

# Elk, Mule Deer, and Cattle Foraging Relationships on Foothill and Mountain Rangeland

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## Abstract

Foraging niche overlap among Rocky Mountain elk (*Cervus elaphus nelsoni*), Rocky Mountain mule deer (*Odocoileus hemionus hemionus*), and cattle (*Bos taurus*) was studied for 2 years on 37 000 ha of nonforested foothill and mountain habitat in northwestern Wyoming. Microhistological analysis was used to quantify botanical composition of ungulate diets from monthly fecal collections. Feeding habitat use was determined through monthly surveys from fixed-wing aircraft to record nonsolitary animals in nonforested habitat. Kulczynski's similarity index was used to calculate dietary and feeding habitat overlap among the 3 ungulates, and these 2 indices were multiplied together to estimate foraging niche overlap. In all seasons, elk and cattle consumed grass-dominated diets (mean = 61% and 81%, respectively), although elk diets were more diverse. Mule deer consumed more forbs and shrubs than either elk or cattle ( $P < 0.10$ ). Foraging niche overlap was high (45%) between mule deer and elk in spring. Cattle in summer and fall had  $\geq 60\%$  foraging niche overlap with elk in spring, indicating that, in spring, elk foraged in many of the same places (largely sagebrush grassland) and ate diets similar in botanical composition to what cattle did during summer and fall (principally *Festuca idahoensis*, *Pseudoroegneria spicata*, and *Achnatherum* spp.). Foraging niche overlap also was high (41%–51%) between elk in winter and cattle in summer and fall. Therefore, if competitive or complementary relationships existed between elk and cattle, these interactions most likely occurred on sagebrush grasslands where cattle use in summer–fall was followed by elk use in winter–spring. We recommend that resource managers focus their forage utilization and range trend monitoring in foothill sagebrush grasslands.

## Resumen

Se estudió el traslape del nicho de forrajeo entre el alce de las Montañas Rocallosas, (*Cervus elaphus nelsoni*), el venado mula de las Montañas Rocallosas (*Odocoileus hemionus hemionus*) y el ganado (*Bos taurus*); el estudio se condujo por dos años en 37 000 ha de hábitats deforestado al pie de montaña y montañoso situados en el noroeste de Wyoming. La composición botánica de la dieta de los ungulados se determinó a partir de muestras fecales colectadas mensualmente y con el uso del análisis microhistológico. El uso de hábitat alimenticio se determinó a través de muestreos mensuales por medio de un dispositivo aéreo de alas fijas para registrar los animales no solitarios en el hábitat deforestado. El índice de similaridad de Kulczynski se usó para calcular el traslape de la dieta y del hábitat alimenticio entre los tres ungulados, y estos dos índices se multiplicaron para estimar el traslape del nicho de forrajeo. En todas las épocas de año, el alce y el ganado consumieron dietas dominadas por zacates (media = 61% y 81%, respectivamente), aunque las dietas del alce fueron más diversas. El venado mula consumió más hierbas y arbustos que el alce y el ganado ( $P < 0.10$ ). En primavera, el traslape del nicho de forrajeo fue alto (45%) entre el venado mula y el alce. En verano y otoño, el ganado tuvo un traslape del nicho de forrajeo  $\geq 60\%$  con el alce, indicando que en primavera, el alce forrajeó en muchos de los mismos lugares (principalmente pastizal de "Sagebrush") y comió dietas similares en composición botánica a las del ganado en verano y otoño (principalmente (*Festuca idahoensis*, *Achnatherum* spp. y *Pseudoroegneria spicata*). El traslape del nicho de forrajeo también fue alto (41%–51%) entre el alce en invierno y el ganado en verano y otoño. Por lo tanto, si existieron relaciones competitivas o complementarias entre el alce y el ganado, estas interacciones ocurrieron más probablemente en los pastizales de "Sagebrush," donde el uso por el ganado en verano–otoño es seguido por el uso del alce en invierno–primavera. Recomendamos que los manejadores de los recursos enfoquen sus monitoreos de utilización de forraje y tendencia del pastizal en los pastizales de "Sagebrush."

