BEEF CATTLE NUTRITION AND PERFORMANCE ON SEEDED CLEARCUTS IN SOUTHERN INTERIOR BRITISH COLUMBIA

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The nutrient content of diets consumed, using a bite count technique, and the performance of beef cows and their calves grazing spruce and pine clearcuts in the southern interior rangelands of British Columbia on continuously and rotationally grazed pasture systems were evaluated in a 3- to 5-yr study. Forage species and plant parts ingested by cows were collected by hand clipping to simulate the diet. Nutrient composition of each sample forage was determined chemically and the nutrient levels of cattle diets were estimated from the bite counts of forages consumed and the chemical composition of the clipped samples. Dietary deficiencies, based on estimates of dietary intake of cows and chemical composition of samples, were noted for protein and phosphorus during August and September (rotational grazing); sodium during September; iodine, copper and zinc throughout the grazing season with the exception of zinc in the September diet of rotationally grazed cows. Selenium was adequate to excessive in the diet. Cow diets consisted of from 50 to 72% grass, from 23 to 42% forbs and from 4 to 20% shrubs. The diversity of diet components maintained nutrient levels of the diet above those provided by grass alone. Weight gains of cows and calves were obtained at monthly intervals for 3 yr and seasonally for 5 yr. There were no significant differences in cow performance among years or between grazing treatments. Cows gained an average of 0.22 kg d^{-1} over a 90-d grazing period. Average daily gains of cows decreased from 0.55 kg in July to −0.21 kg in September. Calf gains were significantly different between treatments over 5 yr. Calf gains averaged 0.92 kg^{-1} d on the continuously grazed pastures vs. 0.83 kg d^{-1} on those rotationally grazed. Total beef production of saleable beef (calves) under the continuous and rotational grazing system was 72.7 kg ha^{-1} and 65.3 kg ha^{-1}, respectively.

Key words: Beef cattle, production, nutrition, clearcuts, daily gains

[Nutrition et rendement des bovins de boucherie dans des zones de coupes rases réensemencées du centre-sud de la Colombie-Britannique.]

Titre abrégé: Conduite des troupeaux en zones de coupes rases.

Nous avons évalué la teneur en matière nutritive des aliments consommées, à l'aide d'une méthode fondée sur le dénombrement des bouchées ainsi que le rendement des vaches de boucherie et de leurs veaux au pâturage dans des zones de coupes rases d'épinettes et de pins des parcours de centre-sud de la Colombie-Britannique selon des systèmes de pâturage en continu ou en rotation, dans le cadre d'une étude d'une durée de 3 à 5 ans. Les espèces fourragères et les parties de plantes consommées par les vaches ont été recueillies à la main pour simuler la composition du régime. La composition en matières nutritives de chaque échantillon de fourrage a été déterminée chimiquement et la valeur nutritive des régimes des bovins a été évaluée à partir du dénombrement des bouchées de fourrage consommé et de la composition chimique des échantillons recueillis. Les carences alimentaires, fondées sur les valeurs estimatives de la consommation des vaches et sur la composition chimique des échantillons, ont été notées pour les protéines et le phosphore au cours des mois d'août et de septembre

(pâturage en rotation); nous avons également noté une carence en sodium en septembre et une carence en iode, en cuivre et en zinc pendant toute la saison de pâturage à l'exception du zinc, en septembre, dans le cas de la rotation. Le sélénium existait en quantités variant d'adéquates à excessives dans le régime. Le régime des vaches était fait de 50 à 72% de graminées, de 23 à 42% d'espèces autres que les graminées et de 4 à 20% d'espèces arbustives. La diversité du régime maintenait les teneurs en matière nutritive au-delà de celles fournies par les graminées seules. Les gains de poids des vaches et des veaux ont été mesurés tous les mois pendant 3 ans et toutes saisons pendant 5 ans. Nous n'avons observé aucune différence significative dans le rendement des vaches d'une année à l'autre ou d'un système de pâturage à l'autre. Les vaches montraient un gain moyen de 0,22 kg j^{-1} pendant une période de pâturage de 90 jours. Le gain moyen quotidien des vaches passait de 0,55 kg en juillet à −0,21 kg en septembre. Les gains des veaux étaient significativement différents d'un système à l'autre sur la période de 5 ans. Le gain moyen des veaux atteignait 0,92 kg j^{-1} dans les pâturages utilisés en continu, comparativement à 0,83 kg j^{-1} dans les pâturages utilisés en rotation. Les valeurs de la production totale de boeuf vendable (veaux) obtenues avec les systèmes de pâturage en continu et en rotation étaient de 72,7 et de 65,3 kg ha^{-1}, respectivement.

