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HABITAT USE BY ELK, MULE DEER, AND CATTLE IN ARIZONA

THE UNIVERSITY OF ARIZONA

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HABITAT USE BY ELK, MULE DEER, AND CATTLE
IN ARIZONA

by
Mark Christopher Wallace

A Thesis Submitted to the Faculty of the
SCHOOL OF RENEWABLE NATURAL RESOURCES
In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE
WITH A MAJOR IN WILDLIFE ECOLOGY

In the Graduate College
THE UNIVERSITY OF ARIZONA

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ACKNOWLEDGMENTS

Financial support for this study was provided by the University of Arizona Agricultural Experiment Station, the U.S. Forest Service, and the Arizona Game and Fish Department. I wish to thank all the Chevelon District Forest Service personnel, especially Mark Whitney, for their assistance during this study.

I am most grateful to Dr. Paul R. Krausman, my major advisor, for his guidance and support. I would also like to thank Drs. M. J. Zwolinski, J. Rodiek, W. W. Shaw, R. W. Mannan, and B. D. Leopold for their assistance in the preparation of this thesis.

Special thanks to my mother Nelsa M. Buckingham who sparked my interest in science and who, with my stepfather "Buck," made constructive comments throughout the study.

Finally, I wish to express my sincere appreciation to my wife Janet for her loving support and cheerful encouragement without which this study would not have been possible.

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ABSTRACT

Elk (Cervus elaphus) and mule deer (Odocoileus hemionus) distribution and habitat use in relation to the presence of cattle was determined on ponderosa pine (Pinus ponderosa)--bunchgrass summer range in north-central Arizona. Changes in distribution, food habits, and habitat use were observed when cattle were introduced. Significantly fewer elk ($P < 0.10$) and mule deer ($P < 0.01$) were seen on pastures grazed by cattle. Elk-mule deer diet overlap decreased when cattle grazed. Elk-cattle diet overlap was greatest in late summer-fall. Mule deer-cattle diet overlap was greatest in mid-summer. Habitat use by elk showed an apparent shift from open mesic and silviculturally disturbed areas to more closed forest and associated understory species after cattle were introduced. Habitat use by mule deer did not change with the presence of cattle.

CHAPTER 1

INTRODUCTION

In North America, elk and mule deer share ranges with livestock. The forest resources of central Arizona are being used for timber, grazing, recreation, and wildlife habitat. Sound management decisions for the optimization of forested range use by elk, mule deer, and cattle will be facilitated by understanding each species' ecological niche. Hutchinson (1965) depicted the ecological niche as a hypervolume in which the "fitness" of the species is positive. The axes of this hyperspace correspond to relevant environmental variables. Though useful as a theoretical model this has been a difficult concept to apply to field data. The number of environmental variables involved make it difficult to know a priori which may be important, irrelevant, or redundant (Hudson 1976). Multiple discriminant analysis is an appropriate statistical model when the environmental parameters measured are interval or ratio scale data (Green 1971). Ferrar and Walker (1974), Hudson (1976) and Sivinski (1979) have applied this technique to evaluating niches of large herbivores.

There is greater likelihood of niche overlap between wild and domestic herbivores than between native herbivores. Domestic herbivores did not evolve with native species and, have not evolved separate niches distinct from those of wild herbivores. Evolution of domestic stock has been directed by man by selecting for efficient use of a wide ecological niche. Ecological niches of wild herbivores may be narrower and more inflexible than those of their domestic counterparts. Consequently, as successional stages and plant associations are altered through timber management and grazing, wild species habitat may be detrimentally altered while the range continues to be favorable for domestic animals (Wagner 1978).

Julander and Jeffery (1964), Skovlin et al. (1968), Mackie (1970, 1976, 1978, 1981), Urness (1976, 1982), Berg and Hudson (1982), McIntosh and Krausman (1982), and Nelson (1982) suggest that elk and mule deer range use is altered by cattle grazing. Skovlin et al. (1968), Nelson and Burnell (1975), and Knowles and Campbell (1982) indicated elk use decreased in response to cattle grazing, whereas, Ward et al. (1973), and Long and Irwin (1982) state that cattle grazing did not affect elk use. Andersen and Scherzinger (1975) demonstrated that cattle grazing can even be used to improve elk range. Stuth

and Winward (1977) indicated little cattle-deer overlap on good moderately stocked range. Julander and Robinette (1970), and Lucich and Hansen (1981) showed high overlap on overgrazed and seriously depleted ranges could lead to competition. Urness (1976) and Longhurst et al. (1982) argue that cattle grazing pressures have created much of our western deer habitat and agree with Mclean and Willms (1982) that cattle grazing can be used as a deer management tool.

