Forage Selection by Mule Deer on Winter Range Grazed by Sheep in Spring

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Abstract

Late spring grazing by sheep altered the amount of several forage categories available to deer the subsequent autumn and winter. Total herbaceous plant material was much reduced by spring-time sheep grazing, but regrowth following fall precipitation increased the proportion of green herbaceous material available. Current year's growth of bitterbrush was also increased relative to the nongrazed situation due to the release of moisture and nutrients accompanying the removal of herbaceous plants by sheep. Subsequently winter diets of mule deer on the sheep-grazed area were higher in herbaceous components but lower in shrub components than on the adjacent area where sheep had not been previously grazed. Implications of these findings are that quality of deer diets was not detrimentally affected where sheep had grazed during the preceding spring and a much greater animal yield is possible through dual use.

A deficit of winter forage apparently limits mule deer (*Odocoileus hemionus hemionus*) population over much of their range (Aldous 1945; Doman and Rasmussen 1944). This can be viewed in terms of both extent of winter rangeland and quantity of forage (principally shrubs) produced there. The Utah Division of Wildlife Resources estimates that there are approximately 7,424,000 ha of mule deer winter range in Utah, including some 1,149,000 ha dominated by the sagebrush complex, primarily big sagebrush (*Artemisia tridentata*). However, big sagebrush is viewed as only moderate quality winter forage for deer because of its low acceptability (Smith and Hubbard 1954). This is a particular problem where sagebrush exists in stands devoid of more palatable shrub species. Winter deer losses in Utah appear to be inversely related to the amount of palatable browse species available (Robinette et al. 1952).

The grazing of deer winter ranges by domestic livestock is common throughout the Intermountain West. Such ranges are grazed in spring when forage is typically in short supply for the livestock industry. Hence, the generally low state of productivity of these ranges is viewed as a limitation to livestock production (Cook and Harris 1968) as well as to deer production.

Recent research indicates that with properly designed grazing strategies, livestock-big game competition can probably be minimized (Jensen et al. 1972; Jensen et al. 1976). Moreover, these same studies suggest that livestock may be used to manipulate vegetation on deer winter ranges to effectively increase quantities of browse available to wintering deer. However, the specific responses of mule deer to such grazing systems have not been well established. Thus, the study reported in this paper was designed to determine: (1) the plant species present and available to wintering mule deer following spring-time sheep grazing and (2) the relative proportions of the various plant species in the diets of mule deer during the winter following the spring sheep grazing treatment.

Methods

The study was conducted at Hardware Ranch, Cache County, Utah, on an area similar in physiography and vegetation to much of the northern Utah and southern Idaho deer winter range. The area has southerly and southeasterly slopes supporting a mixed shrub-forb-grass plant community codominated by antelope bitterbrush (*Purshia tridentata*) and big sagebrush (*Artemisia tridentata* subsp. *tridentata*). Two additional sagebrush species (*A. tridentata* subsp. *vaseyana*) and low sagebrush (*A. arbuscula*) occur in limited abundance as do snowberry (*Symphoricarpos oreophilus*), Saskatoon serviceberry (*Amelanchier alnifolia*), and Douglas rabbitbrush (*Chrysothamnus viscidiflorus*). Herbaceous species of most importance are bluegrasses (*Poa pratensis* and *P. secunda*), Junegrass (*Koeleria cristata*), beardless bluebunch wheatgrass (*Agropyron inerme*), and the forbs Pacific aster (*Aster chilensis* var. *adscendens*), and mulesear wyethia (*Wyethia amplexicaulis*).

Annual precipitation of the area varies from 46 to 66 cm, with roughly 60% falling as snow. Mid-winter snow accumulations of 40 to 50 cm are not uncommon; but a sustained snow cover is generally not present on the area until late December, and spring thaw bares patches of ground as early as mid-March.