Mots clés: Bovins de boucherie, pâturage, pâturage en parcours, composition en matières nutritives, coupes rases, gain quotien

Graziers of beef cattle in mountainous areas largely depend on an altitudinal migration over several vegetation zones to meet the forage requirements of their beef herds. Summer grazing in the Pacific Northwest generally occurs on forested range in the Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) and Engelmann spruce (*Picea engelmannii* Parry) zone similar to the southern portion of the province of British Columbia and in the lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) zone similar to central British Columbia. Forage production on these ranges occurs on naturally occurring openings, on logged areas, and in the forest understory, depending on the crown closure of the forest canopy. Logged areas may be seeded with domestic species of grasses and legumes. Beef production in these areas is subject to extensive management and the nutrient composition of forage species grazed by cattle is poorly understood, yet many producers rely on production from these ranges for their livelihood.

There is a lack of data on beef production from forest ranges in the Pacific Northwest. Previous studies have evaluated beef production from sedge meadows (McLean et al. 1963) and from pinegrass ranges (McLean 1967; McLean et al. 1968; Hedrick et al. 1969). Other work has emphasized the chemical compostion of range plants (McLean and Tisdale 1960), and the effects of grazing on plantation tree survival (McLean and Clark 1980). Although all of these studies mentioned beef production, none of them attempted to evaluate the actual diet of cattle nor to measure body weight gains on clearcuts under moderate grazing intensity. Conversely, Quinton (1984) in British Columbia and Holechek et al. (1982) in Oregon evaluated cattle diets on mountainous range but did not mention beef production.

The objective of this study was to compare the nutritive value of the forage consumed and beef production under rotational grazing, as recommended by Clark and McLean (1978) to protect new forest plantations from adverse grazing and trampling, and under continuous grazing as practiced by much of the ranching industry. Data from this study will permit evaluation of management alternatives by ranchers and foresters.

MATERIALS AND METHODS

Site

The study was conducted in the Engelmann spruce-subalpine fir biogeoclimatic zone on the

Community Lake site described by Quinton (1984) and designated as Area 1 by McLean and Clark (1980). The 120-ha site, logged and burned in 1970, had been planted to lodgepole pine and Engelmann spruce in 1971 and seeded by air in 1972 with a grass-legume mix consisting of timothy (*Phleum pratense* L.), orchardgrass (*Dactylis glomerata* L.), bromegrass (*Bromus inermis* Leyss.), intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.) and alsike clover (*Trifolium hybridium* L.).

The experimental area had been crossfenced into 20-ha pastures that were relatively uniform in plant community composition and topography. Three pastures were used for continuous grazing and three for rotational grazing. Grazing in the rotational pastures was alternated each year such that each pasture was grazed once during July, once during August and once during September over a 3-yr period. Each pasture was traversed by a continuously flowing small stream.

Air temperatures from May through September ranged from a maximum of 32°C to a low of −6°C. Mean temperatures were 9.1, 14.5, 17.2, 16.9 and 11.1°C for May, June, July, August and September, respectively. The average frost-free period was 112 d. The average May-October precipitation was 170 mm. The grazing season, restricted by late spring growth, early fall frosts and snow, was from July to mid-October.

Thirty-two spring calves of relatively uniform weight and age were selected yearly, with their Hereford cross dams, from a commercial herd of approximately 400 cows and calves. Cows were paired according to weight and assigned at random to either a continuous or rotational grazing treatment.

