Diet Overlap of Deer, Elk, and Cattle in Southern Colorado

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Highlight: *The monthly diets of mule deer and elk were estimated by microscopic analyses of fecal samples from December, 1970, through November, 1971, and from June, 1971, through September, 1971, for cattle. Seasonal preferences for plants were observed for mule deer and elk. Deer diets consisted primarily of browse except in summer and early winter when grasses were taken in significant amounts. Forbs were eaten by deer in small amounts only in the spring and summer. Elk diets were mostly grasses, but a significant percentage of browse was consumed in all seasons except the summer. Cattle diets from June through September were almost entirely grasses or grass-like plants. Dietary overlap between deer and elk ranged from three percent in winter to 48% in summer; of deer and cattle in summer from 12% to 38%; of elk and cattle in summer from 30% to 51%. The diversity of plants in the diets was similar for deer, elk, and cattle.*

Published reports on herbivore diets differ widely in methodology and analyses of results (Kufeld, 1973; Kufeld et al., 1973). Numerous studies have been conducted on mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*) and cattle (*Bos taurus*) relating food habits to range plants, animal body condition, and interspecific competition for food (Cliff, 1939; Schwan, 1945; Julander, 1955; Morris and Schwartz, 1957; Mackie, 1970; McKean and Bartmann, 1971; Constan, 1973). These studies show large variation by year of study, location, specific herbivore, and research techniques. Therefore, dietary overlap calculated from different reports may or may not be comparable. Hansen et al. (1973) reported that the microscopic analyses of fecal and esophageal samples yield comparable results in terms of degree of dietary overlap between cattle, bison, and sheep.

The purpose of the study reported herein was to estimate seasonal dietary overlaps for mule deer, elk, and cattle which have a free choice of available range plants on the same range for the same dates, using the microscopic analysis of fecal sample technique.

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Study Areas

This study was made on a private ranch encompassing an area of 728 km^2. The ranch headquarters is located 8.3 km east of Fort Garland, Colorado, on the west slope of the Sangre De Cristo Mountains (Fig. 1). Aerial surveys in 1970 revealed that the ranch annually supports approximately 2,500 elk and 4,000 deer. At the time of the study, the ranch did not own range livestock, but sold permits for grazing only in the summers. About 2,000 cattle were grazed during the summer when the study was conducted. The western edge of the ranch is flat, semidesert typical of the San Luis Valley. The foothills vary in altitude from 2,500 to 2,900 m and receive an estimated 18 to 51 cm of precipitation annually. Streams fed from the higher mountains flow through the foothill meadows and provide water for irrigation of crop land. The higher altitudes of the ranch range from 2,750 to 4,115 m and receive in excess of 75 cm of precipitation annually.

There are five relatively distinct range types in the study area. The sagebrush-grass type occurred at elevations of 2,440 to 2,750 m. Terrain varied from flat to rolling hills and to relatively steep slopes at some locations. Big sagebrush (*Artemisia tridentata*) is the dominant plant but other shrubby species of importance are: Douglas rabbitbrush (*Chrysothamnus viscidiflores*), Parry rabbitbrush (*Chrysothamnus parryi*), fringed sagewort (*Artemisia frigida*), broom snakeweed (*Xanthocephalum sarothrae*), and threadleaf snakeweed (*Xanthocephalum microcephala*). Growing in association with these shrubs are a variety of grasses such as: western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), smooth brome (*Bromus inermis*), prairie Junegrass (*Koeleria cristata*), Indian ricegrass (*Oryzopsis hymenoides*), mountain muhly (*Muhlenbergia montana*), and fescues (*Festuca*). Forbs are not abundant in the sagebrush-grass type. Important forbs are pingue actinea (*Hymenoxys richarsoni*), rough goldenaster (*Chrysopsis hispida*), wild buckwheat (*Eriogonum*), fleabane (*Erigeron*), lupine (*Lupinus*), and mustards. The sagebrush-grass type borders on the pinyon-juniper and mountain meadow types.