**Key Words:** dietary overlap, food habits, foraging niche overlap, habitat use, resource partitioning, wildlife–livestock relationships

## INTRODUCTION

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Foothill and mountain rangeland in the northern Rocky Mountains provides important foraging habitat for many wild and domestic ungulates, including Rocky Mountain elk (*Cervus elaphus nelsoni*), Rocky Mountain mule deer (*Odocoileus hemionus hemionus*), and cattle (*Bos taurus*). To sustain these ungulate populations and the ecological health of their

foothill and mountain rangeland habitats, resource managers must understand the foraging relationships among these 3 ungulate species (Vavra et al. 1999).

Dietary overlap and feeding habitat use overlap are the traditional measures used to evaluate resource partitioning among free-ranging ungulates. Conclusions based on either measure alone, however, may lead to misinterpretation of foraging relationships. For example, Vavra et al. (1989) documented high dietary overlap between elk and cattle but only moderate to low spatial overlap, indicating that although elk and cattle were eating similar plant species, elk and cattle were foraging in different plant communities. Vavra et al. (1989) also documented high spatial overlap between mule deer and cattle but found low dietary overlap, indicating that mule deer and cattle were eating different plant species within the same plant communities. More recently, competition among elk, mule deer, and cattle was strongly inferred on the basis of high habitat use overlap (Stewart et al. 2002), but later discounted when a companion study revealed low dietary overlap (Stewart et al. 2003). These examples illustrate that foraging niche overlap (i.e., % dietary overlap  $\times$  % feeding habitat use overlap) provides a more meaningful metric for assessing resource partitioning (Putman 1996). It is also important to remember that although resource use overlap is often mistakenly interpreted as a measure of competition, resource use overlap can be an equally important measure of complementary relations (Berg and Hudson 1982; Keddy 1989). Even when ungulates consume identical diets from within the same plant communities at the same time, the nature of the interactions remains unknown and can be competitive, complementary, or neutral (Keddy 1989; Putman 1996).

Mule deer and elk inhabiting foothill and mountain rangeland in the northern Rocky Mountains generally have low foraging niche overlap (Vavra et al. 1989; Sheehy and Vavra 1996). Feeding habitat overlap and dietary overlap also are typically low between mule deer and cattle in these habitats (Berg and Hudson 1982; McLean and Willms 1982; Kasworm et al. 1984); however, foraging niche overlap can be significant in spring, when graminoids are succulent (Mackie 1981; Miller and Vavra 1982).

Elk and cattle are often sympatric in time and space on foothill and mountain rangeland. When this occurs, elk–cattle dietary overlap is generally high in fall, winter, and spring but not summer (Stevens 1966). Low elk–cattle dietary overlap in summer helps partition forage resources because elk–cattle feeding habitat overlap in summer is often moderate to high on foothill and mountain rangeland (Ward et al. 1973; Stewart et al. 2002, 2003).

Significant dietary and feeding habitat use overlap often occurs on foothill and mountain rangeland between summer–fall cattle grazing and elk or mule deer grazing in the winter–spring (Kasworm et al. 1984; Vavra et al. 1989; Crane 2002). This overlap can be beneficial to wild ungulates, for example, when elk or mule deer preferentially select feeding sites where previous cattle grazing has improved forage palatability (Willms et al. 1979; Grover and Thompson 1986; Jourdonnais and Bedunah 1990; Frisina 1992; Yeo et al. 1993; Crane 2002). However, elk and mule deer will avoid or not select sites previously grazed by cattle if cattle utilization is excessive and extant (Hudson et al. 1976; Crane 2002). Similarly, elk or mule

deer grazing in late spring can compete with cattle in the subsequent summer–fall if elk or mule deer remove too much forage (Hobbs et al. 1996a, 1996b; Brewer 2002). Finally, high foraging niche overlap can contribute to unsustainable levels of forage utilization.

Whether foraging relationships between 2 or more ungulate species are benign, competitive, or complementary depends on site-specific conditions, including when grazing occurs, how much forage remains after grazing, plant community health and structure, and the ungulates' feeding strategies (Mosley 1994; Kingery et al. 1996). The sustainability of ungulate populations and their foothill and mountain rangeland habitats depends, in part, on management actions that limit competitive interactions and encourage complementary relationships whenever possible. To accomplish these goals, resource managers must first identify when (e.g., in which seasons of the year) and where (e.g., in which vegetation types) significant foraging niche overlap is likely. The objective of this study was to identify when and where foraging niche overlap was significant among nonsolitary elk, mule deer, and cattle on nonforested foothill and mountain rangeland in northwestern Wyoming. We hypothesized that foraging niche overlap would be high 1) between summer–fall cattle use and elk use in winter–spring, and 2) among elk, mule deer, and cattle in spring.