My objectives were to study elk and mule deer distributions and their ecological niches on ponderosa pine-bunchgrass pastures grazed by cattle under a managed rest-rotation grazing system in central Arizona. McIntosh and Krusman (1982) showed changes in mule deer distribution under this system and suggested that elk use also shifted. I hypothesized that livestock grazing alters habitat use by native ungulates.

CHAPTER 2

MATERIALS AND METHODS

Study Area

This study was conducted in July and August 1981 and from May to October 1982 on the Apache-Sitgreaves National Forest, Arizona (Figure 1). The 80 km² study area is characterized by broad flat plateaus cut by steep north draining canyons. The elevation ranges from 1930 m in the north to 2500 m in the south. Average annual precipitation at the lower elevations is 46 cm and rises to 64 cm at the higher elevations. As much as 40% of the annual precipitation falls in July and August. August was wetter than normal in 1981 and the summer storms ended early in 1982 as compared to a 15 year average (Adams et al. 1979) (Figure 2).

Potable water for ungulates was available throughout the study but was widely scattered in dry months.

Ponderosa pine is the dominant overstory species with interspersed gambel oak (Quercus gambelii) and quaking aspen (Populus tremuloides) stands occurring in more mesic sites. Douglas fir (Pseudotsuga menziesii), limber pine (Pinus flexilis), and white fir (Abies