The pinyon-juniper type is found at elevations of from 2,500 to 2,900 m. The topography is similar to the sagebrush-grass type varying from flat to hilly. The dominant vegetation in this type is pinyon pine (*Pinus edulis*), Utah juniper (*Juniperus osteosperma*), Rocky Mountain juniper (*Juniperus scopulorum*), and common juniper (*Juniperus communis*). Occasionally Gambel oak (*Quercus gambeli*) and ponderosa pine (*Pinus ponderosa*) will be found at the higher elevations. Important grasses include: western wheatgrass, blue grama, prairie Junegrass, mountain muhly, and fescues. Forbs and browse species include: big sagebrush, fringed sagewort, true mountainmahogany (*Cercocarpus montanus*), small soap-

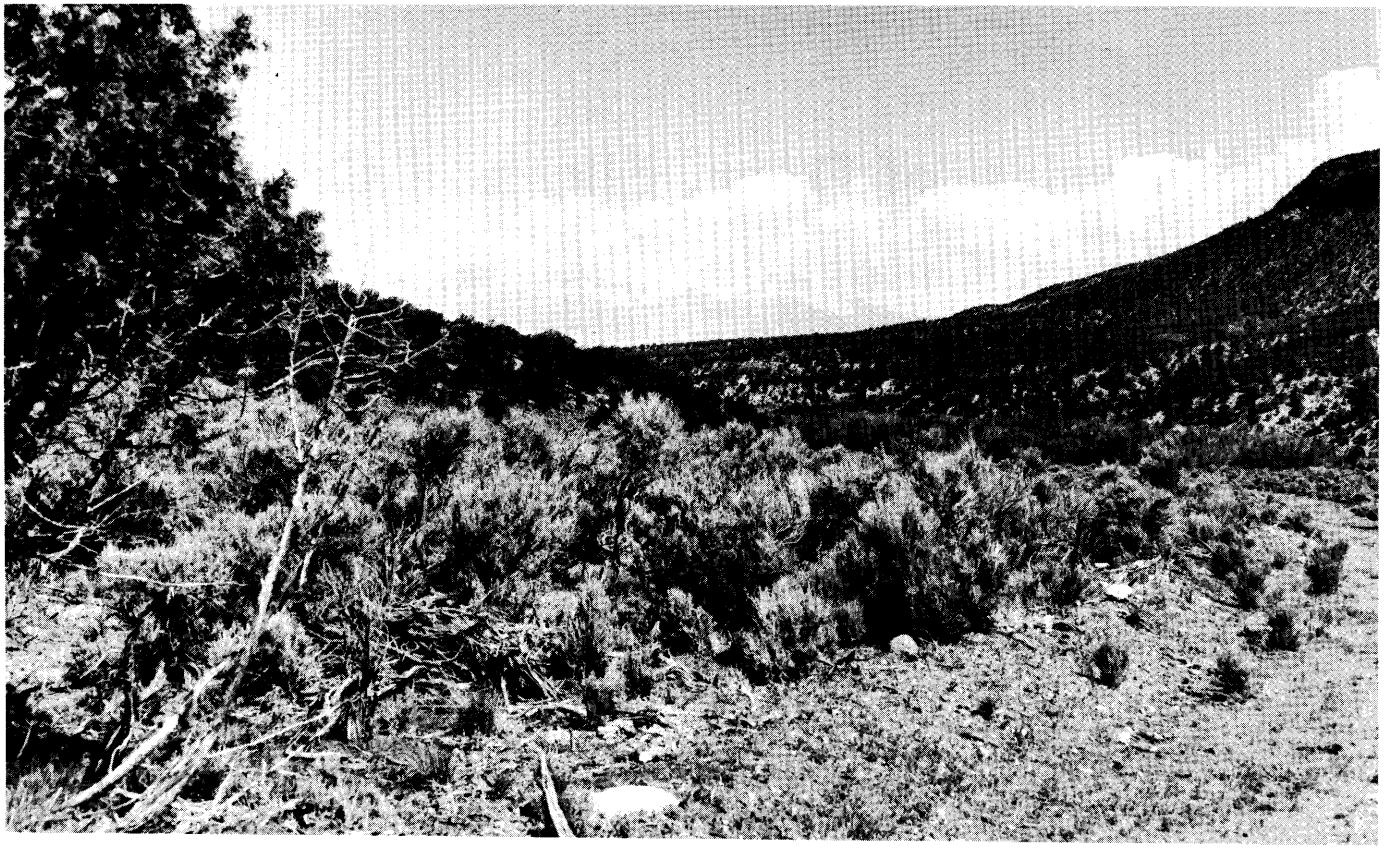

Fig. 1. *Winter range of deer and elk, consisting of the sagebrush-grass and pinyon-juniper range types (foreground).*

weed (*Yucca glauca*), pingue actinea, pricklypear (*Opuntia*), lupine, wild buckwheat, and snowberry (*Symphoricarpos*). This type borders on the sagebrush-grass, mountain meadow and conifer-aspen types.

A mountain meadow type is found in the foothill areas where streams provide moisture and in the higher elevations in the draws or canyons. Vegetation is primarily of the grass or forb type and varies greatly with site and elevation, which runs from 2,500 to 3,050 m. Important grasses found in this type are: smooth brome, bluegrass (*Poa*), and sedge (*Carex*). The abundant forbs are common dandelion (*Taraxacum officinale*), alfalfa (*Medicogo sativa*), mountain thermopsis (*Thermopsis montana*), yarrow (*Achillea*), clover (*Trifolium*), vetch (*Vicia*), lupine and mustards. Browse plants include willow (*Salix*), rose (*Rosa*), and snowberry. The mountain meadow type borders on the sagebrush-grass pinyon-juniper, and conifer-aspen types.