The Hardware Ranch, situated at an elevation of approximately 1,760 m, is generally considered at the upper end of the altitudinal gradient occupied by wintering mule deer in northern Utah. The mid-winter snowpack effectively excludes the area from winter-long occupancy by deer during years of above-average snow fall. However, substantial early winter and late winter grazing use by deer occurs every year. Elk (*Cervus canadensis*) winter on the ranch, but a large-scale hay feeding program generally keeps heavy elk concentrations localized on meadows and peripheral foothills. The ranch had not received livestock grazing for approximately 25 years preceding this study.

Two adjacent 2.4-ha pastures were fenced on an area previously selected for uniformity of topography and vegetative cover. In late May and early June (1974) one pasture (designated sheep-deer) received 150 sheep-days per ha[1] of grazing use over a 20-day period. Previous research on comparable pastures in the vicinity of the study site (Jensen et al. 1976) indicated that this time and intensity of grazing by sheep would achieve approximately 70% mean utilization of the current year's forage crop. *Artemisia* species were not included as part of the available forage for sheep, due to their low acceptability in

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[1] Forage consumed by the average 57-kg ewe and her 15-kg lamb was considered as one sheep-day of grazing use. Similarly, the quantity consumed by the average 57-kg adult doe was considered as one deer day of grazing use. Fawns (average weight = 23 kg) were calculated as 0.4 deer units.

spring. A flock of 20 range ewes and their lambs were obtained on loan from a local rancher and were used for the sheep grazing treatment. The other pasture (designated deer-only) was not grazed by sheep.

The following winter (1974-1975), five deer (two adult does and three fawns, born the previous June) were placed in each pasture for two 6-week periods. The first (early winter period) extended from early November to mid-December, and the second (late winter period) from mid-March to late April. Total cumulative deer grazing use was 100 deer-days per ha, an amount considered typical of northern Utah winter ranges.

The deer used in this experiment were hand reared on goat's milk on a feeding schedule similar to that of Reichert (1972). Frequent handling was emphasized during the fawns' first 2 months of life so that they imprinted on their handlers. Highly tractable animals were essential for making feeding observations in the experimental pastures, and the rearing process employed resulted in such animals. Any of the deer could be touched and handled by observers in the field situation.

Vegetation in the experimental pastures was sampled before and after deer grazing by using an electronically powered inclined point frame. The basic sampling unit, one frame of 20 pins, was observed on permanently located 1.0-m^2 quadrats during each sampling period. Forty-three and 62 randomly located quadrats were sampled in the deer-only and sheep-deer pastures, respectively. Point frame sampling (Warren-Wilson 1963), utilizing an angle of inclination of 32.5° from horizontal, identified species available and provided an index to abundance in both pastures before and after grazing by deer. Abundance is expressed here in terms of the mean number of contacts by the inclined point on each plant species and part (i.e., leaves and stems) as the pin traveled through successive 20-cm segments of the 120-cm vertical distance from the bar of the point frame to the soil surface. The vegetation abundance values reported for a species are means of all plant parts averaged over as many of the successive 20-cm strata as the species occupied or as the mean sum of two plant parts (leaves and stems) in the case of current annual growth (CAG), old, live, or dead parts. "All parts" is not a summation of the individual plant part categories but is a value obtained by averaging across part categories (such as stem, current, alive; stem, old, alive; or leaf, current, dead) applicable to a particular species. Values are not directly comparable between species because each species has a unique combination of plant parts and space occupied. CAG is defined as stems and leaves of grasses, forbs, or shrubs that were produced during a particular year's growing season. Old parts included all leaves and stems that had prevailed for one or more years, and in the case of shrubs, this category included all of the contacts on the plant trunk and smaller branches, except current year's twigs. Dead parts were attached to the parent plant. Litter was defined as all unattached ground cover of plant origin.