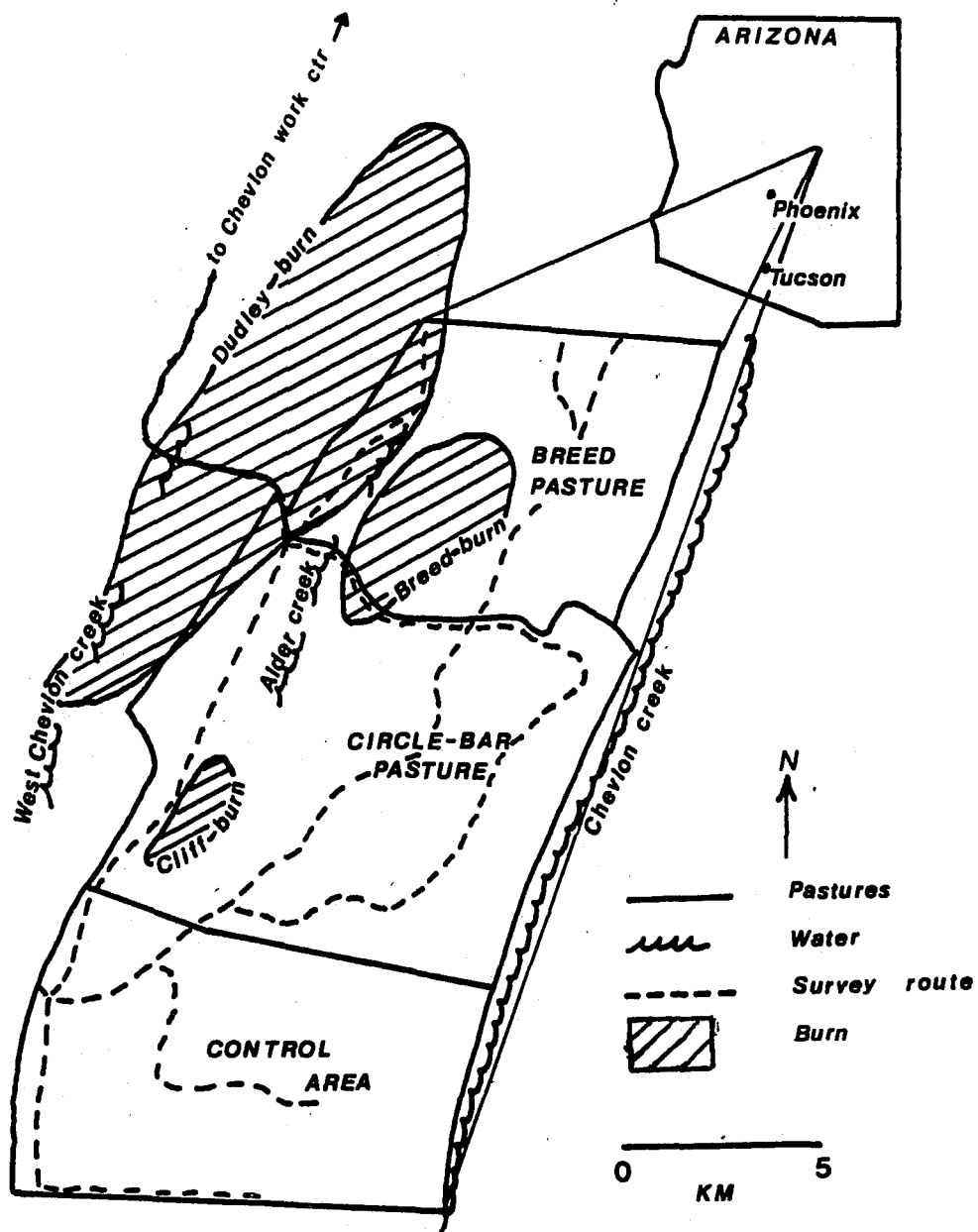


Figure 1. Study area, Chevelon District, Apache-Sitgreaves National Forest, Arizona, 1981-1982.

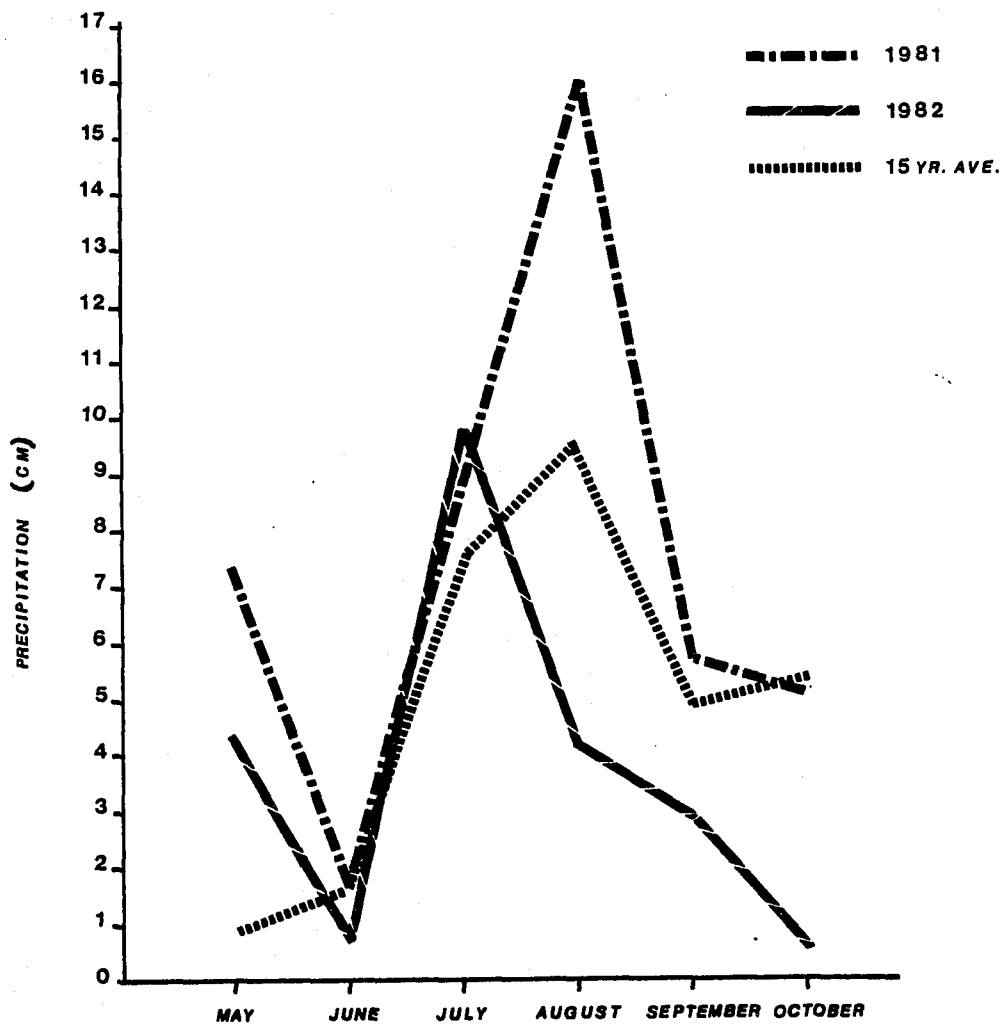


Figure 2. Average monthly precipitation (cm) compared to the 15-year average at Chevelon Work Center, 12 km northwest of the study area. Apache-Sitgreaves National Forest, Arizona, 1981-1982.