Cows and calves were weighed monthly over the 90-d grazing season during each of the first 3 yr when diets and the nutrient contents of forages were also being estimated. Weights were taken for both the continuous grazing and rotational grazing herds each time cattle in the rotational treatment were turned into a fresh pasture. Weights were taken annually for both herds at the time of turn in and turn out of the continuously grazed herd for an additional 2 yr, thus giving 5 yr of July through September weight gains. Initial stocking rates were set at 1.5 ha per animal unit month (AUM) and adjusted as needed to maintain 50% utilization of the forage. This resulted in an initial allocation of 16 animal units per treatment and one additional animal unit to each treatment beginning with the second year.

Diet Estimates

Diet estimates were recorded for animals grazing pastures under both the continuous and the rotational grazing systems described by Quinton (1984). Trained personnel observed cattle from horseback using the bite count technique, noting the bite size and the specific plant part (e.g., flower, leaves, fruit, whole plant, etc.) of each species ingested (Reppert 1960; Free et al. 1971). A minimum of 10 cows per grazing treatment were consecutively observed during 3-h observation periods starting at 0600 h and again at 1600 h for 3 consecutive days per month. Each cow, picked at random, was identified by ear tag and observed until at least 200 bites were recorded. Most cows would disregard the rider's presence, allowing close observation of forage selection under normal grazing behavior. Restless cows were avoided in the sample as were cows that were not actively grazing. Diet estimates were not taken for a period of 7 d before or after cattle on the rotational treatment were introduced to a new pasture. A companion study evaluating the botanical composition of the diet was reported by Quinton (1984).

Immediately after the 3-d observation period, hand clipping was used to simulate each forage species and plant part ingested by cattle. Diet composition was converted from numbers of bites to weights (Free et al. 1971) and the relative contribution of each species and plant part to the overall diet of cattle was calculated. These data were used to simulate the nutritional value of cattle diets following laboratory analysis of the individual forage species. Methods used to determine forage nutrient concentrations were as follows: iodine, nitrogen and selenium by AOAC methods (1975); calcium, cobalt, copper, magnesium, sodium and zinc by the use of a Perkin-Elmer atomic absorption spectrophotometer (1976); neutral detergent fiber and acid detergent fiber by the method of Goering and van Soest as modified by Waldern (1971); digestible dry matter by the method of Tilley and Terry (1963); and phosphorus by the method of Jackson (1958).

Statistics used were analyses of variance and multipe range tests. Significant difference was set at $P<0.05$.

RESULTS AND DISCUSSION

Nutrient Levels of Diets

Deficiencies in dietary protein, phosphorus, sodium, iodine, zinc and copper were identified (Table 1) when compared to National

Table 1. Average nutritive composition of simulated cow diets grazing seeded clearcuts in southern interior British Columbia (1978–1980)

Fraction	Continuous grazed				Rotation grazed				Required
	July	Aug.	Sept.	Average	July	Aug.	Sept.	Average	
DMD†(%)	56*ab*	49*abc*	48*bc*	51*	59*a*	46 *bc*	44*c*	50*	—
Protein (%)	9.4*a*	8.2*b*	9.1*a*	8.9*	9.1*a*	7.1*c*	6.9*c*	7.7*	9.2 –11.0§
NDF† (%)	43.4	44.7	45.5	44.5	34.1	50.7	48.5	44.4	—
ADF† (%)	26.5	30.0	31.9	29.4	25.0	31.6	33.6	30.0	—
Lignin (%)	3.9	5.9	6.5	5.4	4.1	5.2	7.3	5.5	—
Calcium (%)	0.57	1.07	1.13	0.92	0.80	0.68	1.24	0.91	0.28– 0.33
Phosphorus (%)	0.28*a*	0.28*a*	0.32*a*	0.30*	0.27*ab*	0.22*ab*	0.17*ab*	0.22*	0.23
Magnesium (%)	0.15*b*	0.20*a*	0.19*a*	0.18*	0.16*b*	0.16*b*	0.16*b*	0.16*	0.10
Sodium (%)	0.10	0.14	0.05	0.10	0.10	0.09	0.04	0.08	0.08
Copper (ppm)‡	4.1	3.4	4.5	4.0	4.9	2.5	3.4	3.6	8
Zinc (ppm)	24.5	25.4	26.1	25.3	31.8	16.2	53.5	33.9	30
Cobalt (ppm)	1.31	1.67	1.49	1.49	1.49	1.13	1.86	1.49	0.10
Iodine (ppm)	0.3*b*	1.2*a*	0.2*b*	0.5*	0.3*b*	0.2*b*	0.4*b*	0.3*	0.5
Selenium (ppm)	2.56	1.84	0.77	1.72	4.94	0.77	0.69	2.13	0.20