## METHODS

### Study Area

Data were collected from 4 ranches in Park County, Wyoming, encompassing 37 000 ha of nonforested foothill and mountain habitat. Two ranches were located along the North Fork of the Shoshone River, approximately 14 and 26 km west of Cody, Wyoming, and 2 ranches were located along the South Fork of the Shoshone River, approximately 8 and 47 km southwest of Cody, Wyoming. The study area averaged 220–320 mm of annual precipitation historically, with 50% occurring as rain from April through July (NOAA 1999). Elevations on the study site ranged from 1 750 to 3 040 m. Sagebrush grassland dominated the foothill rangelands, whereas mountain grassland dominated the mountain rangeland habitat. In the sagebrush grassland, dominant graminoids were bluebunch wheatgrass (*Pseudoroegneria spicata* [Pursh] A. Love), Idaho fescue (*Festuca idahoensis* Elmer), and Sandberg bluegrass (*Poa secunda* J. Presl); common forbs were spiny phlox (*Phlox hoodii* Richards.), western yarrow (*Achillea millefolium* L. var. *occidentalis* DC.), and rosy pussytoes (*Antennaria rosea* Greene); and dominant shrub species were Wyoming big sagebrush (*Artemisia tridentata* Nutt. spp. *wyomingensis* Beetle & Young), mountain big sagebrush (*Artemisia tridentata* Nutt. spp. *vaseyana* [Rybd.] Beetle), and rubber rabbitbrush (*Ericameria nauseosa* [Pallas ex Pursh] Nesom & Baird). In the mountain grassland habitat, dominant graminoids included Idaho fescue, Columbia needlegrass (*Achnatherum nelsonii* [Scribn.] Barkworth), and bluejoint (*Calamagrostis canadensis* [Michx.] Beauv.), and common forbs were western yarrow, lupine (*Lupinus* spp. L.), and milkvetch (*Astragalus* spp. L.). Primary domestic forage sources were irrigated grass–alfalfa (*Medicago sativa* L.) hayfields and irrigated alfalfa hayfields. Botanical nomenclature followed USDA (2005).

The study area was comprised of a mixture of private, state, and federal lands and was grazed by wild and domestic ungulates. Dominant grazers were Rocky Mountain elk, Rocky Mountain mule deer, and cattle. Pronghorns (*Antilocapra americana*), Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*), and domestic horses (*Equus caballus*) were also present. Grazing by wildlife occurred year-round, whereas cattle were removed from native rangeland by December and fed harvested hay until late April or early May.

### Food Habits and Dietary Overlap

Fresh feces from elk, mule deer, and cattle were collected monthly from each of the ranches from January 1999 through October 2000. Feces were collected opportunistically from throughout the study area to ensure a representative sample. Five fresh fecal samples per animal species were collected monthly from each ranch (5 samples  $\times$  3 ungulate species  $\times$  4 ranches  $\times$  22 months = 1 320 total samples). The 5 samples from each species/ranch/month combination were combined (3 ungulate species  $\times$  22 months = 66 composite samples per ranch). Composite samples were sent to the Wildlife Habitat Laboratory at Washington State University, where experienced technicians used microhistological analysis to estimate botanical composition (Sparks and Malechek 1968). Six microscope slides were prepared from each composite sample, with 25 fields of view examined from each slide at  $\times 100$  magnification. Although microhistological analysis of fecal samples often underestimates forbs and overestimates graminoids in growing-season diets, this bias is much less in dormant-season diets (Holechek et al. 1982). In our study, fecal sampling occurred year-round, and the growing season was confined largely to 2 months (May and June).

Food habits data were averaged each year by season: March, April, and May (spring diets); June, July, and August (summer diets); September, October, and November (fall diets); and December, January, and February (winter diets). Dietary overlap among elk, mule deer, and cattle was determined per season and year using Kulczynski's similarity index (Oosting 1956).