concolor) occur in the canyons and higher elevations. The north end of the study borders on the pinyon-juniper community with gambel oak, pinyon pine (Pinus edulis), and alligator juniper (Juniperus deppeana) becoming more common. The understory throughout the study area is perennial bunchgrasses with Arizona fescue (Festuca arizonica), Mulhy's (Muhlenbergia spp.), June grass (Koeleria cristata), and bottlebrush squirreltail (Sitanion hystrix) as the dominant species.

Numerous small burns, three major fires (Figure 1), human and silvicultural disturbances have created a patchwork of seral stages in the area. The 1956 Dudley burn (80 ha on the study) is mid-successional with 3-5 m tall ponderosa and bunchgrass-buckbrush (Ceanothus fendleri) understory. The 1975 Cliff (20 ha) and 1978 Breed (80 ha) burns are in early successional bunchgrass associations (McIntosh and Krausman 1982).

Seasons recognized during this study are: late spring-early summer, extending from the beginning of May through the end of June, characterized by warming temperatures, early plant green-up and little precipitation; mid-summer from July through August, characterized by most plant growth and heavy precipitation; and late summer-early fall, from September through October, characterized by advanced plant phenology and curing, little precipitation, and decreasing temperatures.

Ungulate Distribution

The study area was divided into 3 pastures (Figure 1). Cattle were excluded from the entire area in 1981. In 1982, 1000 yearling steer were grazed on Circle-Bar pasture from May 15 through July 30. The cattle were then moved to adjacent Breed pasture where they grazed from July 30 through October 24. Elk and mule deer had unrestricted access to all areas in both years.

Observations of elk, mule deer, and cattle were made along a 62.5 km survey route (Figure 1): 14.5 km in Breed pasture, 26.2 km in Circle-Bar pasture and 21.8 km in the control area. The route was driven at 29 kph during crepuscular hours. Number of animals seen per km driven were recorded and tested (Mann-Whitney test) for differences between sightings on the area when cattle grazed and when cattle were excluded.

Diet

Each month a minimum of 5 fecal samples were collected from animals observed defecating. Fecal analysis was conducted by the University of Arizona Range Laboratory following the procedures of Hansen (1971). Two slides were prepared per sample and 20 frequency observations were recorded per slide (Holocheck and Vavra 1981). Diet composition was estimated directly from the

relative densities of identifiable plant particles observed (Sparks and Malechek 1968).

Diet overlap was examined using Moristas' overlap index as modified by Horn (1966), Zaret and Rand (1971) and Alcoze and Zimmerman (1973). The formula for the 2 species overlap coefficient is as follows:

$$C_{xy} = \frac{2 \sum_{i=1}^S X_i Y_i}{\sum_{i=1}^S X_i^2 + \sum_{i=1}^S Y_i^2}$$

where S is the total number of food categories and X_i and Y_i are the proportions of the total diet of species X and species Y taken from food category i.

The overlap coefficient varies from 0 when the diets are completely different to 1 when the diets are identical. Values ≥ 0.60 indicate biologically significant overlap (Alcoze and Zimmerman 1973).

Habitat Use

Observations of animals along the survey route were used as sample points to evaluate habitat use. Physiographic, vegetational, and land use components were recorded using on-site measurements, aerial photographs, and topographic maps. Elevation, slope, exposure, and soil type were recorded at each location. Distance to

critical habitat components such as: water, fencing, meadows, cover, salt, and draws were noted from on site observations and area maps. A subjective description of dominant tree, shrub, grass, and forb species was also noted.

Overstory components were quantified using a spherical densiometer to determine canopy cover (Strickler 1959) and a wedge prism (basal area factor 10) to estimate basal area. A 25 m line-intercept transect (Strong 1966) established in a random direction from the point where animal(s) were observed was used to determine understory species composition, frequency, density, and dominance (percent cover). Utilization of plant species was determined using the percent ungrazed plant technique described by Roach (1950) for species encountered on the 25 m transect. Plant phenology was recorded on a 9 point scale describing stages from leaf bud through flowering and curing (Sensu Bradley et al. 1975).

