %	Citation
leaf		29.9		33.2	13.7	6.9	48.5	Johnston & Bezeau 1962
cured		33.4		38.4	4.7	8.5	32.1	and
weathered		34.8		39.5	4.2	8.6	24.0	Bezeau & Johnston 1962
seed shed (9/15) <sup>1</sup>		36.0			4.2	10.2		McLean & Tisdale 1960
weathered (11/25)	82.6	42.5	46.6		2.1	12.3		"
leaf (6/16)		30.3			12.0	10.1		Clarke & Tisdale 1945
partly cured (8/10)		37.2			5.4	9.8		"

<sup>1</sup>Total carbohydrates

Table 6. Four-year averages of semimonthly analyses of Idaho fescue (dry matter basis) (McCall 1939).

<u>Period</u>	Ash %	Crude Protein %	<u>Carbohydrates</u>	
			Crude Fiber %	N-free extract %
<b>Mature:</b>				
First part of Ja	16.2	4.7	32.6	43.6
Last part of Ja	16.4	4.7	32.7	43.2
First part of Fb	15.3	4.8	33.6	44.1
Last part of Fb	16.6	4.9	32.8	43.0
First part of Mr	18.8	5.1	31.1	42.3
Last part of Mr	18.5	5.0	31.9	42.4
First part of Ap	18.6	5.1	30.8	42.5
<b>New growth:</b>				
First part of Mr	10.0	17.4	26.0	42.4
Last part of Mr	9.9	19.0	24.1	43.0
First part of Ap	10.4	18.9	25.1	42.0
Middle part of Ap	11.1	16.2	24.0	44.8
Last of Ap-first of Ma	13.2	13.8	28.3	41.2
Middle part of Ma	12.9	11.1	28.2	44.3
Last part of Ma	12.1	9.2	30.2	45.2
First part of Jn	13.1	7.8	31.2	44.5
Last part of Jn	13.2	6.5	30.3	46.7
First part of Jl	14.0	5.0	31.6	46.3
Last part of Jl	13.7	4.6	31.4	46.8
First part of Au	13.7	4.1	31.2	47.7
Last part of Au	14.3	4.1	30.9	47.1
First of Sp	14.6	3.9	29.0	48.7
Middle part of Sp	13.6	3.7	30.5	48.9
Last of Sp-first of Oc	15.4	4.2	30.7	46.2
Middle part of Oc	17.0	4.6	29.0	45.9
Last part of Oc	16.4	4.7	30.3	45.0
Middle part of Nv	16.3	4.4	31.6	44.4
Last of Nv-first of Dc	14.8	4.2	32.9	45.2
Middle part of Dc	15.5	4.4	32.7	44.4
Last part of Dc	17.8	4.6	30.9	43.8

protein declined from "new growth" to "maturing" stages then remained stable through the "fall" and "winter". "New growth" crude protein was significantly higher than the other three stages which were not significantly different from each other. Ash rose steadily from "new growth" through the year. Seasonal chemical constituents of Idaho fescue from several studies are summarized in table 7.



Table 7. Nutritional profiles of Idaho fescue from fall dormancy through spring growth.

Stage or Season	Crude Fiber %	NFE %	Cellulose %	Crude Protein %	Ash %	IVDMD %	Citation
new growth	26.0	42.4		17.4	10.0		McCall 1939
fall	30.9	45.3		4.4	16.0		"
winter	32.4	43.3		4.8	16.8		"
post seed shatter	27.2	38.7		4.6	14.6		McCall 1940
seed ripe	32.7		35.0	7.6	7.5	27.0	Johnston & Bezeau 1962
cured	31.9		35.9	4.9	10.6	18.8	and
late winter	33.4		38.8	4.5	9.0	14.6	Bezeau & Johnston 1962

## STUDY AREA

The field work for this project was conducted in Muddy Lake and Jenkin's Gulch drainages, tributaries of Crow Creek located on the southeastern end of the Elkhorn Mountains on the Muddy Lake and Middle pastures of the South Crow cattle allotment on the Helena National Forest, Montana (fig. 1 to 3).

SITE DESCRIPTION

The climate in the region is modified continental with large annual and daily temperature variations (DeSimone et al. 1984). Elevation and precipitation range from 1464 m to 2100 m and 51 cm to 76 cm, respectively. The general vegetation aspect on the study area is a rolling grassland with steep conifer draws and broader cottonwood bottoms. Slopes and ridge tops have stony, loamy soils. The vegetation on the upland sites is dominated by bunchgrasses. Idaho fescue is ubiquitous. Rough fescue occurs on the slightly moister sites and bluebunch wheatgrass on most other sites.

Each transect was located on a site where all three species occurred. There were five sites called South Crow I (SCI) and II (SCII), Jenkin's Gulch I (JGI) and II (JGII) and Muddy Lake (ML). The elevation, aspect and slope of each site are reported in table 8. Based on observations during fieldwork, the Jenkin's Gulch sites were cooler and moister and the South Crow sites were warmer and drier than the others.

Approximately 200 elk have wintered in the study area since the 1960's (DeSimone et al. 1984). Generally winter range is used from

































































































































