### Feeding Habitat Use and Overlap

Monthly survey flights over the ranches began November 1998 and ended October 2000. Each month, the 2 ranches along the North Fork of the Shoshone River were flown one day and the 2 ranches along the South Fork of the Shoshone River the next day. Monthly aerial observations provided a complete reconnaissance of open, nonforested habitats on all 4 ranches. Aerial observations began immediately after sunrise and averaged 3 h per flight, a peak foraging period for elk, mule deer, and cattle (Arnold and Dudzinski 1978; Geist 1981; Skovlin 1982). Aerial transects were 0.8 km wide at a ground speed of  $140 \text{ km} \cdot \text{h}^{-1}$  and an altitude of 150 m above the ground. An Arctic Tern fixed-wing aircraft was used for all flights and flown by the same pilot for the duration of the study.

Feeding habitat (i.e., sagebrush grassland, mountain grassland, hayfield, or cattle feeding grounds) was recorded for each aerial observation of elk, mule deer, or cattle in nonforested areas on the basis of the center point of each group of animals. Only observations of  $\geq 2$  adults per species were included in the

data analysis because of the higher variability in feeding habitat selection exhibited by solitary animals (Sheehy and Vavra 1996). This criterion eliminated less than 10% of the aerial observations of elk, mule deer, or cattle. A sightability index was not applied to our animal counts, as we were recording feeding habitats of observed animals, not estimating total population sizes.

Percent feeding habitat use by each species was calculated per month by dividing the total number of observations into the number of observations recorded from each type of feeding habitat. Seasonal means were calculated per year. Feeding habitat use overlap was estimated using Kulczynski's similarity index (Oosting 1956).

### Foraging Niche Overlap

Foraging niche overlap between species was estimated by multiplying percent dietary overlap and percent feeding habitat use overlap (Putman 1996). Seasonal means were calculated per year.

### Data Analyses

Experimental design was a split plot in time with 3 species of ungulates (elk, mule deer, and cattle) and 2 years (1998–1999 and 1999–2000). Ungulate species was the whole-plot factor and year was the subplot factor. Ranches were the replicates ( $n = 4$ ). Using the GLM procedure of SAS (SAS 2004), analysis of variance and Duncan's Multiple Range Test (Steel et al. 1997) were used to compare the food habits and feeding habitat use patterns among ungulate species within each season. Significant differences were declared at  $P \leq 0.10$ .

Values of dietary overlap, feeding habitat overlap, and foraging niche overlap were compared qualitatively among the 3 ungulate species. Dietary overlap or feeding habitat overlap values  $>50\%$  indicated substantial overlap (Kingery et al. 1996). For foraging niche overlap, values of  $>40\%$  indicated exceptionally high overlap, reflecting the fact that a 40% value requires the dietary overlap and feeding habitat overlap values to be near 60% (e.g., 60% dietary overlap  $\times$  60% feeding habitat overlap = 36% foraging niche overlap).

## RESULTS

### Food Habits and Dietary Overlap

Elk and cattle consumed grass-dominated diets in all seasons, although elk diets included more forbs than cattle diets in summer and fall (34%–36% vs. 8%; Table 1). Cattle diets averaged 90% graminoids in summer–fall and 72% in winter–spring. Alfalfa hay fed to cattle in winter–spring accounted for the fewer graminoids in cattle diets during those seasons. Mule deer diets were more diverse than either elk or cattle diets in all seasons. In winter–spring, mule deer diets averaged 31% graminoids, 33% browse (predominantly *Artemisia* spp.), 18% alfalfa, and 18% forbs other than alfalfa. In summer–fall, mule deer diets averaged 16% graminoids, 27% browse, 24% alfalfa, and 32% forbs other than alfalfa. The high percentage of alfalfa in summer–fall mule deer diets is noteworthy. Although markedly fewer mule deer were observed on the study area during these seasons, the mule deer that did remain were usually observed near hayfields.

**Table 1.** Botanical composition ( $\pm$  standard error) of cattle, elk, and mule deer diets by season on foothill and mountain rangeland in northwestern Wyoming.