Nominal scale data were tested with Chi-squared analyses of contingency tables at $\alpha = 0.10$ level of significance. Interval and ratio scale data were examined using discriminant analysis (Klecka 1975) after Ferrar and Walker (1974) and Hudson (1976). Measures for plant species which occurred on less than 5% of the transects were excluded from the analysis. Analyses were conducted

using the Statistical Package for the Social Sciences discriminant analysis package (Klecka 1975).

Discriminant analysis is a multivariate technique useful for investigating within and between group variability, testing differences in composition of groups, and identifying variables most useful in determining group membership of individual cases (Klecka 1975, Hanley 1980). The technique can be used for hypothesis testing when: the data consist of random samples from a population mixture of multivariate normal populations, covariances are homogeneous across all populations, and maximum likelihood estimates are used in place of parametric values (Williams 1981).

Covariance homogeneity is seldom the case with biological data. Caution must be used when inferences are drawn from data exhibiting covariance heterogeneity as results are not always directly translatable to observational space because distance measures and their corresponding probability measures are often distorted (Williams 1981). Yet, even when the assumption of equal covariance is not met, the technique provides a powerful tool for reducing multivariate complexity in a coherent manner enabling us to detect and examine key components or indicators useful in discriminating between groups (Green 1971, Ferrar and Walker 1974, Hudson 1976, Hanley 1980).

Covariance matrices in this study exhibited significant heterogeneity. Discriminant analysis was used, therefore, to descriptively explore habitat use by ungulates.

A step-wise selection procedure was used in the discriminant analyses to pick the variables most valuable for defining the functions. Variables were chosen by the criteria of maximizing Mahalanobis distance, a procedure which maximizes the functional distance between the closest group centroids. The step-wise selection process was limited to 10 steps. This was a subjective determination but was deemed appropriate because it permitted a high degree of discriminatory power yet was general enough to avoid centering on the personality of these particular data (sensu Hanley 1980). It also ensured that the functions accounted for >95% of the variance in the discriminating variables.

CHAPTER 3

RESULTS

Ungulate Distribution

In 1981, 20 systematic survey routes were driven on which 40 groups ($N = 146$) of elk and 19 groups ($N = 48$) of mule deer were seen. On 36 survey routes driven in 1982, 67 groups ($N = 285$) of elk and 40 groups ($N = 103$) of mule deer were seen (Table 1).

Significantly fewer elk ($P < 0.10$) and mule deer ($P < 0.01$) were seen per km driven on Circle-Bar pasture during July and August of 1982 when cattle grazed than in 1982 when cattle were excluded (Table 2). Cattle were excluded from the control pasture in both years. Neither elk nor mule deer numbers were significantly different ($P > 0.20$) between years on the control pasture. Breed pasture was grazed after 30 July 1982, however, there were too few sightings of elk or mule deer in Breed pasture in 1981 to test for statistical differences between years.

Table 3 summarizes the test for differences in elk and mule deer numbers between times when cattle grazed or were excluded from each pasture during 1982. There were no statistical differences ($P > 0.20$) in the number of

Table 1. Elk and mule deer observed on survey routes in the Apache-Sitgreaves National Forest, Arizona in 1981 and 1982.

	1981		1982	
	Number	Percent	Number	Percent
Elk Observations				
Adult Males	7	4.79	9	3.16
Yearling Males	10	6.85	22	7.72
Adult Females	69	47.26	132	46.32
Yearling Females	22	15.07	76	22.66
Calves	<u>38</u>	<u>26.03</u>	<u>46</u>	<u>16.14</u>
Total	146	100.00	285	100.00
Deer Observations				
Adult Males	9	18.75	8	7.77
Yearling Males	10	20.83	4	3.88
Adult Females	22	45.84	50	48.54
Yearling Females	7	14.58	22	21.36
Calves	<u>0</u>	<u>0.00</u>	<u>19</u>	<u>18.45</u>
Total	48	100.00	103	100.00

Table 2. Elk and mule deer distribution along survey routes during mid-summer in 1981 and 1982 on the Apache-Sitgreaves National Forest, Arizona.

