Grazing Preferences of Cattle in Regenerating Aspen Forest

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Abstract

The relative preferences of cattle for the major plant species in regenerating aspen *(Populus tremuloides)* forest following burning were studied to assist in developing strategies for controlling aspen regrowth by grazing with cattle. The tendency of cattle to graze forest rather than grassland increased as grasses matured towards the end of the growing season. Within the forest, cattle preferred herbaceous species when they were present. Of the shrub species, generally wild rose (*Rosa* spp.) and wild raspberry *(Rubus strigosus)* were preferred over aspen but aspen was preferred over western snowberry *(Symphoricarpos occidentalis)*. Aspen was grazed more readily late in the season than early. Similarly western snowberry, which was of consistently low acceptability, was relatively more acceptable late in the season. Cattle readily consumed wild raspberry in both years and both seasons. Wild rose was accepted early in the season in both years but was less preferred late in the season when it had relatively more woody growth.

Since aspen *(Populus tremuloides)* forest provides very little useful fodder for beef cattle, the carrying capacity of ranches that support areas of forest may be increased by replacing the forest with grassland. Following initial clearing operations such as clear cutting or burning, large numbers of new aspen suckers regenerate (Sampson 1919, Berry 1973, Perala 1979) but generally cattle consume very little of this material. Many beef producers consider that the foliage of aspen suckers is unpalatable to cattle, yet aspen is recognised as an important browse species for deer, elk and moose (Krebill 1972, Mueggler and Bartos 1977, Penner 1978, Parker and Morton 1978). In some situations browsing by ungulates has been heavy enough to threaten survival of aspen stands (Smith et al. 1972, Bartos and Mueggler 1979). If cattle would graze aspen suckers, then grazing might serve as a useful low-cost adjunct to other brush control practices, especially where logs and stumps prevent mechanical operations, and where cost is a limiting factor. Use of the grazing animal to remove regrowth offers the added advantage that the regenerating forest becomes a forage resource rather than simply something to be removed.

Sheep and cattle will graze aspen suckers under certain circumstances. Smith et al. (1972) reported that cattle grazed 18% of available aspen sprouts in the first year after clear cutting in Utah, but only 3 to 4% in the next 2 years. In Alberta, 3 years after herbicide treatment, Hilton and Bailey (1974) found that the consumption of available aspen by cattle with access to both grassland and regenerating forest varied between years from 3 to 43% by weight.

The reason for wide variation in utilization of aspen by cattle is not clear. The availability of alternative forages, and the phenologic stage of all species present, has a major influence on diets (Heady 1964). Rosiere et al. (1975) found that the diets of cattle on open grassland depended, partly, on the relative availability of the species present. Also the relative preference for various species changes through the season (Gammon 1978, Roath and Krueger 1982, Holechek et al. 1982).

Since these factors may influence the propensity of cattle to browse in a regenerating aspen forest, an experiment was conducted to determine the relative preference by cattle for the major species in a regenerating aspen forest seeded to forages and the adjacent grassland, as influenced by (1) season of grazing, (2) stand age and (3) defoliation of plant species present. The effects of grazing treatments on the botanical composition of the regenerat-

