Forage Intake by Cattle on Forest and Grassland Ranges

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Abstract

Forage intake was determined with steers using total fecal collections on forest and grassland vegetation types on mountain range in northeastern Oregon in 1976, 1977, and 1978. Forage intake varied from 1.6 to 2.5% of body weight (BW) on dry matter basis with a mean value of 2.1%. Forage intake did not differ ($P>.05$) between the two vegetation types when data were pooled across periods and years. During the summer grazing periods cattle on the forest had higher ($P<.05$) intakes than cattle on the grassland vegetation type. This is explained by higher forb and shrub consumption, more shade and less advanced plant phenology on the forest compared to the grassland vegetation types. Fecal collections from 5 steers for 3 days were needed to estimate fecal dry matter output with 90% confidence that the estimate was within 10% of the mean.

Information on forage intake by grazing herbivores is useful to the range manager in allocating forage resources so livestock and vegetation productivity is maintained. Cordova et al. (1978) and Van Dyne et al. (1980) provide comprehensive literature reviews on forage intake by cattle and sheep on rangelands. Van Soest (1982) provides a detailed review of factors determining forage intake by ruminants. Little data are available on differences in forage intake by cattle between vegetation types, stocking rates, and years on mountain range in the northwestern United States.

Forage factors affecting cattle intake have not been evaluated in other intake studies on rangelands. Cattle on grassland ranges may have different intakes than those on forested ranges with a high component of browse. The leaves of forbs and shrubs yield their nutritional potential much more quickly than grass leaves and stems (Short et al. (1974). Rapid digestion and decomposition results in quicker rumen turnover and higher intake of shrub and forb leaves compared with grass leaves and stems. Ingalls et al. (1966) found the average rumen retention time of two grasses was 21 hours compared with 16 hours for two legumes. Arthun (1981) reported the organic matter intake by cattle was 33% higher for alfalfa hay *(Medicago sativa)* than for bermuda-grass *(Cynodon dactylon)* although the digestibility of the two forages was the same. Thornton and Minson (1973), working with sheep, found that voluntary intake was 14% higher for legumes than grasses, although digestibility was 63% for the grasses compared with 53% for the legumes. White-tailed deer intake averaged 15% higher when they were fed browse diets averaging 58% digestibility than when fed brome hay (*Bromus* sp.) averaging 72% digestibility (Robbins et al. 1975). These studies indicate that ranges supporting a high component of palatable forbs and shrubs may permit higher intakes by cattle and other ruminants than grassland ranges.

Total fecal collection has become the method of choice for determining forage intake and/or digestibility of forages consumed by grazing livestock (Cordova et al. 1978). Significant differences apparently do not exist in individual feed consumption nor body weight gains between bagged and nonbagged animals (Price et al. 1964, Phar et al. 1971). When total fecal collections are used to estimate forage intake under range conditions, they are either combined with a digestibility estimate usually obtained in vitro from samples collected by esophageally fistulated animals or with a regression equation if the fecal N method (Arnold and Dudzinski 1963) is used. One problem with this procedure is that variability in fecal excretion between individual animals is often high (Van Dyne and Meyer 1964, Minson and Milford 1967, Scales 1972).

The objectives of this study were to determine forage intake by cattle on forest and grassland ranges in northeastern Oregon during different years and to calculate the number of steers and days needed for adequate sampling of fecal output. The influence of diet nutritive quality on intake was also evaluated.

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Experimental Site and Procedure

The study site was located at the Starkey Experimental Range and Forest near La Grande, Ore. Broad rolling uplands separating moderately deep canyon drainages characterize the topography of the Starkey range (Skovlin et al. 1976). Elevations range from 1,070 to 1,525 m. The average annual precipitation is approximately 59 cm, and comes as snow and rainfall in the winter and spring. In approximately 1 year out of 2, there is sufficient rainfall in the summer to result in early fall regrowth on the grassland areas.