	Season											
	Summer			Fall			Winter			Spring		
	Cattle	Elk	Mule deer	Cattle	Elk	Mule deer	Cattle	Elk	Mule deer	Cattle	Elk	Mule deer
------(%)-----												
<b>Graminoids</b>												
<i>Achnatherum hymenoides</i>	1						T <sup>1</sup>			1		
<i>Achnatherum</i> spp.	13	5	1	11	8	2	13	17		13	19	7
<i>Agrostis</i> spp.	3	2	T	5	T		7	4	1	7	2	1
<i>Bromus marginatus</i>	1			2								
<i>Bromus</i> spp.		1			T							
<i>Calamagrostis canadensis</i>						1						
<i>Calamagrostis</i> spp.	7	6		10	10	2	6	6	5	4	5	4
<i>Carex aquatilis</i>	2	2	1	1		T						
<i>Carex geyeri</i>	1											
<i>Carex praegracilis</i>	1	1		1						T	T	
<i>Carex rostrata</i>	2	T	1	2						1	T	
<i>Carex</i> spp.	9	3	1	6	1		3			3	2	1
<i>Danthonia</i> spp.	T			1	T					1	T	1
<i>Deschampsia caespitosa</i>		1						3			T	
<i>Eleocharis</i> spp.	1			1								
<i>Elymus</i> spp.	1						1					
<i>Festuca idahoensis</i>	8	4	1	11	4	T	5	1		5	9	3
<i>Hordeum</i> spp.	T	1		1			1		T	1	1	T
<i>Juncus</i> spp.	1			2			1			1		
<i>Koeleria macrantha</i>	1	1			1					T		
<i>Phleum</i> spp.						T						1
<i>Poa alpina</i>	T	1					1					
<i>Poa</i> spp.	5	2	1	4	2	T	8	3	2	6	5	2
<i>Pseudoroegneria spicata</i>	8	4	1	6	6	2	11	8	3	9	9	3
<i>Puccinellia nuttalliana</i>	3			5	1		1	10		4	4	2
<i>Scirpus</i> spp.	2			2			T					
Other graminoids	21	20	7	19	20	11	16	14	10	15	16	12
Total graminoids	91 (1.8)a <sup>2</sup>	54 (4.6)b	14 (5.2)c	90 (1.7)a	53 (2.1)b	18 (3.5)c	74 (2.8)a	66 (12.8)a	26 (4.4)b	71 (4.6)a	72 (3.8)a	36 (5.6)b
<b>Forbs</b>												
<i>Astragalus</i> spp.	T	2	6		4	8	4	7	4	9	2	5
<i>Equisetum</i> spp.										1		
<i>Erigeron</i> spp.			T						T			1
<i>Lupinus</i> spp.		3	2		1	2						T
<i>Medicago sativa</i>	1	10	28	2	12	21	12	8	18	10	3	18
<i>Melilotus</i> spp.						1						
<i>Oxytropis sericea</i>						1						
<i>Penstemon</i> spp.		T	1		5	4	T	3	7	1	1	2
<i>Phlox</i> spp.			T			1						
<i>Sphaeralcea</i> spp.					T							
Other forbs	7	19	20	6	14	19	8	4	7	6	7	9
Total forbs	8 (1.6)a	34 (4.2)b	57 (4.9)c	8 (1.3)a	36 (2.6)b	57 (3.2)c	24 (2.6)a	22 (4.6)a	37 (3.9)b	26 (3.9)a	13 (2.7)b	35 (5.1)c
<b>Browse</b>												
<i>Artemisia</i> spp.		1	4	1 (0.1)	3	14	1	11	28	1	10	21
<i>Cornus</i> spp.		2	1			T			1		T	1
<i>Mahonia repens</i>					1						T	
<i>Salix</i> spp.		1	2		2	2			3		1	1
<i>Shepherdia canadensis</i>		4	6		1	2			T			2
<i>Vaccinium</i> spp.			9			T			1			T
Conifer needles			2	T	T	1		T	2	T	1	1
Other browse	1	4	5	1	4	6	1	1	2	2	2	3
Total browse	1 (0.2)a	12 (1.8)b	29 (3.1)c	2 (0.6)a	11 (1.4)a	25 (5.6) b	2 (0.6)a	12 (9.4)a	37 (6.0)b	3 (1.0)a	14 (2.5)a	29 (5.5)b
Moss/lichen	T	T	T	T			T	T		T	1	
Total	100	100	100	100	100	100	100	100	100	100	100	100

<sup>1</sup>T = Trace amounts, less than 1%.

<sup>2</sup>Values in the same row within seasons with the same letter were not different ( $P > 0.10$ ).

**Table 2.** Dietary overlap among cattle, elk, and mule deer by season on foothill and mountain rangeland in northwestern Wyoming.