†DMD, digestible dry matter; NDF, neutral detergent fiber; ADF, acid detergent fiber.
‡ppm, parts per million.
§Smaller value is for milking cow, larger value for growing calf.
*a-c*Values in same row followed by different letters are significantly different ($P<0.05$).
*Significantly different ($P<0.05$).

Table 2. Components of forage (%) in the diets of cows grazing seeded clearcuts in southern interior British Columbia

	Continuous grazing			Rotation grazing		
	July	Aug.	Sept.	July	Aug.	Sept.
Grass and sedge	64 ± 9†	50 ± 4	51 ± 11	67 ± 3	72 ± 5	54 ± 3
Forbs	24 ± 7	42 ± 7	40 ± 9	26 ± 6	23 ± 4	25 ± 3
Shrubs	10 ± 2	7 ± 2	4 ± 1	6 ± 3	4 ± 0	20 ± 13
Non vascular	0	0	3 ± 2	0	0	Tr‡

†Percent of total diet.
‡Tr, trace.

Academy of Sciences-National Research Council (NAS-NRC) standards (1984) for growth and production of beef cattle. These nutrients plus selenium are generally accepted as being deficient in range forages in British Columbia (Richmond 1980).

Protein concentrations in the diets were different ($P<0.05$) over the grazing season and between grazing treatments (Table 1). Protein was marginally adequate for milking beef cows for the continuous grazed herd over the season, probably as a result of this herd selecting regrowth from previously grazed plants as they reworked the pasture. At this altitude there was sufficient moisture for continual growth, and forage remained green through the grazing season. The protein content in the diet of the rotationally grazed herd was adequate during July but barely met maintenance requirements of dry stock during August and September. Cattle on the deferred rotation grazing treatment had access to new plant growth at turn out in July. By August the forage had headed out and was more mature and coarse with reduced protein concentrations and a trend of reduced digestibility ($P<0.08$). The diet of calves was not monitored, however, the protein content of the diet selected by cows was below the NAS-NRC recommendation for optimum growth of calves.

Dry matter digestibility of the diet selected by cattle varied between grazing treatments and decreased as the season progressed (Table 1). The decrease can be explained by the trend of increased fiber and lignin contents of forages in the diet over the season. The cattle grazing the rotation pastures were consuming more shrubs (Table 2) with a higher lignin content (Table 3) which, in combination with their consumption of more mature grasses, resulted in lower digestibility of the diet. In contrast, the continuous treatment cattle grazed more regrowth of grasses and more forbs which gave a more digestible diet.

Concentrations of phosphorus and magnesium in the rotation grazed cattle diet (Table 1) reflect the concentrations of these minerals in diet constituents. Cattle grazing the rotation treatment used more grass and the principle forb in their diet was horsetail (*Equisetum pratense Ehrh.*; Quinton 1984). These forages were low in phosphorus by September.

Iodine and sodium needs were met by supplementing salt as these nutrients were deficient in cattle diets.

Selenium concentrations in the diets of cattle at this location are of particular interest. Selenium is generally recognized as being deficient in forages over much of southern interior British Columbia (Richmond 1980), as a result, the feeding of supplemental selenium is increasing. Our data for Community Lake shows selenium levels were far above NAS-NRC dietary recommendations (Table 1). Concentrations of selenium of 28 ppm were found in aster (*Aster* spp.), which comprised up to 16% of one August period diet. There were no clinical signs of selenium toxicity apparent in either the animals in this study or in those from a producer's herd grazing in the area.