A complete description of the vegetation on the experimental area is given by Ganskopp (1978). The primary herbage species on the grassland vegetation type are bluebunch wheatgrass *(Agropyron spicatum)*, Idaho fescue *(Festuca idahoensis)*, Sandberg bluegrass *(Poa sandbergii)*, junegrass *(Koeleria cristata)*, and common snowberry *(Symphoricarpos albus)*. On the forest, the principal herbage species are Idaho fescue, elk sedge *(Carex geyeri)*, Kentucky bluegrass *(Poa pratensis)*, common snowberry, ninebark *(Physocarpus malvaceus)* and spiraea *(Spiraea betulifolia lucida)*. Forbs and shrubs were much more important in the vegetation composition and cattle diet on the forest than on the grassland pastures (Holechek et al. 1982 a,b).

Two grassland and two forest pastures, all of equal grazing capacity, were delineated and fenced in the summer of 1975. Grazing was conducted on the pasture in 1976, 1977, and 1978. Cattle were grazed under a two-pasture-one herd rest-rotation grazing system on both vegetation types. Management under this system involved grazing one pasture all season and resting the other pasture in 1976. In 1977 grazing was conducted on the pasture rested in 1976 until mid-season when cattle were moved to the other pasture. In 1978 cattle were grazed all season on the pasture rested in 1976. Both the forest and grassland types were stocked with 18 head of yearling heifers during each year of study. In addition 8 head of experimental cattle were grazed on each vegetation type. The grazing season lasted 120 days during the 3 years of study. Cattle were placed on the pastures on June 20 and removed on October 10. The grazing season was divided into 4 periods which included June 20 to July 18 (late spring), July 19 to August 15 (early summer), August 16 to September 12 (late summer) and September 13 to October 10 (fall).

During the 3 years of study, diet samples were collected on 2 days every other week with 4 esophageally fistulated cows on each pasture. In vitro dry matter digestibility (IVDMD) and in vitro organic matter digestibility (IVOMD) were determined using the technique of Tilley and Terry (1963).

Four steers fitted with fecal collection bags were used on each pasture to determine total fecal output. Total fecal collections were made from all 4 steers on each pasture on the same day every other week. This resulted in 8 estimates of intake for each vegetation type for each period of study (4 steers × 2 days). Dry matter intake and organic matter intake were calculated from total 24-hour fecal output by using the equations of Van Dyne (1968):

$$\text{Dry matter intake (DMI)} = \frac{(100) \times (\text{total fecal dry matter output})}{100 - \%\ \text{IVDMD}}$$

$$\text{Organic matter intake} = \frac{(100) \times (\text{total fecal organic matter output})}{100 - \%\ \text{IVOMD}}$$

Intake was expressed as a percentage of body weight (BW) as discussed by Cordova et al. (1978). Data on livestock performance and diet quality on the forest and grassland pastures are discussed in Holechek et al. (1981). Botanical composition data for the pastures and cattle diets on the pastures are given in Holechek et al. (1982,ab).

Correlation analysis was used to determine the relationship between intake and diet quality characteristics associated with esophageal fistula samples. These characteristics included diet crude protein %, neutral detergent fiber (total cell wall) %, acid detergent fiber %, permanganate lignin % and in vitro digestibility %. Crude protein was determined by standard AOAC (1980) procedures. Neutral detergent fiber was determined by the Van Soest (1963) procedure. Acid detergent fiber and permanganate lignin were determined by the procedure by Van Soest and Wine (1968). Intake was also related to the percent by weight of each forage class in the diet. All correlations involved a sample size of 22 for each vegetation type and were conducted using procedures of Steel and Torrie (1960). Data converted to an organic matter basis were used for all intake and diet quality correlations.

Statistical comparisons were made between the forest and grassland pasture within each period and year. A completely randomized design with a one-way classification model and a standard *F*-test were used for all comparisons (Steel and Torrie 1960). Variation associated with steers was used to estimate experimental error while variation associated with days was used to estimate sampling error (Steel and Torrie 1960). Adequacy of sample size for estimating fecal output was evaluated using the formula of Stein (1945):

$$n = \frac{(t^2)(s^2)}{d^2}$$

In this formula n is the computed sample size, t is the tabulated value for the desired confidence level and the degree of freedom of the initial sample, d is the half-width of the desired confidence interval and s^2 is the variance of initial sample. Sums of squares associated with steers and days for each vegetation type/period/year combination were partitioned using a completely randomized analysis of variance. Steer and day variances were then calculated by the formula of Steel and Torrie (1960):

$$S^2 = \frac{s_w^2}{nm} + \frac{s_a^2}{n}$$

In this formula S^2 represents the minimum variance, n represents the number of steers (4), m represents the number of days (2), s_w^2 is the sum of squares for days and s_a^2 is the sum of squares for steers. This procedure made it possible to determine the optimal number of steers and days needed for determinations of fecal output for each vegetation type.

