Growth, Productivity and Chemical Composition of a Sub-Alpine Meadow in Interior British Columbia

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The spruce-alpine fir zone is an important summer grazing region in the interior of British Columbia (Spilsbury and Tisdale, 1944; Tisdale, 1950). Grazing is, however, confined largely to the numerous wet meadows and park-like openings in the forest. The meadows are often extensive and furnish large amounts of moderately palatable forage. On the Tranquille range near Kamloops meadows occupy about six percent of the spruce-fir zone; the Cariboo is ten to 70 percent meadow. In the Cariboo district most of the winter feed for livestock is produced on these meadows. They are cut for hay in mid summer and then grazed until late fall. Farther south meadows are used largely for summer grazing.

The meadows are situated in drainage basins and, therefore, flood in spring and early-summer. Many have been made larger by the impounding of water by beavers. They vary greatly in both vegetation and soils. The soils vary from gleysolic mineral to muck and peat types; some meadows occur as floating peat bogs. Few references are available on these meadows, their types, characteristics, composition and response to grazing. They were briefly referred to by McLean and Tisdale (1960), who reported some chemical analyses of the forage.

This paper reports on the characteristics of a typical sedge meadow; its growth pattern, chemical composition, forage yields both natural and with fertilization and effect of periodical clipping during the grazing season from 1956 to 1959. It also reports animal weight gains and beef production from 1956 to 1962.

The Study Area

An 18-acre meadow on the Tranquille Forest Reserve near Kamloops (Figure 1) was selected for study. For many years, before being fenced in 1956 for grazing trials with beef cattle, the meadow had been heavily grazed. It lies at approximately 4800 feet elevation within the Englemann spruce *(Picea engelmanni)*—alpine fir *(Abies lasiocarpa)* zone and was selected as typical of a number in the area.

The soil of the meadow is mucky sedge peat, pH 5.5, slightly more humified at a depth of three feet than at the surface. In places near the centre of the area the depth exceeded 20 feet as indicated by pressing a pole of this length into the bog. The topography is slightly concave with the centre being 12 to 18 inches lower than the edges.

The meadow was dominated by a uniform, dense stand of sedges *(Carex)*, along with lesser

FIGURE 1. Sedge meadow under study in the spruce-alpine fir zone near Kamloops, B. C.

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amounts of rushes *(Juncus)* and spike rushes *(Eleocharis)*. The principal tall sedges were beaked sedge *(Carex rostrata* Stokes), water sedge *(C. aquatilis* Wahl.), Sitka sedge *(C. sitchensis* Pres.), *C. exisiccata* L. Bailey, *C. arcta* Boot., and the small ones *C. gynocrates* Wormskj., mud sedge *(C. limosa L.)*, and *C. disperma* Dewey. Grasses, mostly bluejoint *(Calamagrostis canadensis* (Michx.) Beauv.) and red top *(Agrostis alba* L.), provided only a small part of the plant cover. Small patches of American mannagrass *(Glyceria grandis* S. Wats.) and occasional plants of marsh cinquefoil *(Potentilla palustris* (L.) Scop.), buttercup *(Ranunculus* spp.), dwarfed bog birch *(Betula glandulosa* Michx.) and willow *(Salix* spp.) occurred. No attempts were made to estimate the proportions of the species as the plants seldom headed out and were difficult to identify. Most of the species grew 12 to 18 inches high.

The meadow was fed by two small streams that ran most of the summer. It was covered with a few inches of water from spring breakup until between late June and mid July. The water table remained within a few inches of the surface for the rest of the season.

Mean monthly air temperatures, measured in a Stevenson screen, over the three-year period 1960 to 1962, for June, July, August and September, averaged 48, 54, 52 and 45°F, respectively, at the meadow. Soil temperatures in the bog remained rather low throughout the summer. The mean monthly temperatures at 4.5 inches below the surface during 1960 from June to September were 53, 55, 53, 42°F respectively. The mean weekly soil temperature dropped 10° between the first week of August and the first week of September in 1960, 1961 and 1962 to 43°F, 48°F and 47°F, respectively.

Frosts may occur in any month at the altitude of the meadow and regularly stop growth in the first half of September. The frost-free period (minimum above 32°F) averaged 35 days for the three years 1960 to 1962.

Heavy June and July rains during 1956 and 1957 maintained high water levels. Grazing was not possible until late July. In 1958, because of extremely dry weather in early summer the water level dropped early. In 1959, although May was wetter than average, both June and July were considerably drier than usual.