The monthly diets of cows by forage class and grazing treatment are shown in Table 2.

Table 3. Nutrient composition of classes of forage from cow diets on seeded clearcuts in southern interior British Columbia

	Grass			Forbs			Shrubs			
Fraction	July	August	Sept.	July	August	Sept.	July	August	Sept.	Required
DMD (%)†	56*a*§	45*b*	47*ab*	66*a*	57*b*	49*c*	47*a*	41*ab*	37*b*	—
Protein (%)	7.6	5.3	5.3	10.5	12.1	10.8	12.3	10.3	9.1	9.2 -11.0§
NDF (%)†	55.3	60.9	61.2	16.7*b*	31.5*a*	32.8*a*	25.0*b*	30.1*ab*	32.2*a*	—
ADF (%)†	30.7	37.9	38.0	20.7	22.9	28.8	19.9	28.6	29.1	—
Lignin (%)	3.5*b*	5.0*a*	5.7*a*	3.6*b*	5.9*a*	8.0*a*	8.7	12.4	10.6	—
Calcium (%)	0.30*b*	0.28*b*	0.47*a*	1.14	1.98	1.89	1.02*b*	0.65*b*	1.56*a*	0.28– 0.33
Phosphorus (%)	0.25*a*	0.19*ab*	0.17*b*	0.34	0.35	0.31	0.41*a*	0.30*b*	0.28*b*	0.23
Magnesium (%)	0.12	0.11	0.14	0.21	0.31	0.25	0.23	0.15	0.16	0.10
Sodium (%)	0.08	0.07	0.02	0.14	0.21	0.07	0.11	0.13	0.05	0.08
Copper (ppm)‡	3.0*a*	1.4*b*	1.2*b*	6.6	7.0	7.3	5.7	3.0	7.3	8
Zinc (ppm)	14.9	16.8	13.2	32.1	28.4	32.8	68.6	28.5	140.9	30
Cobalt (ppm)	1.70	0.81	0.94	1.32	2.63	1.88	1.72	1.11	2.92	0.10
Iodine (ppm)	0.2	1.4	0.2	0.2	0.2	0.2	0.4	0.2	0.3	0.5
Selenium (ppm)	0.22*ab*	0.19*b*	0.54*a*	10.5	4.09	1.43	0.80	0.12	0.18	0.20

†DMD, dry matter digestibility; NDF; neutral detergent fiber; ADF, acid detergent fiber as a percent of dry matter.
‡ppm, parts per million.
§Smaller value is for milking cow, larger value is for growing calf.
*a-b*Figures in same row in same forage followed by different letters are significantly different ($P<0.05$).

Table 4. Average daily gains of beef cows and calves on seeded clearcuts in southern interior British Columbia, 1978–1980

Month	Cow (kg d^{-1})	Calf (kg d^{-1})
July	0.55*a*	0.99*a*
August	0.33*ab*	0.93*ab*
September	−0.21*b*	0.76*b*

a-b Figures in the same column with different letters are significantly different at $P<0.08$ for calves.

Cows on the continuous grazing treatment consumed more forbs in August and September with correspondingly less grass. During this period, the protein content of grass had declined below maintenance requirements, whereas that of the forbs and shrubs remained relatively high (Table 3). thus, by consuming more forbs, the continuous grazing treatment cattle compensated for the decline in the protein content of grass.

The concentrations of protein, phosphorus, copper, zinc and iodine were lower in grasses than are recommended for cattle NAS-NRC 1984; Table 3). These deficiencies were not generally reflected in the overall cattle diets, however, because their concentrations in other forages were usually adequate. This is of importance to cattle managers, as there is continued pressure by forest managers for removal of forbs and brush from clearcuts. Our data indicate that removal of these forage species would reduce nutrient levels and subsequent beef production from seeded clearcuts.

Forage at the research site compared favorably in nutrient composition to forage on sedge meadows (McLean et al. 1963), native forested range (McLean and Tisdale 1960), and to pinegrass (McLean 1967, 1972). Domestic grasses seeded on the clearcut had slightly higher protein content during the later part of the grazing season than those in these studies, but they were still below maintenance requirements for the class of cattle using these ranges.