Results and Discussion

Relative intake values (Table 1) between pastures, periods and years showed the same trends regardless of whether intake was expressed as a percentage of body weight on a dry matter basis (BWDM) or an organic matter basis (BWOM). Therefore our discussion will concern BWDM because it is more interpretable to managers.

Forage intake varied from 1.6 to 2.5% BWDM with the lowest values occurring in the late summer on the forest and highest values in the fall on the grassland. Forage intake on the forest and grassland pastures did not differ (P>.05) when data were pooled across years and periods. Cattle never consumed over 2.6% BWDM during any period on any pasture and average intake level was 2.1% BWDM. These intake values fall within previously reported levels. Cordova et al. (1978) and Van Dyne et al. (1980) reported that in most studies concerning cattle on ranges in the western United States intake was between 1 and 3% of BWDM. Some values reported in their reviews were 0.9 to 2.2% in Nevada (Connor et al. 1963); 1.4 to 2.6% in Nebraska (Rittenhouse et al. 1970); 1.0 to 2.4% in Colorado (Scales 1972); 0.6 to 3.6% in Oregon (Handl and Rittenhouse 1972, Kartchner 1977, Kartchner et al. 1979); and 1.7 to 2.8% in Wyoming (Jefferies and Rice 1969). On mountain range in Colorao, Streeter et al. (1974) reported average intake values of 3.1, 3.2 and 2.8% BWDM for Brown Swiss, Charolais × Angus and Hereford cows, respectively, for a grazing season that extended from June through October. In this study chromic oxide was used to estimate fecal output and the authors felt their values slightly overestimated actual intake. Cordova (1977) reported a mean intake value of 2.0% BWOM over all seasons for steers at the Fort Stanton Experimental Ranch in southcentral New Mexico. On the same range Rosiere et al. (1980) found that heifers consumed from 1.4 to 2.1% BWOM while the intake for cows ranged from 1.7 to 2.5% BWOM. Their data show that different classes of cattle do not have similar intakes even when data are corrected to body weight. Van Dyne et al. (1980) reviewed 31 studies that reported forage intake values for cattle on

Table 1. Forage intake on a dry and a organic matter basis as a percentage of body weight on the forest (F) and grassland (G) in 1976, 1977, and 1978.

Sampling period	F (1976)	G (1976)	F (1977)	G (1977)	F (1978)	G (1978)	$\bar{X}$
				Dry matter basis			
Late spring	—	—	2.43	2.46	2.14[a]	2.38[a]	2.35
Early summer	2.17[a]	1.87[b]	2.15	2.12	2.05[a]	1.98[b]	2.06
Late summer	2.12[a]	2.00[b]	2.16[a]	1.97[b]	1.55	1.56	1.89
Fall	1.91[a]	2.02[b]	2.25[a]	2.54[b]	2.46[a]	2.01[b]	2.20
$\bar{X}$	2.07	1.96	2.25	2.27	2.05[a]	1.98[b]	2.10
				Organic matter basis			
Late spring	—	—	2.36	2.39	2.05[a]	2.28[b]	2.27
Early summer	2.10[a]	1.73[b]	2.06	2.04	1.97	1.94	1.97
Late summer	2.08	1.92[b]	2.05[a]	1.87[b]	1.50	1.49	1.82
Fall	1.77[a]	1.89[b]	2.16[a]	2.39[b]	2.39[a]	1.95[b]	2.09
$\bar{X}$	1.98	1.85	2.16	2.17	1.98[a]	1.92[b]	2.04

[1]Means within rows and years with different superscripts differ significantly (P<.05)

several different ranges using a variety of methods. They found that cattle consumed 1.8% BWDM when mean values for all these studies were averaged. During the spring and summer intake values averaged 2.1% BWDM while fall and winter values averaged 1.5% BWDM.