Some effective rainfall can usually be expected during the summer months. The recorded summer rainfall (July to September inclusive) at the study site in 1960, 1961 and 1962 was 4.9, 4.1 and 4.1 inches respectively.

The winter snowpack on a snow course about two miles from the meadow from 1956 to 1959 was higher than the 10-year average as indicated in the following summary[4]:

	1956	1957	1958	1959	1953-62 av.
	(Inches)				
Snow depth	41	36	45	37	34
Water content	13.9	9.7	12.1	10.1	9.6

Methods

The meadow was fenced into two 8.5-acre fields. Continuous-grazing trials involving different numbers of yearling beef cattle were conducted on the fields. The degree of utilization aimed at full season of use and in most years had about 30 percent carryover. Animal weights were taken bi-weekly and the total number of animal days on pasture recorded. In 1956 and 1957 the test period used for the calculation of gains was 14 days less than the total because of the shrunken condition of the animals when weighed at turnout time. It is recognized that the estimated production of the meadow was, therefore, less than its potential for those two years. In the other years the starting weights were taken three or four days after turnout. Grazing was started when the fields were judged ready as determined by the height of the forage and the lack of surface water and continued until severe frosts forced removal of the animals. Digestibility trials were conducted twice in 1959 with six animals over seven-day periods. The penned animals were fitted with bags for the total collection of feces and the forage was cut and hauled to them. Forage and feces samples were collected and analyzed by standard methods (Association of Official Agricultural Chemists, 1955).

A one-acre exclosure was fenced to provide an area for study which was free from grazing. Plots of one square meter were staked out for clipping at different times. Each time of clipping was replicated four times. Clipping was done with sheep shears to a height of two inches. The forage from each harvest was oven-dried and weighed. The material from each plot was analyzed for crude protein, crude fibre, total ash, calcium and phosphorus.[5] The dates of first clipping varied from year to year, depending on development of the species; they were July 30, July 30, June 28, and July 15 from 1956 to 1959, respectively.

The plots were clipped as follows: Treatments A to C, every two, four and eight weeks respectively throughout the grazing period; D, every six weeks starting two weeks after grazing started; E, every four weeks starting four weeks after grazing started; and F, at the end of the grazing period only. In 1958 because of the cutting schedule, treatments C and D were not clipped after August 20 although some regrowth did take place.

In the fall of 1958 a four-replicate, randomized-block fertilizer experiment was laid out adjacent to the clipping trial using

Table 1. Hay yields (oven-dry) from plots clipped every two weeks (treatment A) for four seasons in a sub-alpine meadow near Kamloops, B. C.

Year	Date of first clip	Clipping period (bi-weekly intervals) 1	2	3	4	5	6	7	Total
		(Pounds per acre)							
1956	July 30	527	61	NR[1]	23				612
1957	July 30	648	42	12	0				702
1958	June 28	483	49	0	70	0	51	139	792
1959	July 15	540	20	22	14	9	0		605

[1]No record taken as poor flying conditions prevented access to the meadow.

lime, gypsum, and six commercial fertilizers. Yields were obtained by harvesting the cured forage in the fall with a sicklebar plot mower. The material was weighed and a 250 gm. sample oven-dried to obtain moisture content.

Results

Pattern of Growth

Eighty-six to 92 percent of the season's growth based on yields took place before the end of July in three of the four years in Treatment A (Table 1). In 1958, 21 percent of the total growth took place in the first half of September, probably as a result of the relatively warm weather. In 1959 the fall growth was less on the plots clipped every two weeks than on those clipped less frequently.

Visual observations indicated that no significant change had yet taken place in the botanical composition of the plots despite the intensive clipping on some treatments.

Only on a few plots in the exclosure did the plants head, so that it was difficult to determine the pattern of physiological development from the flowering characteristics. Flowering was greater in 1958 than in the other years, perhaps as a result of the warmer summer.

Forage Yields

Frequent clipping retarded growth and lowered forage yields as compared with unclipped plots or those not clipped late in the season (Table 2) in all years except 1956.

In 1958 treatments C and D had the lowest yields. These treatments were not clipped at the end of the season and there was considerable fall regrowth that year. In 1959, however, these treatments had the highest yields of all. It is presumed that the 1959 yields benefited from the lack of clipping the previous fall.