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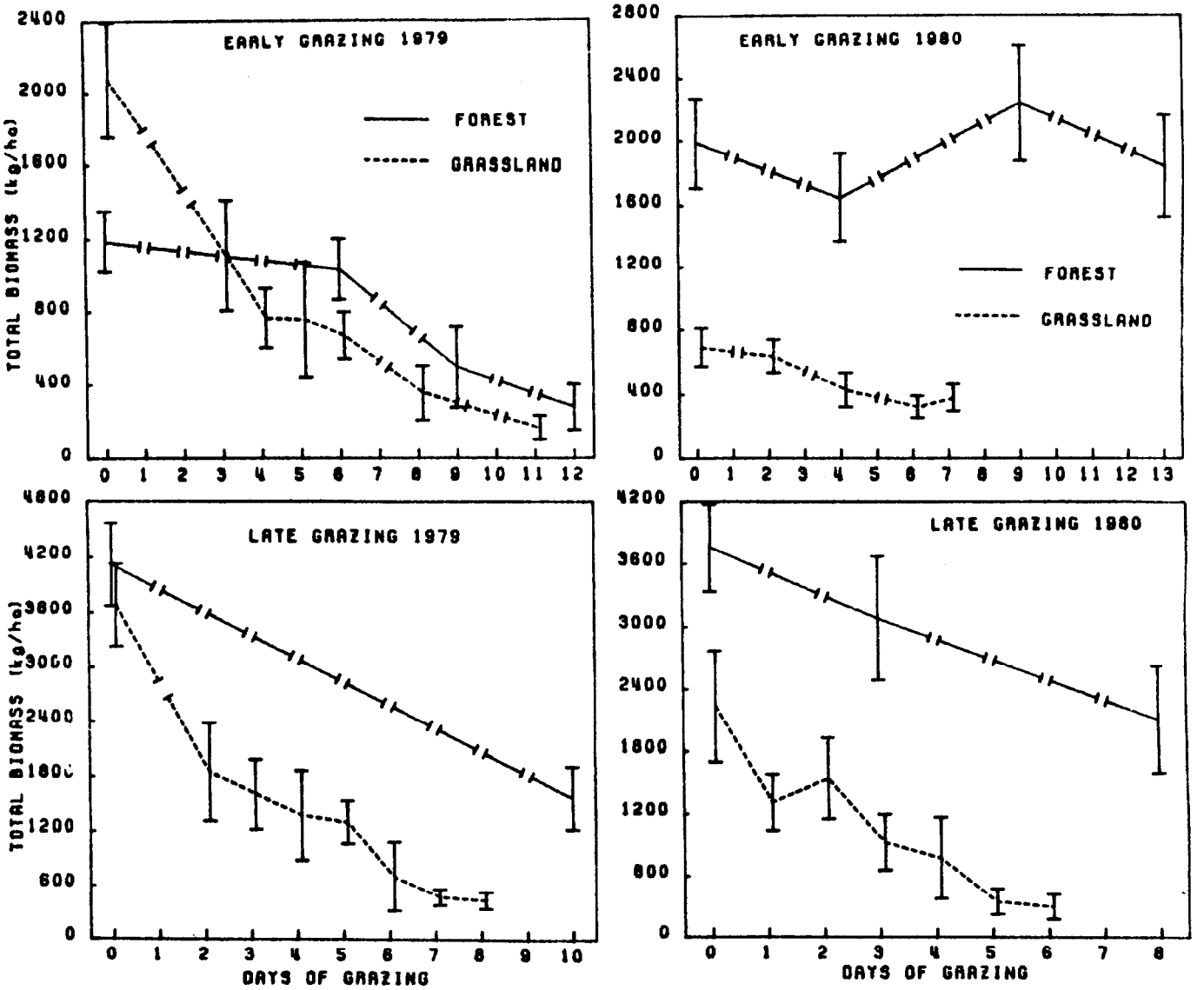

Fig. 1. *Biomass estimates of grassland and forest (kg ha^{-1}) during early and late grazing in 1979 and 1980 showing 95% confidence intervals. In late-grazed forests 1979, only pre- and post-grazing estimates were available.*

ing forest have been described by FitzGerald and Bailey (1984).

Methods

Experimental Site

The experiment was conducted during 1979 and 1980 on the University of Alberta Ranch at Kinsella, in the aspen parkland of Alberta. Average annual precipitation is 432 mm, 75% of which falls in the growing season. Precipitation in the growing season of 1979 and 1980 was 259 mm and 503 mm, respectively. The topography is strongly undulating, with aspen groves occupying most of the more mesic sites.

Experimental Procedure

A 7-year-old stand of aspen was burned on 15 May 1979. Fine fuel within the forest was estimated at 10 tonnes ha^{-1} and total fuels at 40 tonnes ha^{-1}. With a wind speed of 2.4m sec^{-1} and relative humidity of 40%, the fire (a headfire) consumed 15-20 tonnes of fuel and killed over 95% of all topgrowth. Three days after the fire, a seed mixture of 2.8 kg ha^{-1} of alfalfa (*Medicago sativa* cv. Drylander) inoculated with rhizobium, and 7 kg ha^{-1} each of bromegrass (*Bromus inermis* cv. Magna), orchard grass (*Dactylis glomerata* cv. Kay), and creeping red fescue (*Festuca rubra* cv. Boreal) was broadcast into the ashes.