The summers of 1977 and 1978 were hot and cattle spent much of their time in shaded areas resting. However, the weather cooled in the fall and cattle were observed to spend more time grazing. Other researchers have reported heat stress reduced forage intake (Vohnout and Bateman 1972, Gengler et al. 1970, McDowell et al. 1976). The cooler microclimate created by the tree overstory may have contributed to increased forage intake on the forest.

Intake in the fall appeared to be dependent on fall rains and the observed subsequent forage regrowth. In 1976 and 1977 fall rains stimulated regrowth of grass on the grassland. Interception of moisture by the tree canopy may have affected the forest understory as no herbaceous regrowth was noted. Intake in 1976 and 1977 was higher ($P<.05$) on the grassland. In 1978, little precipitation occurred during the fall and cattle consumed significantly more forage on the forest.

Forage intake was higher on the forest than on the grassland in the summer during all 3 years of study. Forage species on the forest appeared to be less advanced in phenological development than on the grassland. Minson (1972) reported a substantial decline in forage intake with plant phenological advance when 6 tropical grasses were fed to sheep. During the summer cattle diets on the forest averaged 71% forbs and shrubs over the 3-year period compared to 32% on the grassland (Holechek et al. 1982a,b). Forbs and shrubs have faster digestion and passage rates in the ruminant digestive tract than grasses on basis of research by Ingalls et al. (1966) Short et al. (1974), Mertens (1973), and Milchunas et al. (1978). This could also explain the higher intake on the forest compared to the grassland during the summer periods.

The movement at mid-season of cattle on the forest in 1977 to the ungrazed pasture did not result in a significant change in forage intake. However, on the grassland, intake during the next period declined ($P<.05$) after movement indicating that intake was limited on both vegetation types by forage quality rather than availability.

Diet total cell wall % (neutral detergent fiber) was more closely associated with forage intake than other diet quality characteristics (Table 2). Our research is consistent with that of Mertens (1973) and Osbourne et al. (1974), who found cell wall % was highly associated with intake of a wide range of forages fed to sheep. Van Soest and Mertens (1977) found voluntary intake of 187 forages was more highly correlated with cell wall % than percentages of in vivo digestibility, in vitro digestibility, lignin, acid detergent fiber, crude protein, cellulose or hemicellulose. Forages with a low cell wall content typically have rapid rates of rumen fermentation (Smith et al. 1972, Short et al. 1974) and faster passage rates (Ingalls et al. 1966, Mertens 1973) than those with high cell wall content. Leaves of forbs and shrubs typically have lower cell wall contents than grass leaves and stems at comparable stages of maturity (Short et al. 1974 Huston et al. 1981).

Forages with high lignin contents (primarily forbs and shrubs) tend to have low cell wall contents and higher intakes than those of low lignin contents (primarily grasses) (Van Soest 1965, 1966). Within forage classes lignin is well related to intake but little relationship exists between intake and lignin when forage classes are mixed on the basis of studies by Osbourne et al. (1974), Van Soest (1965) and Mertens (1973).

Table 2. Correlation coefficients between intake and diet quality characteristics on the forest and grassland.

	CP	NDF	ADF	LIG	IVOMD
Forest[1]	+.49*	-.71*	-.34	-.01	+.31
Grassland[1]	+.63*	-.67*	-.51*	-.21	+.55*
Forest and grassland[2]	+.56*	-.69*	-.42*	-.10	+.43*

[1]n=22.
[2]n=44.
*=Significant at $P<.05$.
CP=Diet crude protein %.
NDF=Diet neutral detergent fiber (total cell wall constituents) %.
ADF=Diet acid detergent fiber %.
Lig=Diet permanganate lignin %.

Table 3. Correlation coefficients between intake and forage class % in cattle diets from the forest and grassland.

	% Grass	% Forbs	% Shrubs	% Forbs and shrubs
Forest[1]	-.11	+.15	+.24	+.11
Grassland[1]	-.21	+.25	+.02	+.21
Forest and grassland[2]	-.16	+.20	+.11	+.16

[1]n=22.
[2]n=44.