Dietary composition sampling consisted of ocular observations on four deer (two adults and two fawns) in each pasture. The fifth deer was maintained in each pasture to achieve the specified level of grazing use and was excluded from dietary observations. Each of the four were observed for one 30-minute period of actual grazing time daily for 4 consecutive days during the middle 4 weeks of the two grazing periods. Each deer was observed at a different time on successive days during a 4-day period. An observer counted the number of mouthfuls of each plant species and part consumed during the 30 minutes of daily grazing, and immediately following the observation, he hand-plucked representative mouthfuls of each species selected during that sampling interval for an estimate of mouthful weight. A mouthful was defined as the amount of forage for a particular species taken into the mouth between acts of swallowing. The slight, but obvious, contraction of throat muscles was the observer's visual cue to swallowing. Size of mouthfuls varied widely among different plant species but appeared to be relatively uniform for a particular species. Observations were conducted simultaneously by a separate observer in each pasture. Plucked samples were oven dried and weighed. The percent contribution of each species to the total mass of plant material consumed during a 30-minute grazing period was calculated and served as the experimental unit for statistical analysis. Calculations consisted of multiplying the number of mouthfuls of each species consumed during a 30-minute daily sampling period for individual deer times the oven dry weight of the hand-plucked mouthful estimate. This gave the weight of forage of each species consumed during the sampling period. The weight of each species consumed divided by the sum of weights for all species yielded the proportion of the diet belonging to each species consumed during the 30-minute daily sampling period for each of the four deer sampled in each pasture. These procedures are adaptation of the methods of Reppert (1960) and Neff (1974). Neff (1974) discussed at some length the confidence to be placed in hand-plucked samples of deer diet components and the use of hand-reared deer. This method is similar to that described by Free et al. (1971) except that the mouthful is a composite of several bites, the number depending on the individual deer and the plant species. The strong tendency of deer to graze on one plant species at a time facilitated using this adaptation of the bite-count method.

Data were analyzed statistically by analysis of variance, using least squares procedures (Draper and Smith 1966). The components of the fixed model for diets were treatments (sheep-deer and deer-only), winter periods (early and late), and weeks (four within each period). Fixed model components for vegetation analysis were treatments (sheep-deer and deer-only) and time of measurement (before and after deer grazing). The vegetation experimental unit was number of pin hits on a plant part category of a species.

Results

Vegetation

Big sagebrush, bitterbrush, and bluegrasses (the aggregate of *Poa pratensis* and *P. secunda*) were the most abundant plant species growing on the study area (Jensen unpubl. data). Although we attempted to select the two pastures for uniformity of vegetal cover as well as physiographic features, appreciable differences were subsequently found in abundance of several shrub species. Considering that data in Table 1 are treatment means reflecting the combined effects of possible site differences, spring-time sheep grazing, and two winter periods of deer grazing, direct attribution of differences in shrub abundance to specific sources of variation is not uniformly possible. However, several strong inferences are possible. For example, big sagebrush was 77% more abundant in the sheep-deer pasture than in the deer-only pasture, while all bitterbrush was 59%

Table 1. Forage available to deer in two grazing regimes. Tabular values are mean numbers of point contacts per quadrat, averaged over October (before deer grazing) and May (after deer grazing) inventories.

Plant species and parts	Grazing regime		Standard error
	Sheep and deer	Deer only	
Big sagebrush			
All parts[1]	0.19a[3]	0.11b[3]	0.01
Bitterbrush			
All parts[1]	0.10a	0.18b	0.01
Current year's parts[2]	0.05	0.05	0.01
Old live parts[2]	0.21a	0.35b	0.03
Bluegrasses			
All parts[1]	0.09a	0.24b	0.03
Live parts[2]	0.12	0.15	0.03
Standing dead parts[2]	0.11a	0.41b	0.04
Litter	9.71	9.32	0.50

[1] Values are quadrat means for each plant part occurring in all strata considered.
[2] Values are quadrat means of the sum of leaves and stems in all strata considered.
[3] For a particular plant species or plant part means followed by different letter suffixes are significantly ($P<0.01$) different.