The area was subdivided into 6 paddocks, each 0.5 ha in size, to provide 3 replications each of the 2 grazing treatments. Approximately 30% of each paddock was native grassland; the remainder was regenerating aspen forest.

Cattle (cows and heifers) which had been maintained on aspen forest/fescue grassland were placed on the treatment paddocks either early or late in the growing seasons of 1979 and 1980. Each treatment paddock was grazed either early or late, not both. Cattle were retained in the treatment paddocks until all edible material had been consumed or trampled, in order to determine how their apparent preference responded to selective depletion of the various plant species present.

Grazing times were:

1979 Early	July 5 to 17	(12 days)
Late	22 August to 1 September	(10 days)
1980 Early	31 May to 13 June	(13 days)
Late	August 15 to 23	(8 days)

The early grazing treatments took place when plant growth was

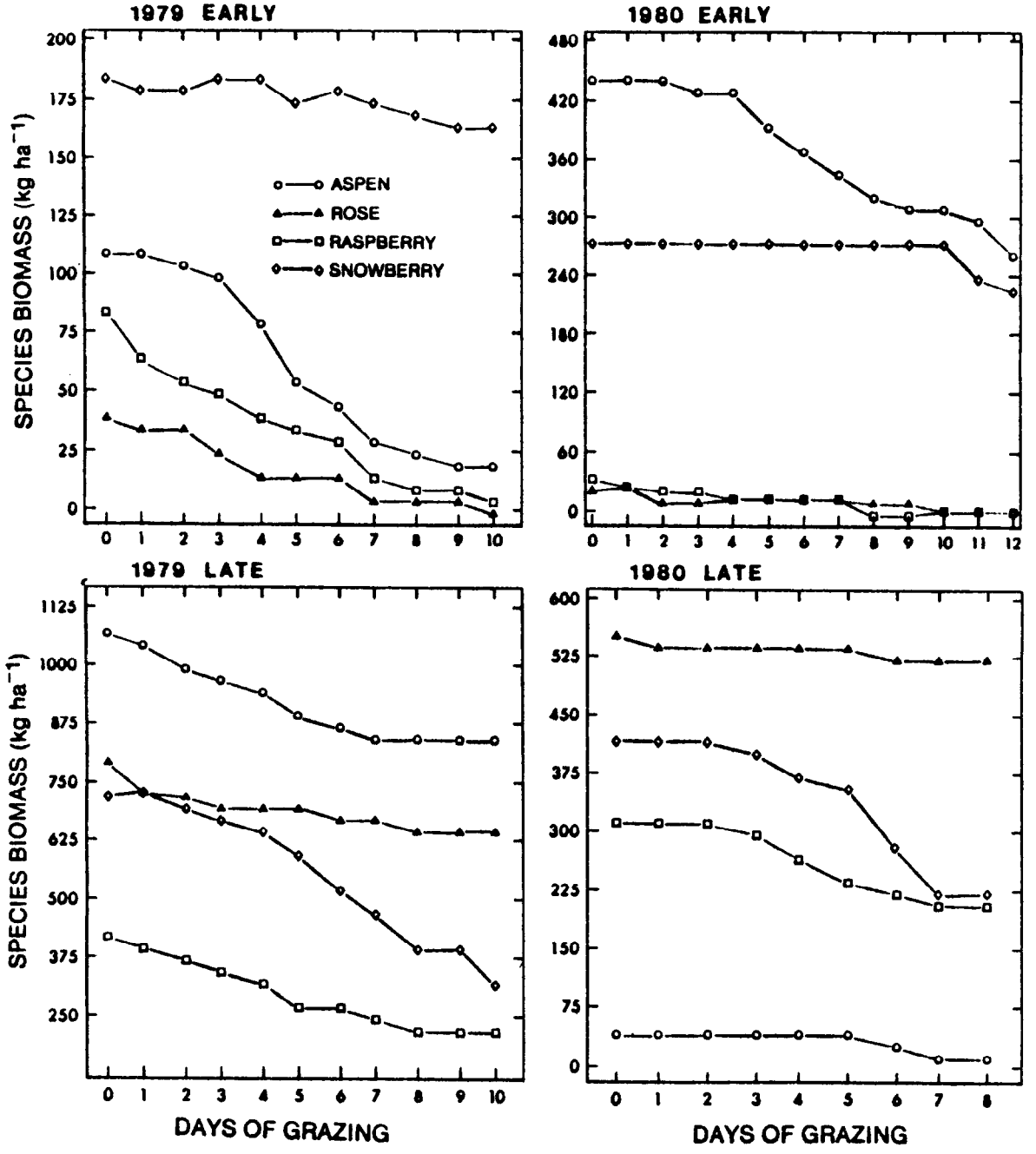

Fig. 2. *Daily estimates of the biomass of aspen, wild rose, wild raspberry and western snowberry during early and late grazing trials in 1979 and 1980.*

sufficient to support the smallest practical herd (3 animals) for 10 days. The late grazing treatments took place after elongation of aspen stems had ceased but before aspen leaves showed any yellowing prior to senescence. In 1979, complete defoliation within about 10 days required 8 animals ha^{-1} for early grazing, and 25 animals ha^{-1} for late grazing since there was more plant material to be removed. In 1980 the early treatment was grazed with 8 animals ha^{-1}, and the late treatment with 27 animals ha^{-1}.

Measurements

Herbage yield in the grassland was estimated prior to grazing and daily throughout the grazing period from the dry weight of plant material clipped from 6 (0.5-m^2) frames randomly placed in the grassland community in each paddock. Total yield of herbaceous and woody species within the forest was estimated prior to grazing and at intervals throughout the grazing period by harvesting all plant material within randomly placed 0.5-m^2 quadrats, 10 per paddock. In late-grazed forest in 1979, only pre- and post-grazing estimates were available.

To observe the differential grazing of individual species, 10 permanent 1-m^2 quadrat sites were established randomly within the aspen forest in each paddock. The height and number of each species within these quadrats was measured prior to grazing and daily during the grazing period.