Species/season	Species											
	Cattle				Elk				Mule deer			
	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring
	------(%)-----											
Cattle/summer		82	70	68	58	57	55	70	24	27	26	45
Cattle/fall			66	68	55	61	53	71	24	27	28	46
Cattle/winter				80	64	67	65	70	39	43	43	60
Cattle/spring					57	62	64	70	39	44	42	60
Elk/summer						72	50	57	55	58	43	59
Elk/fall							60	63	50	60	54	63
Elk/winter								70	33	49	48	60
Elk/spring									34	43	44	63
Mule deer/summer										71	50	55
Mule deer/fall											65	67
Mule deer/winter												70

Dietary overlap between elk and cattle was >50% in all seasonal combinations (Table 2), and elk diets in spring were very similar to cattle diets in all seasons (mean = 70% dietary overlap). Mule deer diets in spring also overlapped notably with spring diets of cattle (60% dietary overlap) and with elk diets in all seasons (mean = 61% overlap). Elk–mule deer dietary overlap was >50% in 9 of 16 seasonal combinations (Table 2).

### Feeding Habitat Use and Overlap

Seasonal feeding habitat selection by cattle was restricted, in part, by cattle grazing management practices that were typical of many ranches in the northern Rocky Mountains. During winter and spring, cattle were confined primarily to feeding grounds and fed hay, with some time spent grazing within foothill sagebrush grasslands (Table 3). During summer, cattle progressed from sagebrush grasslands into higher-elevation mountain grasslands before the pattern was reversed in fall and cattle again returned to foothill sagebrush grasslands and feeding grounds.

Although elk movements were not constrained by fencing and herding as were cattle, elk exhibited similar seasonal adjustments in feeding habitat use (Table 3). In winter and spring, elk foraged predominantly within foothill sagebrush grasslands (54% and 72% of observations in winter and spring, respectively), whereas elk foraged predominantly in mountain

grassland during summer and fall (67% and 87% of observations in summer and fall, respectively).

Mule deer feeding habitat was predominantly within foothill sagebrush grassland during all seasons, especially in winter and spring (92% and 98% of observations in winter and spring, respectively; Table 3). About 29% of mule deer feeding habitat use in fall occurred on hayfields.

Feeding habitat overlap (Table 4) between elk and cattle during summer–fall was high (mean = 50% overlap), but overlap was even greater between where cattle foraged in summer–fall and where elk foraged in winter–spring (mean = 86% overlap). Cattle feeding habitat in summer–fall also overlapped greatly with mule deer feeding habitat in all seasons (mean = 65% overlap). Elk and mule deer feeding habitat during summer–fall did not overlap greatly (mean = 43% overlap). However, overlap was very high between where elk foraged in winter–spring and where mule deer foraged in all seasons (mean = 68% overlap), principally in the foothill sagebrush grasslands.

### Foraging Niche Overlap

Elk, mule deer, and cattle may eat similar diets, as expressed by dietary overlap, or occupy similar vegetation types when foraging, as expressed by feeding habitat overlap. However, the potential for competitive or complementary interactions between elk, mule deer, and cattle is greatest when these

**Table 3.** Feeding habitat use ( $\pm$  standard error) by cattle, elk, and mule deer on foothill and mountain rangeland in northwestern Wyoming.

Vegetation type	Season											
	Summer			Fall			Winter			Spring		
	Cattle	Elk	Mule deer	Cattle	Elk	Mule deer	Cattle	Elk	Mule deer	Cattle	Elk	Mule deer
	------(%)-----											
Hayfield	1 (1.2)a <sup>1</sup>	13 (5.2)a	0a	5 (2.7)a	3 (1.9)a	29 (8.5)a	0a	0a	<1a	0a	<1a	1 (0.7)a
Mountain grassland	40 (10.1)a	67 (12.0)a	25 (16.7)a	24 (9.8)a	87 (3.0)b	24 (20.1)a	0a	46 (12.0)b	8 (4.1)a	0a	28 (8.3)b	1 (0.5)a
Sagebrush grassland	59 (10.1)a	20 (12.1a)	75 (16.7)a	67 (12.0)a	10 (4.5)b	47 (20.8)ab	11 (4.2)a	54 (12.0)b	92 (4.2)c	22 (1.2)a	72 (8.4)b	98 (1.2)c
Cattle feeding grounds	0a	0a	0a	4 (2.7)a	0a	0a	89 (4.2)a	0b	0b	78 (1.2)a	0b	0b

<sup>1</sup>Values in the same row within seasons with the same letter were not different ( $P > 0.10$ ).