The conifer-aspen type occurs above an elevation of 2,590 m and is highly heterogeneous. Mixed stands of quaking aspen (*Populus tremuloides*), white fir (*Abies concolor*), Douglasfir (*Pseudotsuga menziesii*) and limber pine (*Pinus flexilus*) are more likely to be found than are pure stands of one species. Blue spruce (*Picea pungens*), ponderosa pine, bristlecone pine (*Pinus aristata*), and Engelmann spruce (*Picea engelmanii*) occur less frequently. The understory of the conifer-aspen type varies with the altitude and the tree density. Dominant grasses are mountain muhly, smooth brome, sedge, and bluegrass. Forbs show great variation with the most prominant ones being: Common dandelion, mountain thermopsis, yarrow, vetch, peavine (*Lathrus*), and fleabane. Bearberry manzanita (*Arctostaphylos uvar-ursi*) also occurs frequently. This type borders on the pinyon-juniper, mountain meadow, and open park types.

The open park type occurs at about 2,900 m and is characterized by dense stands of grasses with very few forbs, trees, or shrubs. Grasses relatively important in this type are muhly, fescue, bluegrass, danthonia (*Danthonia*), sedge, brome, blue grama, and needlegrass (*Stipa*). This type is surrounded by the conifer-aspen type.

Methods

The bontanical compositions of the diets were determined by a microscopic analysis of a composited sample of recently-dropped fecal material from each of the three herbivores. It is known that forage species can be recognized in fecal samples by microscopic analysis of the plant cuticle (Storr, 1961; Williams, 1969). Fecal samples were collected from eight areas which varied in size from approximately 13 to 16 km^2 each and were identified by the ranch manager as the major seasonal feeding places of mule deer, elk and cattle during the year (Table 1). Monthly fecal samples were collected for mule deer and elk from December, 1970, through November, 1971, and from June, 1971, through September, 1971, for cattle. The samples for each herbivore were collected randomly on an equal weight basis, from each of 50 piles of droppings about

Table 1. Percentage coverage of vegetation types on study areas near Fort Garland, Colo.