During the grazing trials in 1979, samples of the 4 major woody species in the regenerating forest were collected and used to establish relationships between plant height, entire or browsed, and above-ground plant weight, by the procedure described by Fitz-Gerald (1983). The process was repeated in 1980, for early-grazed aspen. Having estimated the mean weight of a species and recorded its density, the total above-ground weight (biomass) of that species could be calculated.

Statistical Analysis

The linear regression between biomass and days of grazing was computed within grazing period and species. Determination of differences among the regression coefficients of the 4 species within each grazing period was made using analysis of covariance homogeneity of regression procedures (Neter and Wasserman 1974, p. 702). Specific differences in species intercepts and slopes were computed according to Neter and Wasserman 1974, p. 166. The intercepts were estimates of species biomass before grazing.

Preference Index

Silen and Dimock (1978) developed a model to describe the relationship between plant palatability and availability. We used this model to develop a diet selection or preference index based on the changing level of availability of individual species through the grazing period.

The model employed a relative preference index (P), which encompassed the factors affecting an animal's response to a given species if availability of all species was equal. It also required an availability index (A), which was calculated as the biomass of a given species, expressed as a percentage of total biomass. The overall preference (P) for a given plant species could be determined from the re-arranged model as follows.

$$P = \frac{A_i}{\sum_{i=1}^{n} A} \times \frac{P_i}{E_i} \times W_{(i-1)}$$

where A_i = availability of a given species on the i th day.
P_i = preference of the given species on the i th day.
$W_{(i-1)}$ = total plant biomass at the beginning of the i th day.
$\sum_{i=1}^{n} A$ = availability of all plant species on the i th day.
E_i = consumption of the given species on the i th day.

Daily consumption was assumed to be the weight of plant material removed each day. Material removed by trampling was assumed to be proportional to the amount consumed. The preference index was calculated for each day of grazing using an iterative computer program which substituted and readjusted estimated values of P.