more abundant in the deer-only pasture. Although no specific observations were made on diet selection by sheep during the spring grazing treatment, big sagebrush was not consumed by sheep in a previous study (Iskander 1973) on an adjacent site. Neither did deer consume big sagebrush in the present study. Thus, pretreatment differences between pastures were undoubtedly the major contributor to differences noted for that species. Both sheep and deer consumed bitterbrush, but the remarkably larger quantity of old live parts in the deer-only pasture (Table 1) suggests that pretreatment differences between pastures also played an important role for that species. Spring-time sheep grazing may have had the effect of increasing the proportion of CAG on bitterbrush, however. CAG on bitterbrush was 24% of old live parts in the sheep-deer pastures and only 14% in the deer-only pasture (Table 1). The uniformity of climatic and soil conditions on the two pastures seems to eliminate other possible causes for this difference. This supports earlier findings by Jensen et al. (1972) and Smith and Doell (1968) who suggested that regulated livestock grazing during spring can have favorable effects on subsequent shrub production, primarily through suppression of competition from herbaceous understory plants. The least favorable interpretation is the habitat quality for deer is not diminished by regulated sheep grazing and that a greater proportion of the total plant community can be utilized. Jensen et al. (1976) found that heavy intense sheep grazing as used in this study may favor an increase in shrubs.

The removal of herbaceous plant material by sheep was indicated by the lesser amounts of bluegrasses present in the sheep-deer pasture. All bluegrass material was only 39% as abundant in the sheep-deer pasture as in the deer-only pasture (Table 1). Although live parts were about equally abundant in both pastures, dead leaves and stems were only 28% as abundant in the sheep-deer pasture as in the deer-only pasture. The ratio of live bluegrass parts to dead parts was 106% in the sheep-deer pastures and 37% in the deer-only pasture (Table 1). Grass plants in the sheep-deer pasture were characterized by short, dense tufts of new leaf material in comparison to those in the deer-only pasture that had few, but long and flexuous leaves dispersed through a sward of standing dead herbaceous material approximately 5-20 cm deep.

Temporal changes in plant material that occurred during the two deer-grazing periods (Table 2) were due to consumption and trampling by deer, breakage of snow cover, and beginning of spring growth. Lack of control area, free from deer or other grazing effects, precluded quantification of grazing removal of plant material. However, the disappearance of 75% of bitterbrush CAG during the course of the winter (Table 2) should be largely attributable to deer grazing. Old live bitterbrush parts were 25% less abundant at the end of the winter due to deer use and breakage while grasses were 83% less abundant than prior to deer grazing. The effect of the snowpack in layering herbaceous material is evident in the reduction of bluegrass dead parts from 0.52 to 0.0 contacts per quadrat over the winter period (Table 2).

Table 2. Temporal changes in the forage resource during winter. The interval between measurements included six weeks of early winter deer grazing, 12 weeks of no grazing but heavy snow cover, and six additional weeks of late winter deer grazing. Tabular values are mean numbers of point contacts per quadrat, averaged over both grazing regimes.

Species	Time of measurement: October 1974 (before deer grazing)	Time of measurement: May 1975 (after deer grazing)	Standard error
Big sagebrush			
All parts[1]	0.16	0.14	0.01
Bitterbrush			
All parts[1]	0.17a[2]	0.11b[3]	0.01
Current parts[2]	0.08a	0.02b	0.01
Old live parts[2]	0.32	0.24	0.01
Bluegrass			
All parts[1]	0.29a	0.05b	0.02
Live parts[2]	0.18a	0.09b	0.03
Standing dead parts[2]	0.52a	0.00b	0.04
Litter	9.93	9.09	0.50

[1] Values are quadrat means for each plant part occurring in all strata considered.
[2] Values are quadrat means of sum of leaves and stems in all strata considered.
[3] For a particular plant species or plant part, means followed by different letter suffixes are significantly ($P<0.01$) different.

Diets

Treatment Effects

With the notable exception of big sagebrush and Oregon grape (*Mahonia repens*), plant species most common on the study area comprised the largest proportions of mule deer's diets in winter (Table 3). Big sagebrush, highly abundant in

Table 3. Diets (% botanical composition) selected by mule deer during two grazing seasons on a pasture grazed by sheep in spring and on a pasture grazed only by deer.