Mann-Whitney tests of the two-tailed hypothesis H_0 : there is no difference in number of elk or mule deer seen per km driven between years when pastures were grazed or ungrazed by cattle.

	CONTROL AREA				CIRCLE-BAR PASTURE				BREED PASTURE			
	(ungrazed both years)				(grazed May-July 1982)				(grazed Aug.-Oct. 1982)			
	N^1	\bar{X}^2	U^3	P^4	N	\bar{X}	U	P	N	\bar{X}	U	P
ELK												
1981	20	.3100			20	.1325			13	.0		
1982	13	.6646	138.5 (>.20)		14	.0693	192.5 (.10>P>.05)		14	.0043	97.5 (>.20)	
MULE DEER												
1981	20	.0165			20	.745			12	.0158		
1982	13	.0169	134.5 (>.20)		14	.0029	203.0 (.01>P>.005)		14	.0807	102.0 (>.20)	

1. N = Number of survey routes driven.
2. \bar{X} = Average number of animals seen per km driven.
3. U = Mann-Whitney test statistic.
4. P = Probability of incorrectly rejecting H_0 .

Table 3. Elk and mule deer distribution along survey routes from spring to fall in 1982 on the Apache-Sitgreaves National Forest, Arizona.

Mann-Whitney tests of the two-tailed hypothesis H_0 : there is no difference in the number of elk or mule deer seen per km driven between times when pastures were grazed or ungrazed by cattle in 1982.

		CONTROL AREA (ungrazed both years)				CIRCLE-BAR PASTURE (grazed May-July 1982)				BREED PASTURE (grazed Aug.-Oct. 1982)			
		N ¹	\bar{X} ²	U ³	P ⁴	N	\bar{X}	U	P	N	\bar{X}	U	P
ELK													
cattle present						16	.0800			13	.0323		
	cattle never present							132.5	(>.20)			141.0	(>.20)
cattle absent						20	.2130			21	.0029		
MULE DEER													
cattle present						16	.0888			13	.0185		
	cattle never present							205.5	(.20>P>.10)			185.5	(>.20)
cattle absent						20	.0370			21	.0690		

1. N = Number of survey routes driven.
2. \bar{X} = Average number of animals seen per km driven.
3. U = Mann-Whitney test statistic.
4. P = Probability of incorrectly rejecting H_0 .

elk or mule deer seen on Circle-Bar pasture or Breed pasture.

Diet

Elk, mule deer, and cattle seasonal diet composition is presented in Table 4. Buckbrush (Ceanothus fendleri) and shrubby cinquefoil (Potentilla fruiticosa) were important in the diets of all three ungulates. Gramma grasses (Bouteloua spp.) and bromes (Bromus, spp.) were the major grass species in all diets. Mule deer ate only small amounts of grasses. The major forbs were lupines (Lupinus spp.), clover (Trifolium spp.), many-flowered viguiera (Viguiera multiflora) and western yarrow (Achillea lanulosa). Use of forbs generally decreased as the season progressed.

Mule deer are primarily browsers ($X = 74.69\% \pm SE 0.41\%$) (Figure 3). Grasses were not used ($X = 0.40\% \pm SE 0.03\%$) but forbs were an important part of the diet ($X = 24.61\% \pm SE 0.39\%$). Mule deer ate significantly more grasses and forbs ($t = 1.8132$, $p < 0.10$ and $t = 1.7837$, $p < 0.10$ respectively) when cattle were excluded.

Shrubs are a major component of elk diets ($X = 46.02\% \pm SE 4.89\%$) but grasses ($X = 24.83\% \pm SE 3.49\%$) and forbs ($X = 27.08\% \pm SE 23.08\%$) were also important (Figure 3). Grasses in the diet increased as the season progressed and forbs increased through summer but

Table 4. Seasonal percent composition of mule deer, elk, and cattle diets on the Apache-Sitgreaves National Forest, Arizona 1981 and 1982.