The same analysis used for plant biomass was used to analyse apparent changes in relative species preference over the grazing period, the relative preference of plants on offer in an ungrazed forest, and their mean relative preference over the grazing period. For the latter, the preference index means adjusted to the covariate (days-grazing) mean were compared among species.

Results

Plant Community

The botanical composition of the regenerating forest estimated from height and density data in 1979, and direct sampling in 1980, is presented in Table 1. In addition to aspen, the major woody species were wild rose *(Rosa woodsii)*, western snowberry *(Symphoricarpos occidentalis)* and wild raspberry *(Rubus strigosus)*. Sown grasses became a significant component in 1980.

Habitat Selection

The biomass of regenerating aspen forest and adjacent grassland declined as it was consumed by cattle during the grazing periods in 1979 and 1980. (Fig. 1). In the early-grazing trial in 1979, cattle browsed very little in regenerating forest until the adjacent grassland yield had been reduced to 750 kg ha^{-1}. In the late-grazing trial, although measurement was limited to the beginning and end of the grazing period, field observations showed that the regenerating forest was utilized from the beginning of the grazing period and extensive browsing occurred when the grassland still yielded 180 kg ha^{-1}.

In 1980, a similar pattern of grassland and shrub removal was evident in the late grazing treatment but in the early grazing treatment the pattern changed. Consumption of 'forest' species up to day 4 was more rapid than consumption of grassland species.

Table 1. Botanical composition (%) and total biomass (kg ha^{-1}) of regenerating aspen forest in early and late grazed paddocks, estimated prior to grazing in 1979 and 1980.

	1979†		1980	
	Early	Late	Early	Late
Aspen	23	36	29	2
Rose	10	25	9	19
Raspberry	17	14	2†	10†
Snowberry	44	24	17	35
Grass	—	—	28	18
Other	6	1	15	16
Total Biomass	450	3000	1400	2000

†Estimated from density and height data.

The reason was that herbaceous species, mainly orchard grass, made up 30% of available forage in the regenerating forest under early grazing and animals grazed these preferentially. After day 4, the cattle preferred grassland, and reduced yields to about 300 kg ha^{-1} by day 7. Dry weather prevailed in May 1980. On days 3, 4, and 5 of the early grazing period it rained. The effect of relief from drought on woody plants (as yet unbrowsed), produced a non-significant increase in available forest species from day 4 to day 9 (Fig. 1).

Forage Selection within Regenerating Forest

Aerial biomass of the 4 major woody species in the regenerating forest (Fig. 2) declined as it was consumed during each of the 4 grazing trials. Furthermore, the coefficients for the linear regressions of biomass on days grazing (Table 2-slope) showed significant differences among rates of decline of biomass during grazing. This analysis describes the rates of decline in biomass over the whole grazing period. In the early grazing period of both 1979 and 1980, there was little consumption of aspen in the first few days of grazing, after which it was consumed in preference to other species (Fig. 2). This was not evident in the late grazing periods.

Relative Preference Indices

Preference indices were calculated daily from each species by

Table 2. Estimates of the biomass (kg ha^{-1}) of four woody species at the commencement of grazing (intercepts) in early and late grazing treatments in 1979 and 1980, and coefficients *(b)* from the regression of species biomass on days grazing with grazing periods.

Grazing period	Spp.	Intercept (a)	Slope *(b)*	r^2
1979 Early	Aspen	130.1b	-11.1a	.33
	Rose	44.1d	- 4.3c	.53
	Raspberry	81.4c	- 7.5b	.35
	Snowberry	189.4a	- 2.1c	.00
Std. Error		7.15	1.05	
1979 Late	Aspen	1079.9a	-24.9b	.16
	Rose	765.5c	-12.1c	.01
	Raspberry	432.2d	-21.8b	.52
	Snowberry	825.7b	-44.1a	.39
Std. Error		14.6	2.16	
1980 Early	Aspen	487.5a	-16.7a	.06
	Rose	19.2c	- 1.3b	.16
	Raspberry	31.6c	- 2.6b	.27
	Snowberry	286.1b	- 2.5b	.00
Std. Error		7.1	0.89	
1980 Late	Aspen	53.7d	- 5.6c	.05
	Rose	557.8b	- 4.5c	.00
	Raspberry	352.3c	-17.3b	.06
	Snowberry	489.6a	-28.8a	.36
Std. Error		13.5	2.38	

a or b values within a grazing period followed by the same letter are not significantly different ($P<0.05$).
r^2 significant if greater than 0.12 ($P<0.05$, 30 df).