Species	Early winter: Sheep and deer	Early winter: Deer only	Late winter: Sheep and deer	Late winter: Deer only	Treatment means: Sheep and deer	Treatment means: Deer only
All shrubs	43.1a[1]	52.0b[1]	65.5	65.6	54.3	58.8
All bitterbrush	27.8a	42.0b	49.5	55.5	38.7a[2]	48.8b[2]
Current bitterbrush	27.8	33.1	32.9a[1]	26.7b[1]	30.4	29.9
Old bitterbrush	0.6a	8.9b	16.6a	28.8b	8.3a	18.9b
Oregon grape	9.0	8.0	9.3a	5.4b	9.2a	6.7b
Low sagebrush	2.7	1.1	5.5a	2.2b	4.1a	1.7b
Miscellaneous shrubs	3.5a	0.9b	1.2a	2.5b	2.3	1.7
All herbaceous	56.9a	48.0b	34.4	34.4	45.7	41.2
Green grasses	39.2a	32.4b	26.5	25.0	32.9	28.7
All forbs	17.7	15.6	7.9	9.4	12.8	12.5
Pacific aster	4.8	5.9	0.8	1.2	2.8	3.5
Mulesear wyethia	6.3	4.7	0.4a	4.3b	3.3	4.5
Miscellaneous forbs	6.7	5.2	6.7	3.9	6.7a	4.5b

[1] Within a particular grazing season, treatment means followed by different letter suffixes are significantly ($P<0.10$) different.
[2] Treatment means differing significantly ($P<0.10$) between grazing treatments are noted by different letter suffixes.

both pastures, received no measurable dietary use, whereas the infrequently occurring Oregon grape, not found in any vegetation sample quadrat, was consumed in significant amounts. Smith (1950) found big sagebrush to be only moderately acceptable to deer, yet he maintained that it is an important forage species in the Intermountain region, particularly on ranges where other browse species are absent or have been fully utilized. The lack of use of big sagebrush as food in the present study is probably explained by the relative abundance of other, more palatable forage species. However, dietary selection of plant species having high concentrations of secondary compounds (e.g., terpenes in sagebrush) is a complex and poorly understood process. For example, Smith and Hubbard (1954) observed yearly variation in consumption of big sagebrush by penned deer ranging from complete rejection one year to moderate consumption the next.

We cannot completely discount that our deer were reared under artificial circumstances and were not exposed to a wide array of native plant species prior to the grazing trials. Early experience or food imprinting has been found important in such monogastric species as wild and domesticated rats (Galef and Clark, 1971). Arnold and Maller (1977) recently demonstrated the importance of nutritional experience upon subsequent food selection in adult sheep. Unfortunately, our experimental design did not provide opportunities for evaluating the importance of such relationships in deer.

Bitterbrush and grasses (principally Kentucky and Sandberg bluegrass) were consistently greatest in dietary importance, comprising in aggregate at least 67% of the diets. Other plant species and species categories, including Oregon grape, low sagebrush, miscellaneous shrubs, Pacific aster, mulesear wyethia, and miscellaneous forbs were variably important (Table 3). The relationship of all bitterbrush and low sagebrush consumption between the two grazing regimes was similar to the relationship of amounts available. The deer-only pasture had more bitterbrush and less low sagebrush available than did the sheep-deer pasture.

The major dietary difference between grazing regimes involved the greater quantity of grasses and markedly more herbaceous species consumed by deer during early winter in the sheep-deer pasture than in the deer-only pasture (Table 3) even though equal amounts of bitterbrush CAG were available in both pastures. These differences are probably attributable to the smaller quantity of standing dead grass material in the sheep-deer pasture (Table 1). Heavy spring grazing by sheep had effectively utilized or layered the grass sward that would have otherwise accumulated during the early summer growing season. Thus, the absence of standing dead herbaceous material in the sheep-deer pasture had the important effect of making forbs, low growing shrubs (e.g., Oregon grape), and the new green leaf material resulting from autumn regrowth of the cool-seasonal bluegrasses more accessible to deer in early winter. Arnold (1964) suggested that tall grasses reduced consumption of low growing clover by sheep in Phalaris-annual grass-clover pasture. Other directly pertinent work recently reported by McLean and Willms (1977) showed that fall grazing by cattle removed mature stalks of bluebunch wheatgrass making new grass more accessible to deer in spring. Thus livestock grazing can delay the time when deer must depend on shrubs as the source of forage.