Digestibility in our study was not highly related to intake. Part of this may be explained by environmental factors such as heat stress during the summer of 1978 that could have suppressed intake without influencing diet quality. Another important factor is that intake is more a function of passage rate than total digestibility (Mertens and Ely, 1982). Studies by Ingalls et al. (1966), Mertens (1973), Thornton and Minson (1973), and Milchunas et al. (1978) show forbs and shrub leaves, which are typically more lignified and have lower digestibilities than grass leaves and stems, have higher intakes due to more rapid decomposition and quicker passage through the ruminant digestive tract. The higher lignin content of forb and shrub leaves and stems compared to grass leaves and stems may increase passage rate by making these parts more brittle and causing finer fragmentation (Milchunas et al. 1978). Finer particles pass more quickly out of the reticulo-rumen compared to larger ones (Van Soest 1966, Mertens 1973, Milchunas et al. 1978). There is also evidence that the short, broad and cubicle shape of the forb and shrub fragments permits quicker passage out of the reticulo-rumen than the long, thin and fiber-like particles of the grasses (Troelson and Campling, 1968, Mertens 1973). We believe the fact cattle diets in our study were comprised of mixed forage classes largely explains the low association between intake and cattle diet in vitro digestibility.

Diet crude protein level in our study was not highly associated with forage intake. Milford and Minson (1965) found intake by sheep of forages about 7% crude protein was not well related to crude protein content. However, their data show intake declines precipitously in forages below this level. Apparently diet crude protein concentrations below 7% do not meet the needs of the rumen bacteria. Crude protein concentrations in our study never fell below 8% on either vegetation type (Holechek et al. 1981).

Table 4. The number of steers and days required to determine fecal dry matter output on the forest and grassland pastures in 1976, 1977, and 1978 with 90% confidence the estimate is within 10% of the mean.

	Forest				Grassland			
Sampling period	1976	1977	1978	$\bar{X}$	1976	1977	1978	$\bar{X}$
	Number of Animals							
Last spring	—	9	4	6	—	6	4	5
Early summer	5	5	3	4	5	6	3	5
Late summer	5	5	6	5	4	7	6	6
Fall	4	5	8	6	2	5	3	3
$\bar{X}$	5	5	5	5	4	6	5	5
	Number of Days							
Last spring	—	1	2	2	—	2	3	2
Early summer	2	4	6	3	3	3	4	3
Late summer	3	3	2	3	4	3	2	3
Fall	3	2	2	2	6	3	5	5
$\bar{X}$	3	3	2	3	4	3	3	3

None of the correlations between intake and forage class were significant ($P<.05$) (Table 3). However there was a tendency for intake to be positively associated with forb and shrub consumption and negatively associated with grass consumption.

Sample size (steers × days) needed to determine fecal dry matter output at the 90% confidence level to be within ± 10% of the population mean are given in Table 4. These data indicate that 5 steers and 3 days of collection are needed to adequately sample each period.

Van Dyne and Meyer (1964) reported that 2 steers for 2 days would estimate forage intake in drylot within 10% of the mean and 95% confidence. Under grazing conditions these investigators found 4 steers were needed to estimate fecal output with the same precision level based on an average fecal output over 9 days. Van Dyne (1968) concluded about 5 steers were needed per treatment to estimate fecal output within 10% of the mean with 95% confidence. Scales (1972) considered 6 steers necessary to estimate fecal excretion within 15% of the mean with 95% confidence.

It is important to recognize that days should represent subsamples of the fecal output values of the individual steers when data are analyzed statistically. Therefore, samples should be composited across days for an estimate of experimental error. The variance associated with days represents sampling error and should not be used for testing treatment effects. Steel and Torrie (1960) provide a complete discussion of procedures for variance partitioning when the experiment involves subsamples.

Conclusions

Daily forage intake by cattle averaged 2.1% BW on a dry matter basis during typical northeastern Oregon grazing seasons. Recent studies show that 2% BW provides a very good estimate of daily forage dry matter intake for cattle on most ranges when estimates are averaged across seasons. Our data were collected with steers and may not apply to other classes of cattle. Ranges supporting a high component of palatable forbs and shrubs should improve intake by cattle over ranges supporting primarily grasses, particularly during periods of forage dormancy or drought. There was no difference in intake between the forest and grassland vegetation types when data were averaged across periods and years. However cattle on the forest had higher intakes than cattle on the grassland during the summer periods. In these periods forb and shrub consumption was considerably higher on the forest than on the grassland. More shade and less advanced plant phenology also explain the higher intake of cattle on the forest compared to grassland vegetation type during the summer periods.

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