In a number of cases plots were not clipped in the latter part of the season because of insufficient regrowth. A check of the data revealed that in all cases these plots were the highest yielding of the clipped plots in the following year.

Chemical Analyses

Crude protein — The protein content of the forage declined slowly throughout the season until the fall frosts occurred (Figure 2).

Protein levels were not high at any time and fell below ten percent, the level required for rapid growth of yearling cattle (National Research Council, 1958), by mid August; however, the forage met maintenance requirements (six percent) until the animals left the area in the fall. The levels compared closely with those reported by McLean and Tisdale (1960) for the principal forest forbs from the same region but were considerably above that of pinegrass (*Calamagrostis rubescens* Buckl.).

Crude fibre — The average crude-fibre content changed little during the grazing period (Figure 2). Throughout the grazing period it was similar to that for the principal forest forbs and considerably lower than that of pinegrass (McLean and Tisdale, 1960).

Table 2. Yields of hay, pounds per acre (oven-dry) for four years on a sub-alpine meadow near Kamloops, B. C., subjected to six clipping treatments.

Year	Treatment[1]						Standard error of mean
1956	D	F	A	B	C[2]		
	789	664	612	575	570		39.5 (15 d.f.)
	a	a					
		b	b	b			
1957	F	D	E	C	B	A	
	921	906	850	815	722	702	44.2 (23 d.f.)
	a	a	a	a			
		b	b	b	b		
				c	c	c	
1958	F	E	B	A	D[2]	C[2]	
	1226	978	879	792	701	695	44.3 (15 d.f.)
		a	a				
			b	b			
1959	D	C	F	E	B	A	
	885	865	776	774	629	605	41.5 (23 d.f.)
	a	a	a	a			
					b	b	
Av.	F	E	D	C	B	A	
	897	867	820	736	701	678	

Significance at five percent level expressed by Duncan's Multiple Range Test.

[1]See text for schedules of clipping.

[2]Yields not included in analysis since plots were not clipped at the end of the season.