**Table 4.** Feeding habitat overlap among cattle, elk, and mule deer on foothill and mountain rangeland in northwestern Wyoming.

Species/season	Species											
	Cattle				Elk				Mule deer			
	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring
	------(%)-----											
Cattle/summer		84	11	22	62	51	94	87	73	58	67	60
Cattle/fall			15	26	50	36	78	84	64	54	74	68
Cattle/winter				89	9	2	11	11	11	11	11	11
Cattle/spring					20	10	22	22	22	20	22	22
Elk/summer						80	67	49	45	56	29	22
Elk/fall							56	38	35	37	18	11
Elk/winter								82	73	57	62	55
Elk/spring									80	64	80	73
Mule deer/summer										71	69	74
Mule deer/fall											48	48
Mule deer/winter												93

ungulates consume similar diets while foraging within similar vegetation types, as expressed by high foraging niche overlap.

Foraging niche overlap (Table 5) was very high between summer–fall cattle use and elk use in winter (46% overlap) and spring (60% overlap). Foraging niche overlap between cattle and elk did not exceed 40% overlap in any other seasonal combinations (Table 5). Foraging niche overlap between cattle and mule deer was low (<40% overlap) in all seasonal combinations. Between elk and mule deer, foraging niche overlap also was generally low; however, elk and mule deer had a relatively high foraging niche overlap (45%) during spring.

## DISCUSSION

The grass-dominated diets of cattle and elk reported in this study (Table 1) agree with results from previous studies on foothill and mountain rangeland in the northern Rocky Mountains (Stevens 1966; Miller and Krueger 1976; McLean

and Willms 1977; Skovlin and Vavra 1979; Berg and Hudson 1982; Kasworm et al. 1984; Vavra et al. 1989; Ngugi et al. 1992). For elk, graminoids were an especially important dietary component in winter and spring (66% and 72%, respectively; Table 1). These values compare favorably with elk diets on foothill rangeland in northeastern Oregon (60% graminoids in winter–spring; Skovlin and Vavra 1979), southwestern Alberta (95% graminoids in winter–spring; Berg and Hudson 1982), north-central Montana (84% graminoids in winter and 65% graminoids in spring; Kasworm et al. 1984), west-central Montana (77% graminoids in spring; Stevens 1966), and south-central Wyoming (84% graminoids in spring; Ngugi et al. 1992).

Elk and cattle in our study had high feeding habitat overlap during summer (62%; Table 4). This is common during summer in foothill and mountain rangeland in the northern Rocky Mountains (Long and Irwin 1982; Coe et al. 2001; Stewart et al. 2002), but elk sometimes favor upper and midslopes, while cattle favor lower portions of slopes (Julander and Jeffery

**Table 5.** Foraging niche overlap among cattle, elk, and mule deer on foothill and mountain rangeland in northwestern Wyoming.

Species/season	Species											
	Cattle				Elk				Mule deer			
	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring
	------(%)-----											
Cattle/summer		69	7	15	36	29	51	61	19	16	17	27
Cattle/fall			9	18	27	22	41	60	15	14	21	31
Cattle/winter				71	5	1	6	7	4	5	4	6
Cattle/spring					12	6	14	15	9	9	9	13
Elk/summer						58	33	28	26	32	12	13
Elk/fall							34	25	19	21	10	8
Elk/winter								58	28	29	29	33
Elk/spring									28	27	35	45
Mule deer/summer										50	33	40
Mule deer/fall											29	33
Mule deer/winter												65

1964). Selection of higher slopes by elk also may limit feeding habitat overlap between cattle use in summer and elk in winter (Hart et al. 1991). We found high feeding habitat overlap between summer–fall cattle use and elk in winter–spring (mean = 75% overlap), but the potential effects of slope were not accounted for in our data. However, slope use by cattle and elk was documented on our study area in 2 companion studies (Crane 2002; Brewer 2004). These 2 studies found that both cattle in summer–fall and elk in fall–winter–spring grazed primarily on slopes less than 25%, indicating that cattle and elk did not use slope position to partition forage resources.