Season:	<u>Mule Deer Diet</u>			
	<u>May-June</u>	<u>July-August</u>		<u>Sept-Oct</u>
	(5) *	1981 (5)	1982 (11)	(6)
<u>SHRUBS</u>				
Ceanothus fendleri	32.13	2.30	51.50	45.67
Pinus ponderosa/ Pseudotsuga menziesii	1.20	-	1.64	0.17
Potentilla fruticosa	18.30	41.50	17.00	20.17
Quercus gambelii	16.90	-	1.73	3.75
Robinia neomexicana	5.20	-	6.32	0.33
Janusia gracilis	-	-	1.64	-
Juniperus spp.	-	-	0.09	-
TOTAL	73.73	43.80	79.92	70.09
<u>GRASS GRASSLIKE</u>				
Bouteloua spp.	-	4.83	0.09	0.25
Bromus spp.	0.60	4.17	-	0.25
Poa fendleriana	-	-	-	0.17
Unk. grass	-	1.17	-	-
TOTAL	0.60	10.17	0.09	0.67
<u>FORBS</u>				
Achillea lanulosa	6.70	20.67	0.64	0.25
Geranium spp.	1.00	1.33	0.91	-
Lupinus spp.	10.40	1.33	3.36	26.67
Phacelia magellanica	1.30	0.83	9.18	1.08
Silene lacinata	2.60	-	-	-
Sidalcea neomexicana	1.50	-	-	-
Viguerra multiflora	0.20	8.33	2.32	0.17
Cirsium spp.	0.20	-	-	-
Eriogonum alatum	-	-	-	-
Erodium cicutarium	-	1.00	0.45	-
Lotus wrightii	-	0.67	0.67	-
Monarda menthaefolium	0.40	-	-	-
Plantago spp.	-	0.17	-	-
Solidago spp.	-	-	0.18	-
Senecio spp.	-	-	0.18	-
Thermopsis pinetorum	0.40	-	0.36	-
Trifolium spp.	0.55	1.67	0.50	1.00
Vicia americana	-	9.17	0.59	0.17
Unk. forb	-	0.33	0.18	-
TOTAL	25.25	45.50	19.58	29.34

Table 4. Seasonal percent composition of mule deer, elk, and cattle diets on the Apache-Sitgreaves National Forest, Arizona 1981 and 1982.

Season:	<u>May-June</u>	<u>July-August</u>		<u>Sept-Oct</u>
		<u>1981</u>	<u>1982</u>	
	(5)*	(5)	(11)	(6)
TOTAL PERCENT DIET	99.58	99.47	99.59	100.10

* number of fecal samples analyzed

Season:	<u>Elk Diet</u>			
	<u>May-June</u>	<u>July-August</u>		<u>Sept-Oct</u>
		<u>1981</u>	<u>1982</u>	
	(13)*	(12)	(22)	(13)
<u>SHRUBS</u>				
Ceanothus fendleri	0.23	0.00	4.98	11.12
Pinus ponderosa/				
Pseudotsuga	5.42	10.83	5.07	6.81
menziesii				
Potentilla fruticosa	6.08	17.04	10.66	9.23
Quercus gambelii	41.92	2.08	10.64	19.69
Janusia gracilis	0.12	-	-	0.27
Populus tremloides	0.12	0.13	0.86	-
Robinia neomexicana	0.42	0.08	0.48	2.08
Rosa spp.	0.00	-	1.41	0.57
Unk.	0.12	-	-	-
TOTAL	54.43	30.16	34.11	49.77
<u>GRASS GRASSLIKE</u>				
Agropyron spp.	2.74	1.29	1.41	1.85
Agrostis spp.	2.97	0.13	0.57	0.15
Bouteloua spp.	1.08	1.92	3.39	5.62
Bromus spp.	4.50	2.71	4.80	12.69
Festuca spp.	1.61	2.25	3.34	2.16
Poa spp.	2.55	0.46	2.52	3.66
Aristida spp.	0.08	0.33	0.39	-
Dactylis glomerata	0.58	0.21	0.16	0.12
Danthonia intermedia	-	-	-	0.12
Glyceria spp.	0.27	-	0.30	-
Lolium perenne	-	-	-	0.23
Muhlenbergia spp.	0.12	0.13	0.43	0.27
Sporobolus spp.	-	-	0.05	-
Stipa spp.	0.19	-	0.07	0.12
Carex spp.	0.12	0.46	0.43	0.92
Cyperus spp.	0.27	-	0.07	0.27
Juncus spp.	0.31	-	-	-
Unk. grasses	2.19	2.62	4.14	6.85

Table 4. Seasonal percent composition of mule deer, elk, and cattle diets on the Apache-Sitgreaves National Forest, Arizona 1981 and 1982.