	Vegetation types				
Area	sagebrush-grass	pinyon-juniper	mountain-meadow	conifer-aspen	open park
1	25	50	25		
2	25	55	20		
3	30	25	15	30	
4	15	10	5	50	20
5	60	35	5		
6	30		10	45	15
7			5	35	60
8	35		5	35	25

the middle of each month. The subsamples of dung were composited for each species of herbivore to make a monthly sample.

Microscope slides were prepared of identified reference plants, and fecal samples as described by Sparks and Malechek (1968), Ward (1969), and Flinders and Hansen (1972). Fields on each microscope slide were viewed at 100 X for identifiable fragments. Twenty fields were examined on each of 20 microscope slides per fecal sample. The average number of identifiable fragments per field averaged approximately three.

The microscope technician was trained to identify the fragments of the species of plants occurring in each study area. The technician learned to identify and quantify plant fragments with the use of practice slides prepared from samples of known dry weight composition. Each fragment encountered in a field of the microscope was identified if its observed characteristics matched the leaf, stem, flower, seed, or other plant parts of the same material on a reference slide. Analyses were based on comparisons with about 150 species of vascular plants from the study area.

The relative percent density (RD) of recognized plant fragments in each of the fecal samples was estimated by observing fields located systematically on each of the slides. The occurrence of each recognized plant species in each field was recorded. Average percent frequency was computed for all plant species present in the samples. The relationship of percent frequency per field density of discerned fragments per field can be determined by the formula:

$$F = 100\,(1 - e^{-D}).$$

For a given percent frequency (**F**), the mean density (**D**) of discerned particles of a species per microscope field can be determined. The density of particles per field was converted to relative percent density (**RD**). **RD** = (**X** / **Y**) · 100, where **X** = density of discerned fragments for a species and **Y** = sum of densities of discerned fragments for all species. It was assumed that the percentage relative density of identified plant fragments is a good approximation for the relative amount of each plant eaten (Todd and Hansen, 1973).

Similarity indices (Gauch, 1973) were used to compare botanical composition between diets of herbivores by the expression:

$$PS\,(jk) = 100 \cdot \frac{2\sum^{I} \min\,(Pij, Pik)}{\sum^{I}(Pij + Pik)}$$

where **P***ij* and **P***ik* are percentages in the diets for foods *i* in the two samples *j* and *k* being compared. **PS** is the percentage similarity of two diets for the plant species which are shared (= identical).

A trophic diversity index is assumed to indicate variety and evenness components in diets (Hurtubia, 1973). High trophic diversity indices express high potential adapatability for a herbivore to select foods. Trophic diversity was calculated on the basis of Shannon's (1948) formula:

$$H'' = -\sum_{i=1}^{s} (N\,i\,/N) \ln (N\,i\,/N),$$

where **N** is the total number of identified plant fragments in a diet and **N***i* is the number of individual fragments in the i_{th} genus of plant in a fecal sample. Average trophic diversity was estimated by:

$$\bar{H} = \frac{H_1'' + H_2'' + H_3'' \ldots\ldots H_i''}{N},$$

where **H** is a mean monthly trophic diversity for a herbivore.

The plant names used follow the common and scientific name combinations recommended by Beetle (1970).

Results and Discussion

The major foods of mule deer in the winter were big sagebrush, pinyon pine, fringed sagewort, true mountainmahogany, and brome; in spring, big sagebrush, fringed sagewort, true mountainmahogany, bladderpod (*Lesquerella*), and pinyon pine; in summer, true mountainmahogany, sedge, fescue, bluegrass, fleabane, Gambel oak and juniper; and in the autumn, big sagebrush, true mountainmahogany, pinyon pine, juniper, and rabbitbrush (Table 2).