Cattle Weight Gains

The daily gain of cows in all treatments averaged 0.22 kg (±0.07 SE) over the 90-d grazing season when weighed monthly for the three grazing seasons (Table 4) and 0.15 kg (±0.04 SE) per day over the 5-yr period when weighed seasonally. There were no significant differences in weight gains either between continuous and rotation grazing treatments or among years. However, except for two of the nine monthly weight periods, the continuously grazed cattle had a trend of higher monthly weight gains.

The average daily gains (ADG) of cows varied over the grazing season (Table 4). Cows lost weight during September even though forage remained green until after killing frosts occurred at this elevation. This weight loss is partially explained by the forages having ripened, set seed, increased in fiber content and decreased nutritionally (Table 3). This change in nutritive value plus cooler temperatures with frost after mid-September resulted in depressed ADG.

Calves gained an average of 0.89 kg (±0.02 SE) per day over the three grazing months of the three grazing seasons. There were no differences over the 3-yr period between grazing treatment, among months, nor among years. However, there was a trend of smaller weight gains ($P<0.08$) as the 90-d grazing season advanced (Table 4).

Calf gains over the 5-yr period were significantly different ($P<0.05$) between grazing treatments (Table 5). Calves in the continuous grazing treatment gained 0.92 kg d^{-1} (±0.02 SE) compared to an

Table 5. Average daily gains of calves on seeded clearcuts in southern interior British Columbia (kg d^{-1}) for two grazing treatments

Treatment	1978	1979	1980	1981	1982	Average†
Continuous	0.88	0.89	0.95	0.97	0.92	0.92
Rotation	0.76	0.83	0.86	0.85	0.87	0.83

†Average gains are significantly different at $P<0.05$.

Table 6. Animal production from British Columbia forest rangeland, 92-d grazing period

Experiment	Range type	Class of animal	ADG (kg)	Average beef production (kg ha^{-1} d^{-1})
Community Lake (continuous grazed)	Seeded clearcut	Cows	0.22	0.19
		Calves	0.92	0.79
Community Lake (rotation grazed)	Seeded clearcut	Cows	0.22	0.19
		Calves	0.83	0.71
McLean and Clark† (rotation grazed)	Seeded clearcut	Cows	0.13	0.14
		Calves	0.64	0.70
McLean‡ (rotation grazed)	Seeded clearcut	Cows	0.16	0.18
		Calves	0.73	0.72
McLean‡	Pinegrass	Cows	0.32	
		Calves	0.91	
Hedrick§	Pinegrass	2-yr-old steers	0.57	
Quinton¶	Pinegrass	Cows	0.25	0.03
		Calves	0.97	0.10
McLean‖	Sedge meadow	Yearlings	0.64	0.80
McLean††	Pinegrass	Yearling steers	0.79	0.42

† McLean and Clark (1980) and personal communication.
‡ McLean, A., personal communication.
§ Hedrick et al. (1969).
¶ Stout and Quinton (1986).
‖ McLean et al. (1963).
†† McLean (1967, 1972).

ADG of 0.83 kg (±0.02 SE) for calves in the deferred rotation grazing treatment.

The ADG of both cows and calves were higher than those recorded earlier by McLean and Clark (1980) on the same pastures for the same seasonal time frame (Table 6). As a result, the average beef production per hectare from the continuously grazed herd was greater than the average beef production recorded by McLean and Clark (1980; Table 6). The average beef production from the rotationally grazed herd, however, was equivalent to what McLean and Clark reported.

In the present study the ADG for cows were lower than those reported for cows on pinegrass ranges by McLean and by Quinton (Table 6). Quinton, however, reported calf gains on moderately grazed pinegrass range that were higher than gains of calves at Community Lake in this study (Table 6). The ADG for calves at Community Lake were higher than ADG for other classes of cattle (yearlings) reported by McLean et al. (1963) on sedge meadows and by McLean (1967, 1972) for pinegrass range (Table 5).