The greater quantity of old (from previous growing seasons) bitter-brush consumed in the deer-only pasture (Table 3) probably reflects the smaller proportion of bitterbrush CAG to old bitterbrush in that pasture (Table 1). The cumulative effect of these dietary differences would appear to be an increase in the nutritive quality of mule deer's diet in the sheep-deer pasture over those in the deer-only pasture. Short et al. (1972) have demonstrated the higher nutritional quality (digestibility, protein content) of current year's twigs as compared to 1-year-old and older twig material. However, preliminary data on the nutritional quality of diets consumed by deer in the two pastures (Fulgham et al. 1977) indicate that the relationships were complex. Dietary crude protein averaged about 2% higher in the deer-only pasture during the early winter period, while digestible energy content and in vitro digestibility of diets were numerically, although not significantly, higher in the sheep-deer pasture.

In the late winter, consumption of herbaceous species was less influenced by previous sheep grazing than by phenological changes. An exception was mulesear wyethia, which did not begin growth while deer were in the pastures during the late winter grazing period. However, appreciable quantities of the forb's large dry leaves had remained on the ground from the previous year's growing season in the deer-only pasture. Deer consumed these dead leaves soon after snow-melt. Both availability and consumption of mulesear wyethia were lower in the sheep-deer pasture during late winter (Table 3) because of prior use of the species by sheep. Consumption of all herbaceous species, in aggregate, did not differ between pastures.

Shrub content of diets in late winter was similar in both pastures but individual species categories were different (Table 3). More old bitterbrush was selected in the deer-only pasture. This difference probably indicates the combined effects of declining availability of bitterbrush CAG due to greater consumption in the early winter and the greater percentage of old bitterbrush there initially (Table 1). Bitterbrush CAG consumption was slightly greater in late winter in the sheep-deer pasture. Oregon grape and low sagebrush were also used to greater extent in the sheep-deer pasture. These dietary differences suggest, as did those for early winter, that dietary quality for mule deer was probably greater in the sheep-deer pasture than that in the deer-only pasture. Preliminary nutritional data (Fulgham et al. 1977) conditionally confirm this hypothesis. Averaged over the late winter period, dietary crude protein, digestible energy, and in vitro digestibility were all slightly higher in the sheep-deer pasture.

Temporal Effects

Reduction in forage availability due to deer use and snow cover, and changes in plant phenology seemed to account for the general trends in plant species present in mule deer diets through the winter. Considering the two treatments as a whole, shrubs were generally more important than other species in late winter primarily because snow cover (about 25 cm and 20 cm during weeks 1 and 2, respectively) limited availability of herbaceous species during the first half of the period (Table 4). Forbs and grasses declined from an average of 53% in early winter to 34% in late winter, while shrub use increased from 48% in early winter to 66% in late winter. During the early winter when snow cover was not a factor, shrubs (principally bitterbrush) in diets increased from about 40% in weeks 1 and 2 to approximately 55% in weeks 3 and 4, while dietary forbs declined from 22% and 27% in weeks 1 and 2, respectively, to 7% in week 4. This shift apparently resulted from a reduction in forb availability due to consumption. Green grasses consistently comprised about one-third of the diet throughout the early winter period (Table 4).

Table 4. Diets (% botanical composition) selected by mule deer during early and late winter grazing periods.