In winter elk diets mainly consisted of western wheatgrass, brome, needlegrass, bluegrass, winterfat (*Erotia*), true mountainmahogany, and falsetarragon sagewort (*Artemisia dracuncoloides*); in spring, brome, sedge, fescue, bluegrass, needlegrass, creeping barberry (*Berberis repens*), juniper, and true mountainmahogany; in summer, sedge, fescue, bluegrass, needlegrass, and Gambel oak; in autumn, western wheatgrass, falsetarragon sagewort, bluegrass, fescue, sedge, juniper and brome (Table 3).

The cattle ate mainly danthonia, fescue, bluegrass, sedge, and blue grama (Table 4).

Winter monthly diet similarity between mule deer and elk ranged from 2.6 to 20.1% (Fig. 2). For the winter period mule

Table 2. Foods (% in diet) of mule deer near Fort Garland, Colo., in Winter (Dec.-Jan.-Feb.), spring (Mar.-Apr.-May), summer (June-July-Aug.), and autumn (Sept.-Oct.-Nov.), 1970-71.

	Seasonal diets			
Plant name*	Winter	Spring	Summer	Autumn
Western wheatgrass			1	3
Blue grama		1	2	
Brome	4			<1
Sedge			7	
Fescue		1	20	4
Muhly			1	
Bluegrass	1	4	10	2
Dropseed	<1			
Needlegrass	<1	<1	1	
Fringed sagewort	18	9		
Big sagebrush	44	46		23
Milkvetch		2	1	
Saltbush	1			2
Pussytoes			<1	
Creeping barberry	1	<1	2	
True mountainmahogany	6	10	26	45
Rabbitbrush	<1	4		5
Tansymustard		1		
Fleabane			9	
Winterfat	<1			2
Rockspirea		3	1	
Juniper	1	2	7	8
Fireweed summercypress	<1	<1		<1
Peavine	2		<1	
Pepperweed		<1		
Bladderpod	<1	4	<1	
Common starlily		<1	1	
Alfalfa		1		
Pricklypear	1		<1	
Loco			1	
Pinyon pine	22	12		6
Gambel oak			5	
Seed of dicot		<1		
Buffaloberry				<1
Globemallow			4	
Snakeweed			1	

*Plant names follow Beetle (1970).

Table 3. Foods (% in diet) of elk near Fort Garland, Colo., in winter (Dec.-Jan.-Feb.), spring (Mar.-Apr.-May), summer (June-July-Aug.), and autumn (Sept.-Oct.-Nov.), 1970-71.

Plant name*	Winter	Spring	Summer	Autumn
Western wheatgrass	26	2		25
Blue grama	<1	3	1	1
Brome	27	11		5
Sedge	<1	11	21	3
Danthonia				1
Fescue		13	37	12
Muhly	2	2	1	
Indian ricegrass				<1
Bluegrass	7	13	15	14
Dropseed				<1
Needlegrass	10	16	8	
Falsetarragon sagewort		3		
Big sagebrush		3		
Alder				1
Saltbush				1
Creeping barberry	1	6	1	<1
True mountainmahogany	7	4	4	4
Rabbitbrush	1	1		3
Springparsley			1	
Fleabane			1	<1
Winterfat	5			3
Rockspirea		<1	<1	
Juniper	4	8	<1	4
Bladderpod	<1	<1		
Lupine	1		1	
Alfalfa				1
Lanceleaf bluebells			<1	
Pricklypear		1		
Pinyon pine			1	<1
Gambel oak			6	
Sumac			<1	
Seed of dicot				<1
Buffaloberry			<1	3
Globemallow			1	
Small soapweed		2		1
Snakeweed	<1			1

*Plant names follow Beetle (1970).