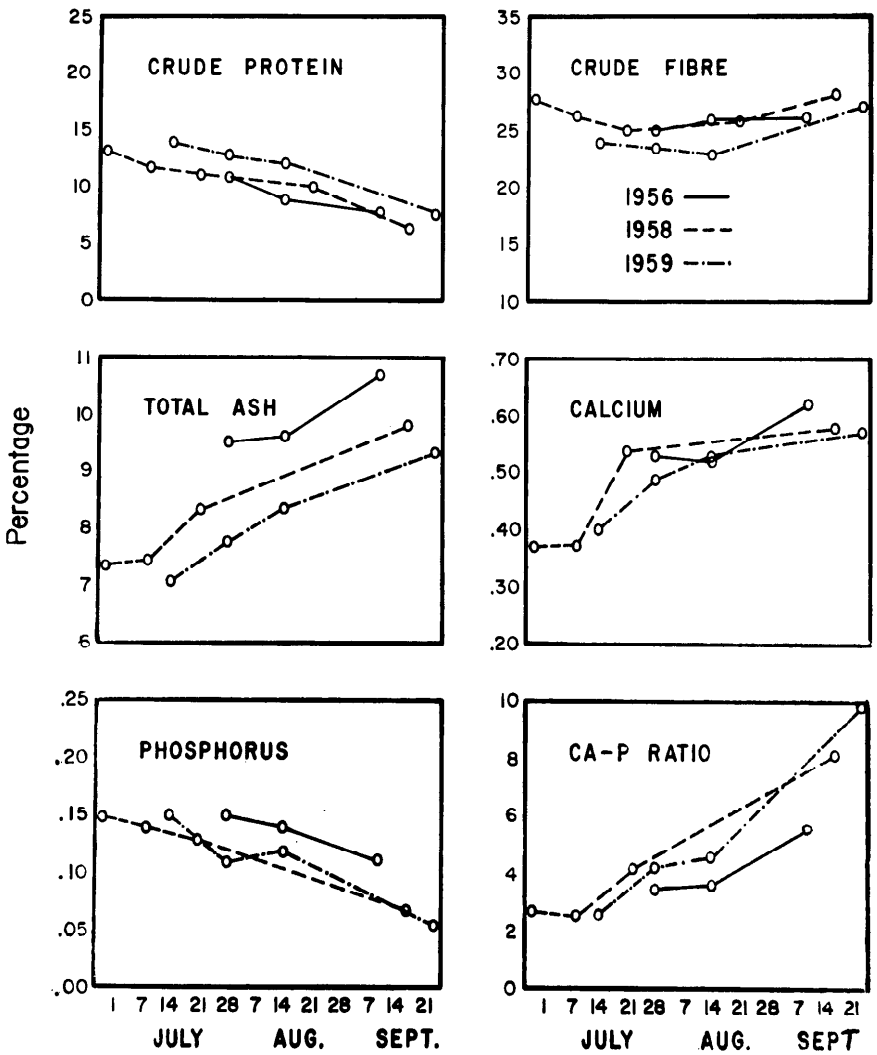

FIGURE 2. Chemical composition of forage from a sedge meadow in the spruce-alpine fir zone near Kamloops, B. C., during the grazing season.

Calcium — The calcium content of the forage (Figure 2) was above the minimum (0.25 percent) required for animal maintenance (National Research Council, 1958) even at the beginning of July. It increased through the grazing period, as in forest forbs but to a lesser extent than in pinegrass (McLean and Tisdale, 1960). The total amounts were lower at all growth stages than for both forest forbs and shrubs.

Phosphorus — The phosphorus content of the forage decreased as the season advanced (Figure 2). The phosphorus level was below that required (0.20 percent) for rapid growth of yearling cattle (National Research Council, 1958) at all times during the grazing period but was adequate for maintenance until about mid August. The total-phosphorus levels were considerably lower than those for forest forbs, shrubs and pinegrass at all growth stages sampled (McLean and Tisdale, 1960).

The Ca/P ratios were greater than 2:1 even at the start of the grazing period and rose to undesirable levels in the fall-clipped forage, especially considering the low phosphorus levels at this time.

Effects of Fertilizer Applications

Response to certain fertilizers applied in the fall of 1958 was not evident until 1960 and was followed by a two-year carry-over response. Treatment yields in each of the three years generally showed similar relationships to each other so that they are closely represented by three-

Table 3. Yields of native forage (three-year average, 1960 to 1962), from plots in a sub-alpine meadow near Kamloops, B. C., having received commercial fertilizer applications.

Fertilizer applications in fall of 1958		Average yields (Oven-dry)	
Formulation	(Pounds per acre)	(Tons per acre)	
10-20-10	400	0.89	a[2]
10-20-10 plus hydrated lime[1]	400 1000	0.81	a
16-20-0	400	0.81	a
Hydrated lime[1]	1000	0.75	a
0-19-0	600	0.75	a
11-48-0	200	0.67	a b
33-0-0	200	0.66	a b
Gypsum	300	0.50	b c
21-0-0	300	0.50	b c
No treatment	0	0.43	c

[1]A re-application of 2000 pounds of lime per acre was made in the fall of 1959.

[2]Significance at five percent level expressed by Duncan's Multiple Range Test.

[2]*Annual Reports 1953 to 1962, Canada Dept. Agric., Research Sta., Kamloops, B.C.*

[3]*Analyses were done by the Analytical Chemistry Research Service, Research Br., Canada Dept. Agric., Ottawa.*

[4]*Annual Reports 1960 to 1962, Canada Dept. Agric., Research Sta., Kamloops, B.C.*

Table 4. Cattle gains and weights and carrying capacity of sub-alpine sedge meadow near Kamloops, B. C. over a seven-year period (1956 to 1962).

	1956	1957	1958	1959	1960	1961	1962	Average
No. of head/field	6	6	9	6	6	6	6	
No. of days on pasture	57	71	82	71	83	84	70	74
No. animal days/acre	40	50	87	50	59	59	49	56
Av. starting wt. (lb)	849*	709*	599	693	656	595	552	665
Av. daily gain/animal (lb)	1.59*	1.17*	1.02	1.69	1.68	1.41	1.26	1.40
Total gain/acre (lb)	64	58	89	85	99	83	62	77
Total TDN yield/acre (lb)[1]	331*	348*	654	542	615	495	381	481
Av. TDN/lb of gain	7.43	7.01	7.13	6.39	6.44	7.11	6.07	6.80
Percent TDN used for gain	46.3	39.6	33.3	45.7	48.6	36.4	36.8	40.9

*Test period started 14 days after turnout because of shrunken condition of the animals. Heifers used in 1956, steers in all other years.