Species	Early winter weeks				Late winter weeks				Means	
	1	2	3	4	1	2	3	4	Early winter	Late winter
All shrubs	39.5a[1]	39.4a	57.4b	53.8b	78.2a[1]	69.8b	72.0ab	42.4	47.5a[2]	65.6b[2]
All bitterbrush	30.1	29.7	38.7	41.2	61.5a	59.5a	57.0a	32.1b	34.9a	52.5b
Current bitterbrush	30.1a	29.7a	38.7b	23.4a	38.1a	38.3a	31.9a	10.9b	30.5	29.8
Old bitterbrush	0.0a	0.0a	0.0a	17.8b	23.4	21.2	25.1	21.9	4.4a	22.7b
Oregon grape	7.1	5.6	12.2	9.1	11.0a	8.3a	7.7a	2.3b	8.5	7.4
Low sagebrush	0.0a	1.1a	4.7b	2.0a	0.8a	1.2a	5.5b	7.9b	1.9a	3.9b
Miscellaneous shrubs	2.4	3.0	1.9	1.5	4.8a	0.7b	1.8b	0.0b	2.2	1.8
All herbaceous	60.5a	60.6a	42.6b	46.2b	21.8a	30.2b	27.9ab	57.6c	52.5a	34.4b
Green grasses	38.8	32.9	32.2	39.2	19.9a	24.0a	20.9a	38.1b	35.8a	25.8b
All forbs	21.6a	27.7b	10.3c	7.0c	1.9a	6.2b	7.0b	17.4c	16.7a	8.6b
Pacific aster	10.8a	7.7b	1.4c	1.5c	0.0a	0.0a	0.5a	3.4b	5.3a	1.0b
Mulesear wyethia	4.7a	11.1b	3.5ac	2.5c	1.3a	5.3b	2.2a	0.5a	5.5a	2.3b
Miscellaneous forbs	6.1ab	8.9a	5.4b	3.0b	0.6a	0.9a	4.4b	15.4c	5.8	5.3

[1] Within a particular grazing season, weekly means for a dietary component are significantly ($P<0.05$) different if followed by different letter suffixes.
[2] Seasonal means differing significantly ($P<0.05$) are denoted by different letter suffixes.

In late winter, snow melt was essentially complete by week 3 in the sheep-deer pasture and by week 4 in the deer-only pasture. Corresponding to the departure of the snow cover and the beginning of growth in cool season grasses and forbs, dietary shrubs declined from 78% in week 1 to 42% in week 4, while use of herbaceous species increased from 21% in week 1 to 58% in week 4 (Table 4). Continuation of observations into subsequent weeks would likely have shown even greater selection of green grass and emergent forbs.

Three dietary components, all bitterbrush, old bitterbrush, and all forbs, did not follow the same trends in both pastures, as indicated by significant season × week interactions in the analysis of variance. Bitterbrush consumption in early winter began at much lower levels in the sheep-deer pasture than in the deer-only pasture (Fig. 1a), probably due to the greater accessibility of the apparently preferred grass regrowth in the former. Consumption of old bitterbrush began during week 4 of early winter in the deer-only pasture, while no old bitterbrush was consumed in the sheep-deer pasture until late winter (Fig. 1b). This dietary component remained consistently lower in the sheep-deer pasture throughout late winter, varying from 5% to 35% lower, apparently in response to the greater proportion of bitterbrush CAG to old bitterbrush present where sheep had grazed in spring. The relatively high and similar consumption of all bitterbrush (about 60% of diets) in both pastures during the first 2 weeks of late winter (Fig. 1a) corresponded to a period when snow cover severely limited the availability of all herbaceous species. Animals in both pastures shifted away from bitterbrush and toward herbaceous species, particularly forbs, during the latter weeks of late winter. However, this shift occurred approximately 1 week earlier in the sheep-deer pasture (Fig. 1a). As mentioned above, snow cover persisted approximately 1 week longer in the deer-only pasture than in the sheep-deer pasture. A possible explanation of this difference is that the relatively deep layer of standing dead herbaceous material in the deer-only pasture presented an insulating effect, thus delaying soil warming (Geiger 1965). The major divergence in dietary forb use in the two pastures occurred during week 2 of late winter when animals in the deer-only pasture consumed appreciable quantities (10% of the diet) of the dry leaves of mulesear wyethia (Fig. 1c). This species had been partially consumed by sheep in the other pasture and was unavailable there because of snow cover. In the deer-only pasture, deer use in early winter had not reduced the stature of