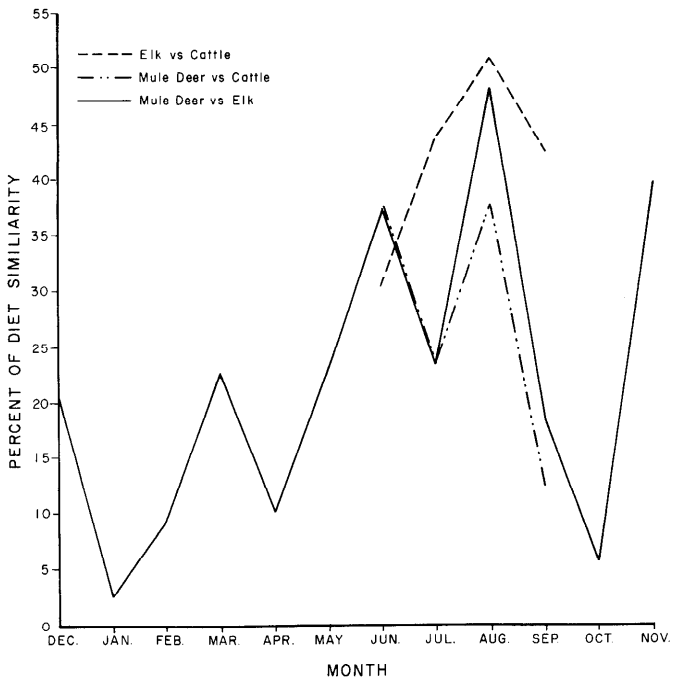

Fig. 2. *Mean percentage diet overlap for deer, elk, and cattle grazing rangeland near Fort Garland, Colorado (1970-71).*

Table 4. Foods (% in diet) of cattle near Fort Garland, Colo., from June through September, 1971.

Plant name*	June	July	Aug.	Sept.
Danthonia	36	28	31	
Fescue	21	32	16	22
Sedge	8	9	7	58
Bluegrass	18	18	25	11
Blue grama	11	1	8	1
Muhly	1	1	9	1
True mountainmahogany	2	5		3
Needlegrass	2	1	3	2
Bladderpod		2		
Wheatgrass		2		
Rabbitbrush				1
Threeawn			1	
Pinyon pine	1			
Fleabane		1		
Buffaloberry				<1
Seed of dicot				<1

*Plant names follow Beetle (1970).

deer and elk concentrated in areas 2 and 3 (Table 5) and both ate significant amounts of true mountainmahogany and brome. Spring diet similarity between mule deer and elk ranged from 10.1 to 23.3% and diet overlap occurred primarily for true mountainmahogany, big sagebrush, fringed sagewort, and bluegrass. Mule deer and elk concentrated in area 4 during March, but most deer and elk fed in different areas in spring. Dietary overlap in March occurred mostly for true mountainmahogany and big sagebrush. The summer diet similarity ranged from 23.3 to 48.0% and was primarily for sedge, fescue, bluegrass, and true mountainmahogany. Mule deer and elk were concentrated in different areas during the summer. The overall diet similarity for the summer period was higher than that for any other season for mule deer and elk.

The autumn diet similarity indices of mule deer and elk ranged from 5.6 to 39.8%. September and October diets overlapped the least and November diets the highest. For two autumn months mule deer and elk occupied area 1 and in November both ate significant amounts of true mountainmahogany, western wheatgrass, fescue, rabbitbrush, winterfat, and juniper.

Diet similarity between mule deer and cattle ranged from 12.1 to 37.8% for the 4 months of cattle grazing. Mule deer and cattle were mostly concentrated in different areas but there was a high overlap in the diets for sedge, bluegrass, fescue, and true mountainmahogany.

Elk and cattle diet similarities ranged from 30.4 to 50.9% and elk and cattle fed in the same areas (areas 1 and 7). Diets overlapped strongly for sedge, fescue, and bluegrass. The average monthly diet similarity index between elk and cattle (42 ± 8%) was higher than that of elk versus deer (22 ± 14% or deer versus cattle (28 ± 12%).