[1]TDN calculated by the reverse use of feeding standards and estimated TDN requirements for maintenance and gain as listed in Sylvester, P. E., and S. B. Williams. 1952. Method of measuring the relative productivity of pasture experiments with livestock. Proc. publ., Animal Husbandry Div., Exptl. Farms Service, Can. Dept. Agr.

year averages (Table 3). All treatments receiving phosphate and/or lime gave significant increases of up to two times the yield of the untreated plots. Yields from ammonium nitrate (33-0-0) applications were significantly higher than those of the check only in 1960 and 1961. This was the only treatment from which initial responses did not carry over into 1962.

Animal Performance

On the basis of animal gains and utilization the two fields appeared reasonably comparable. Consequently the results from the two fields have been averaged. The average daily gain over the seven years was 1.40 pounds (Table 4). This compares somewhat unfavorably with that obtained on Douglas fir forest range in the same district (1.79 pounds per day three-year average) for the same class of stock.[4]

The total gain per acre was 77 pounds for an average 74-day period. One acre would, therefore, have supported an animal for 56 days. The Douglas fir forest range mentioned above carried one animal per acre for nine days.

The total digestible nutrients (TDN) of the meadow forage dropped 13.5 percentage units from August 5 to September 15 (Table 5). Comparable trials on irrigated pastures at the Kamloops Research Station revealed TDN percentages of 69.8 and 67.2 for mid August and mid September respectively.[4] The digestible protein dropped 5.5 percentage units to 3.1 percent. This is below recommended levels for yearling cattle if they are to gain at normal levels (National Research Council, 1958) and indicates that the animals' diets were deficient in protein at this time.

The average TDN required per pound of gain (6.8 pounds) compared unfavorably with 5.5 pounds required on Douglas fir forest range.

There was a downward trend in TDN produced per acre over the last three years (Table 4). The meadow forage was, in general, not efficient for putting gains on yearling steers.

Discussion

The grazing season on the meadow varied considerably depending on the weather. When the weather was wet and cool during the spring and early summer the meadow remained flooded and growth was retarded. When the summer was warm and the fall mild, regrowth added to the yield and nutritive value of the meadow. In most years, however, early-fall frosts prevented further growth.

Frequent clipping throughout the season (treatments A and B)

Table 5. Results of two digestibility trials conducted for seven days on six animals on a sub-alpine sedge meadow near Kamloops, B. C.

	Total nutrients/ 100 pounds	Digestion coefficient		Digestible nutrients/ 100 pounds
July 30 - Aug. 5		(Percent)		
Crude protein	13.5	63.7		8.6
Crude fibre	22.5	63.5		14.3
N. F. E.	55.2	71.9		39.7
Ether extract	2.0	9.4 (x 2.25)	>	.4
T. D. N.				63.1
Sept. 9 - 15				
Crude protein	7.2	42.8		3.1
Crude fibre	28.1	61.9		17.4
N. F. E.	54.7	52.9		28.9
Ether extract	2.2	4.3 (x 2.25)	>	.2
T. D. N.				49.6

depressed forage yields. Rest near the end of the grazing season (treatments C and D 1958 and C in 1956) appeared to improve yields the following year. It is possible that the meadow would benefit from having the cattle removed by the third week in August so that the sedges could build up root reserves before frost.

Chemical analyses suggest that if growing animals were grazed only on this meadow their diets would be inadequate after about mid August. In addition, the low phosphorus content may slow up animal growth as early as the end of July in some years. Normally, live stock grazing in this zone have access to both meadow and spruce-fir forest types. Although the carrying capacity of the adjacent forest range is generally low, the nutrient levels of forest forbs and shrubs are considerably higher than those indicated for the meadow. It would, therefore, be important to arrange that the animals have access to sufficient forest forage to adequately supplement their diets.

The yield response to phosphate fertilizer is substantiated by the low phosphorus values of the forage. The good response to lime on this slightly acid peat soil is probably due to its neutralizing effect resulting in accelerated decomposition and subsequent release of nutrients. Calcium and sulfur do not appear to be deficient as no response was obtained from gypsum or ammonium sulfate.

Application of lime, phosphate or complete fertilizers would improve yields of the meadow. Trials on other types of meadows, however, are necessary before generalizations can be made.

The animals lost weight during September 1958 but gained weight in September 1959. Chemical analysis of the forage indicated that the crude protein content was higher and crude fibre content was lower in September 1959 than in 1958.

The downward trend in average daily gain, total gain per acre, and TDN produced per acre over the last three years suggests that the pastures were either overstocked or that season-long grazing was reducing forage production.

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