Table 3. Preference index means adjusted to covariate zero (intercept), and to the covariate mean (mean), with standard errors, for linear regressions of preference index on days grazing.

Treatment	Intercept.	SE_{int}	Mean	$SE_{\bar{x}}$	r^2
1979 Early					
Aspen	.63b	.19	.70c	.08	.01
Rose	1.22a	.21	1.57a	.10	.16
Raspberry	1.09a	.16	1.17b	.07	.01
Snowberry	.23c	.24	.32d	.11	.00
1979 Late					
Aspen	.79bc	.12	.50b	.06	.53
Rose	1.05b	.14	.59b	.06	.26
Raspberry	1.74a	.12	1.31a	.06	.24
Snowberry	.50c	.12	.96a	.06	.51
1980 Early					
Aspen	.12b	.21	.58c	.09	.18
Rose	2.07a	.24	1.88b	.13	.05
Raspberry	2.44a	.25	3.18a	.14	.03
Snowberry	.18b	.39	.71c	.22	.17
1980 Late					
Aspen	2.25a	.25	2.22a	.11	.01
Rose	.67bc	.19	.36d	.09	.15
Raspberry	1.19b	.18	1.07b	.08	.03
Snowberry	.10c	.23	.65c	.09	.47

Means within grazing periods followed by the same letter are not significantly different ($P<0.05$).
r^2 significant if greater than 0.12 ($P<0.05$, 30 df).

grazing trial. These indices account for differences in the composition of the plant community and should be a more stable representation of preference than slopes that describe biomass disappearance.

Slopes of linear regressions of preference indices on days-grazing were examined by least squares regression (Table 3). The least square means were adjusted to the covariate value zero (regression intercept) and to the covariate mean. The latter is an estimate of the preference index of each species over the whole grazing period at each time of grazing. Hence it is affected by preference characteristics of defoliated plants. The coefficients of determination (r^2) indicate the high degree of variability associated with these preference indices.

Preference for individual species at the onset of grazing (i.e., the intercept) was influenced by both season of grazing, and age of stand. Preference for aspen at commencement of grazing was lower early in the season than late. As early grazing proceeded and alternative species were removed, aspen became more acceptable to cattle, (Table 3-mean); but under late grazing it became progressively less acceptable as the more palatable portions were removed. Rose was relatively more acceptable to cattle early in the season than late. Its acceptance was lowest late in the second year, when rose had developed woody stems. Raspberry was preferred, regardless of season or stand age. This is not surprising, since, in 1980, regrowth consisted of new shoots from below ground. Snowberry was always among the least preferred species, but, like aspen, it became more acceptable as alternative species were removed.

To ensure that absence of some species towards the end of a grazing period was not resulting in unduly high mean preference indices for remaining species, the indices for the first 5 days of the grazing period were analysed separately. Results are not presented because they did not alter the relative preference rating of species, except the mean index for snowberry in late 1979 became equal to rose and aspen. Hence, the high relative preference of snowberry in late 1979 (Table 3) arose after day 5, when other forages were becoming scarce.

Discussion

Aspen was more acceptable to cattle when grazed late in the season than grazed early. This is evident from both indices (intercepts, Table 3) and biomass curves. Similar findings have been reported by Bryant and Kuropat (1980), who showed that young shoots of woody shrubs were avoided by moose. Such shoots had a higher content of resins than older shoots and selection of shrubs by moose was strongly negatively correlated with the concentration of such resins. Smith et al. (1972) also observed that range cattle browsed aspen more readily in the second half of the growing season.

Snowberry was unpalatable in all seasons, but after initial avoidance, there was some evidence that it was grazed less reluctantly late in the season. Again, this may be related to concentration of resins in the foliage.