Using the data from Table 6 and a 93-d grazing season, sedge meadows produced 73.6 kg of market beef per hectare while pinegrass range produced 38.6 kg ha^{-1} in McLean's studies and 9.0 kg ha^{-1} in Quinton's studies. The production data for McLean and associates is an indication of the maximum expected production from native forested range while Quinton's data represent the more usual conditions. In the present study the continuously grazed pastures on seeded clearcuts produced 72.7 kg of saleable beef (calves) per hectare and the rotationally grazed pastures produced 65.3 kg. Thus, although the ADG of cattle grazing the various range types may be equivalent, there is an advantage to grazing seeded clearcuts that is created by the increase in carrying capacity and subsequent increased stocking rates of this type of range.

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Association of Official Analytical Chemists. 1975. Official methods of analysis. 12th ed. AOAC, Washington, D.C.

Clark, M. B. and McLean, A. 1978. Compatability of grass seeding and coniferous regeneration of clearcuts in the south central interior of British Columbia. British Columbia Min. Forests Res. Note 83.

Free, J. C., Sims, P. L. and Hansen, R. M. 1971. Methods of estimating dry-weight composition in diets of steers. J. Anim. Sci. **32**: 1003–1007.

Hedrick, D. W., Eller, B. R., McArthur, J. A. B. and Pettit, R. D. 1969. Steer grazing on mixed coniferous forest ranges in northeastern Oregon. J. Range Manage. **22**: 322–325.

Holechek, J. L., Vavra, M. Skovlin, J. and Krueger, W. C. 1982. Cattle diets in the Blue Mountains of Oregon II Forests. J. Range Manage. **35**: 239–242.

Jackson, M. L. 1958. Vandomolybdenum phosphoric yellow color method in nitric acid system. *in* M. R. Jackson, ed. Soil chemical analysis. Prentice Hall. Englewood Cliffs, N.J.

McLean, A. 1967. Beef production on lodgepole pine-pinegrass range in southern British Columbia. J. Range Manage. **20**: 214–216.

McLean, A. 1972. Beef production on lodgepole pine-pinegrass range in the Cariboo region of British Columbia. J. Range Manage. **25**: 10–11.

McLean, A. and Tisdale, E. W. 1960. Chemical composition of native forage plants in British Columbia in relation to grazing practices. Can. J. Plant Sci. **40**: 405–423.

McLean, A. and Clark, M. B. 1980. Grass, trees, and cattle on clearcut-logged areas. J. Range Manage. **33**: 213–217.

McLean, A., Nicholson, H. H. and Van Ryswyk, A. L. 1963. Growth, productivity and chemical composition of a sub-alpine meadow in interior British Columbia. J. Range Manage. **16**: 235–240.

McLean, A., Freyman, S., Miltimore, J. E. and Bowden, D. M. 1968. Evaluation of pinegrass as range forage. Can. J. Plant Sci. **49**: 351–359.

National Academy of Sciences-National Research Council. 1984. Nutrient requirements of beef cattle. NAS-NRC, Washington, D.C. 90 pp.

Perkin Elmer Corp. 1976. Atomic absorption spectroscopy. Norwalk, Conn. Publ. 993–9301.

Quinton, D. A. 1984. Cattle diets on seeded clearcut areas in central interior British Columbia. J. Range Manage. **32**: 349–352.

Reppert, J. N. 1960. Forage preference and grazing habits of cattle at the Eastern Colorado Range Station. J. Range Manage. **13**: 58–65.

Richmond, R. J. 1980. B.C. cow-calf manual. Bull. British Columbia Ministry of Agriculture and Food, Victoria, B.C. 145 pp.

Stout, D. G. and Quinton, D. A. 1986. Pinegrass: an important forage in interior British Columbia. Tech. Bull. 1986-12E. Agriculture Canada, Research Station, Kamloops, B.C. 41 pp.

Tilley, J.M.A. and Terry, R.A. 1963. A two stage technique for the in vitro digestion of forage crops. J. Br. Grassland Soc. **18**: 104–111.

Waldern, D. E. 1971. A rapid micro-digestion procedure for neutral and acid detergent fiber. Can. J. Anim. Sci. **51**: 67–69.