We found the species of graminoids that elk ate in winter and spring closely mirrored the ones that cattle had eaten the previous summer–fall (54% dietary overlap between summer–fall cattle diets and winter elk diets; 70% dietary overlap between summer–fall cattle diets and spring elk diets; Tables 1 and 2). Kasworm et al. (1984) also reported that winter elk diets and summer cattle diets were highly correlated, and Berg and Hudson (1982) reported an astounding 98% dietary overlap between summer–fall cattle diets and winter–spring elk diets. In a companion study on 2 of the 4 ranches in our study area, Crane (2002) determined that elk in winter–spring preferentially selected feeding habitat where moderate cattle grazing had occurred during the previous summer–fall.

Mule deer diets in this study were comprised of fewer graminoids than elk or cattle diets, but during spring, mule deer diets were about one-third graminoids (Table 1). Mule deer in spring commonly select young, succulent growth from grasses such as bluebunch wheatgrass, Idaho fescue, and Sandberg bluegrass (Willms and McLean 1978; Skovlin and Vavra 1979; Smith et al. 1979). For example, mule deer spring diets were 38% graminoids, 33% graminoids, and 46% graminoids in west-central Montana (Lovaas 1958), north-central Montana (Martinka 1968), and northeastern Oregon (Skovlin and Vavra 1979), respectively. Graminoid consumption by mule deer in spring was even greater on foothill sagebrush grassland and ponderosa pine (*Pinus ponderosa* Dougl.) habitats in south-central British Columbia, where mule deer diets were 70% graminoids in March–May and 92% graminoids in April alone (Willms and McLean 1978). In such situations, dietary overlap can be high between mule deer spring diets and year-round diets of elk and cattle. In our study, elk diets in all seasons averaged 61% dietary overlap with mule deer spring diets, whereas cattle diets in spring and winter had 60% overlap with mule deer spring diets (Table 2). However, in other locales, mule deer spring diets are sometimes browse dominated and have less dietary overlap with elk and cattle. For example, Kasworm et al. (1984) reported mule deer diets in March–April to be 18% graminoids and 67% browse. Of the browse consumed, 67% was creeping juniper (*Juniperus horizontalis* Moench), a prostrate, coniferous shrub. Similarly, Berg and Hudson (1982) found the conifer Douglas-fir (*Pseudotsuga menziesii* [Mirbel] Franco) to be a dominant browse species in mule deer winter–spring diets that averaged 3% graminoids and 97% browse.

Alfalfa and alfalfa hay comprised large proportions of mule deer diets in all seasons (18%–28%; Table 1). In fall, mule deer in our study consumed 21% alfalfa, which compares closely with the 20% documented by Martinka (1968) in the Bear Paw Mountains of north-central Montana. Mule deer were abun-

dant on our study area during winter and spring, and alfalfa comprised 18% of their diets. We conclude that mule deer likely consumed significant amounts of alfalfa hay that had been disbursed to cattle.

## MANAGEMENT IMPLICATIONS

During most of the year on the study area, mule deer and cattle foraged within similar vegetation types but did not eat similar diets. However, in spring after cattle were no longer fed hay and were turned out to graze, nonsolitary cattle, elk, and mule deer all concentrated their foraging activities on graminoids in nonforested foothill sagebrush grassland. Cattle grazing during summer–fall also concentrated on graminoids in foothill sagebrush grasslands and mountain grasslands where elk subsequently concentrated on graminoids during winter–spring. Therefore, if competitive or complementary relationships existed between elk and cattle, these interactions most likely occurred on sagebrush grasslands where cattle use in summer–fall was followed by elk use in winter–spring. Combined with the results of previous studies, our results suggest that this foraging niche overlap between summer–fall cattle use and winter–spring elk use likely benefits elk in our study area when forage utilization by cattle does not exceed moderate levels (Crane 2002). In turn, grazing by elk and mule deer in spring is unlikely to compete with cattle use in summer–fall, provided that elk or mule deer grazing is not excessive (Hobbs et al. 1996a, 1996b; Brewer 2002). We recommend that resource managers focus their forage utilization and range trend monitoring efforts in foothill sagebrush grasslands, particularly on southerly aspects, as these are preferred sites for spring grazing by elk, mule deer, and cattle (Hudson et al. 1976; Willms et al. 1979; Nelson and Leege 1982).

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