Mule deer and elk tended to graze the same areas when (October through March) the range plants were primarily dormant. The dietary overlap averaged (**PS** = 17 ± 13%) lower between deer and elk on fall and winter ranges than it did in the spring and summer (April through September, **PS** 27 ± 14%). Mackie (1970) reported similar findings on the dissimilarity of food habits of deer and elk in Montana. In the Montana study, the feeding areas used by deer and elk overlapped most between April and September and less at other times. Therefore, deer and elk food habits appear to be more similar in the plant growing season and less similar at other times whether or not they primarily use the same

Table 5. Species of herbivore and area primarily used for feeding near Fort Garland, Colo., from December, 1970, through November, 1971.

Area	Herbivore	Months used
1	Cattle	Sept. '71
	Elk	Sept., Oct., Nov. '71
	Mule deer	Oct. and Nov. '71
2	Elk	Dec. '70 and Jan. '71
	Mule deer	Dec. '70 and Jan. '71
3	Elk	Feb. '71
	Mule deer	Feb. '71
4	Elk	March '71
	Mule deer	March '71
5	Mule deer	April '71
6	Elk	April '71
7	Cattle	June, July, and Aug. '71
	Elk	May, June, July, and Aug. '71
8	Mule deer	May, June, July, Aug., and Sept. '71

Table 6. Trophic diversity indices for mule deer, elk, and cattle near Fort Garland, Colo., from December, 1970, through November, 1971.[1]

Months	Species of herbivore		
	Deer	Elk	Cattle
Dec.	1.77	1.95	
Jan.	1.10	1.60	
Feb.	1.50	1.80	
Mar.	1.70	2.12	
Apr.	1.17	1.64	
May	1.53	2.02	
June	2.04	0.91	1.71
July	1.91	1.91	1.71
Aug.	1.74	1.74	1.74
Sept.	0.67	1.80	1.25
Oct.	1.24	1.50	
Nov.	1.86	1.77	

[1] Shannon (1948) diversity index.

feeding areas or adjacent feeding areas.

In this study cattle grazing was restricted to the areas selected by the ranch manager within the rest-rotation livestock management plan for the ranch. At the time of this study the ranch manager was vitally interested in stocking the ranges on the basis that would assure sustained forage and livestock production at a high level during the plant growing season and to "save" as much forage as possible on the lower ranges used in winter by deer and elk. Thus, the interspecific food relations of deer, elk, and cattle were only from June through September on the summer ranges of deer and elk. On summer ranges elk and cattle diets overlap deer diets about the same percentage (elk vs deer, **PS** = 32 ± 13%; cattle vs. deer, **PS** = 28 ± 12%). Cattle and elk diets overlapped the most (**PS** = 42 ± 8%).

The diversity of plant species eaten by each herbivore may constitute a useful parameter in ecological comparisons of sympatric species since it expresses the food niche breadth and it complements the studies on overlap and competition (Schoener, 1971; Hurtubia, 1973). Trophic diversity averaged 1.52 ± .40 for deer and 1.73 ± .31 for elk over the 12 months (Table 6). Although it is generally believed that elk are more versatile than deer in food habits, their mean trophic diversity ($\bar{H}$) values in this study were not significantly different. On summer ranges (June through September) the average $\bar{H}$ values were similar for deer ($\bar{H}$ = 1.59 ± .63), elk ($\bar{H}$ = 1.59 ± .46) and cattle ($\bar{H}$ = 1.60 ± .23). Though all herbivores share the plants in an ecosystem, all feed in a different way. Most large herbivores are adapted to eat a variety of plants and changes in the botanical composition caused by a prolonged drought do not strongly affect their survival as a species population even if their numbers dwindle.

Stocking ranges so that they will assure sustained forage for livestock and wildlife production at a high level is a desirable goal. The frequent selection of planning criteria is by intuition (Gross, 1972) and faulty planning occurs if the wrong criteria are used. Without intensive experimentation a performance measure of the ranch manager's goals cannot be estimated. However, we believe the observed relations may be similar on many "common-use" ranges.

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