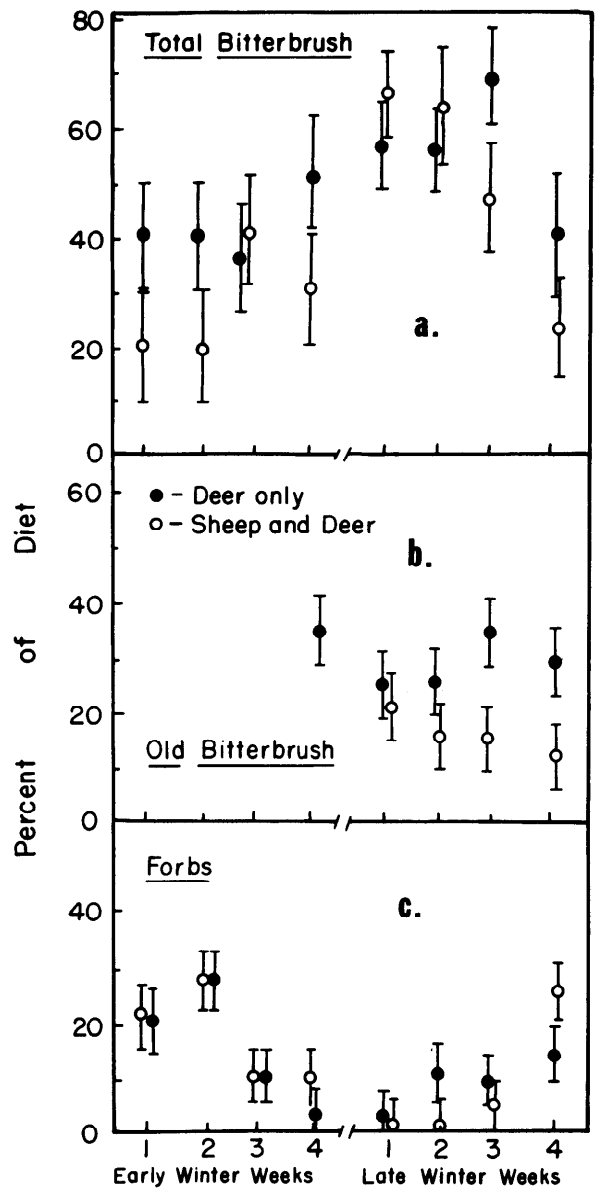

Fig. 1. *Trends of three forage components in diets selected by deer during early and late winter periods. Vertical bars represent 95% confidence intervals.*

the tall plants and they remained partially uncovered and available for consumption. However, by week 4 forb use in the sheep-deer pasture had greatly exceeded that in the deer-only pasture.

Summary and Conclusions

Mule deer grazing in the winter in a pasture grazed by sheep the previous spring selected a diet containing more herbaceous plant material and less shrub material than did deer in a similar pasture not grazed by sheep. Fulgham (1978) in a study concurrent with this found no large differences in overall nutritive quality of forage ingested by deer between the two treatments. These findings indicate that sheep grazing at the time and intensity used in this study will not detrimentally affect mule deer winter ranges in northern Utah. Moreover, the total stocking rate of the sheep-deer pasture (100 deer-da/ha + 150 sheep-da/ha) was more than 2× that of the deer-only pasture (100 deer-da/ha), indicating the potential for increased animal production per unit of land under dual-use grazing. We can offer no firm evidence on the length of time such relationships might persist without marked changes in the plant community structure necessitating changes in the grazing program. This facet is presently being pursued in a related longer-term study (Jensen et al. 1976). However, preliminary information based on 4 years of spring sheep grazing does not suggest major successional changes that would have a direct bearing on food species important to wintering mule deer (Jensen, upubl. data).

Seasonal dietary changes indicated that wintering mule deer will select green grass and some cured forbs as long as they are available in preference to shrubs, although shrubs (primarily bitterbrush) were always the largest single component of diets.

Major dietary components in order of importance by weight were bitterbrush 42%, green grasses 30%, Oregon grape 8%, miscellaneous forbs, 6%, mulesear wyethia 4%, low sagebrush 3%, Pacific aster 3%, and miscellaneous shrubs 2%. Big sagebrush, the co-dominant shrub on the site was totally rejected by deer as a food item probably because of the abundance of other more palatable forages.

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