Rose and raspberry were highly preferred as young shoots in the first year. Raspberry continued to be favoured in the second year as it produced new tender shoots from underground rhizomes. Rose grew a woody stem from which small new shoots arose after each grazing period. This may account for differences in preference between these species late in the year.

Preference indices were calculated from data over the whole grazing period. It should be noted that such a calculation obscures changes in preference that may occur during the grazing period as a result of changes in the composition of the species on offer or changes in their character (e.g., proportion of leaf). Hence it is important when using preference indices either to interpret them in conjunction with species biomass curves, or to select grazing periods in which those curves are essentially linear; i.e., when there is little change in the character of the species on offer to the animals.

Literature Cited

Bartos, D.L., and W.F. Mueggler. 1979. Influence of fire on vegetation production in the aspen ecosystem in western Wyoming. *In:* North American Elk, Ecology, Behaviour and Management. Ed. M.S. Boyce and L.D. Hayden-Wing. Univ. Wyo. Laramie.

Berry, A.B. 1973. Production of dry matter from aspen stands harvested on short rotations. p. 209-218. IUFRO Biomass Studies, Coll. Life Sci. Agr. Univ. Maine at Orono.

Bryant, J.P., and P.J. Kuropat. 1980. Selection of winter forage by subarctic browsing vertebrates: The role of plant chemistry. Ann. Rev. Ecol. Syst. 11:26-85.

FitzGerald, R.D. 1983. An indirect method to estimate the aerial biomass of small single-stemmed woody plants. J. Range Manage. 36:757-759.

FitzGerald, R.D., and A.W. Bailey. 1984. Control of aspen regrowth by grazing with cattle. J. Range Manage. 37:156-158.

Gammon, D.M. 1978. Patterns of defoliation during continuous and rotational grazing of rangeland by cattle. p. 603-605. Proc. 1st Int. Rangeland Congr. Denver, Colo.

Heady, H.F. 1964. Palatability of herbage and animal preference. J. Range Manage. 17:76-82.

Hilton, J.E., and A.W. Bailey. 1974. Forage production and utilization in a sprayed aspen forest in Alberta. J. Range Manage. 27:375-380.

Holechek, J.L., M. Vavra, J. Skovlin, and W.C. Krueger. 1982. Cattle diets in the Blue Mountains of Oregon, I. Grasslands. J. Range Manage. 35:109-112.

Krebill, R.G. 1972. Mortality of aspen on the Gros Ventre elk winter range. USDA Forest Serv. Res. Pap. INT-129.

Mueggler, W.F., and D.L. Bartos. 1977. Grindstone Flat and Big Flat exclosures—a 41 year record of changes in clearcut aspen communities. USDA Forest Serv. Res. Pap. Int-195.

Neter, J., and W. Wasserman. 1974. Applied linear statistical models. Richard and Irwin Inc. Ill.

Parker, G.R., and L.D. Morton. 1978. The estimation of winter forage and its use by moose on clearcuts in north central Newfoundland J. Range Manage. 31:300-304.

Penner, D.F. 1978. Some relationships between moose and willow in the Fort Providence, N.W.T. area. M. Sci. Thesis. Univ. Alberta, Edmonton.

Perala, D.A. 1979. Regeneration and productivity of aspen grown in repeated short rotations. USDA Forest Serv. Res. Pap. NC-176.

Roath, L.R., and W.C. Krueger. 1982. Cattle grazing influence on a mountain riparian zone. J. Range Manage. 35:100-103.

Rosiere, R.E., R.F. Beck, and J.D. Wallace. 1975. Cattle diets on semidesert grassland: botanical composition. J. Range Manage. 28:89-93.

Sampson, A.W. 1919. Effect of grazing upon aspen reproduction. USDA Bull. No. 741.

Silen, R.R., and E.J. Dimock. 1978. Modelling feeding preferences by hare and deer among Douglas-fir genotypes. Forest. Sci. 24:57-64.

Smith, A.D., P.A. Lucas, C.O. Baker, and G.W. Scotter. 1972. The effects of deer and domestic livestock on aspen regeneration in Utah. Utah Div. of Wildlife Resources Pub. No. 72-1.