Season:	May-June	July-August		Sept-Oct
		1981	1982	
	(13)*	(12)	(22)	(13)
TOTAL	18.43	12.64	21.98	35.03
<u>FORBS</u>				
Achillea lanulosa	1.00	10.63	7.61	3.85
Lotus wrightii	3.77	0.68	0.70	-
Lupinus spp.	3.77	1.62	3.30	7.31
Phacelia magellanica	0.42	1.25	2.20	1.46
Sidalacia neomexicana	2.35	0.73	0.09	-
Thermopsis pinetorum	2.19	0.09	1.09	-
Trifolium spp.	6.62	29.54	0.68	-
Vicia americana	-	1.67	5.86	-
Viguerra multiflora	3.96	6.84	12.11	-
Artemesia carruthii	-	-	0.05	-
Aster commutatis	0.23	0.21	-	0.12
Chrysopsis foliosus	-	0.13	-	-
Cirsium spp.	-	0.13	-	-
Eriogonum alatum	0.31	0.79	1.11	-
Eriogonum racemosum	0.23	0.34	-	-
Erodium cicutarium	-	0.42	0.64	-
Geranium spp.	0.27	0.54	0.59	-
Hymenoxys spp.	0.12	-	-	0.08
Melilotus spp.	-	-	0.07	-
Monarda menthaefolium	-	-	0.05	0.27
Plantago spp.	-	0.67	-	-
Potentilla spp.	-	-	-	0.38
Silene lacinata	0.08	-	-	-
Sphaeralcia spp.	-	-	0.20	-
Solidago spp.	0.27	-	-	-
Senecia spp.	0.12	-	-	-
Verbascum thapsus	0.23	-	-	-
Unk. forbs	2.08	-	1.20	0.90
TOTAL	26.50	56.29	42.73	14.36
TOTAL PERCENT DIET	99.36	99.1	99.82	94.26

Cattle Diet

Season:	May-June	July-August	Sept-Oct
	(5)	(20)	(21)
Ceanothus fendleri	0.20	32.90	13.64
Pinus ponderosa/			
Pseudotsuga menziesii	3.60	1.03	4.05

Table 4. Seasonal percent composition of mule deer, elk, and cattle diets on the Apache-Sitgreaves National Forest, Arizona 1981 and 1982.

Season:	<u>May-June</u>	<u>July-August</u>	<u>Sept-Oct</u>
	(5)	(20)	(21)
Potentilla fruticosa	1.20	11.48	5.45
Quercus gambelii	7.60	0.40	10.62
Berberis spp.	-	-	0.33
Janusia gracilis	-	0.10	0.12
Populus tremuloides	-	0.48	-
Robinia neomexicana	-	0.50	-
Rosa spp.	-	0.03	-
TOTAL	12.60	46.90	34.21
<u>GRASS GRASSLIKE</u>			
Agropyron spp.	3.80	1.13	1.13
Agrostis spp.	2.70	0.88	0.71
Bouteloua spp.	18.40	15.63	24.00
Bromus spp.	5.60	2.33	9.00
Dactylis glomerata	5.50	0.10	0.29
Festuca spp.	11.90	2.88	1.53
Muhlenbergia spp.	1.40	0.13	2.74
Poa spp.	3.90	1.68	1.33
Danthonia intermedia	-	0.05	-
Eragrostis spp.	0.30	-	-
Lolium perene	-	0.08	0.07
Sporobolus spp.	-	0.05	-
Stipa spp.	0.30	-	0.05
Carex spp.	0.40	-	1.02
Cyperus spp.	-	0.18	0.10
Unk. grass	1.60	1.75	4.38
TOTAL	61.20	26.83	46.35
<u>FORBS</u>			
Achillea lanulosa	0.30	0.23	1.02
Agastache pallidiflora	6.30	0.73	-
Lupinus spp.	8.70	15.95	1.10
Phacelia magellanica	1.00	1.58	0.88
Sidalcea neomexicana	3.00	-	-
Sphaeralcea spp.	-	0.53	2.57
Trifolium spp.	2.60	0.08	-
Verbascum thapsus	-	0.50	7.83
Viguera multiflora	2.60	4.18	6.02
Artemesia carruthii	-	0.08	0.02
Bahia dissecta	-	0.05	0.07
Erodium cicutarium	0.30	0.05	-
Geranium spp.	-	0.03	-
Hymenoxys spp.	-	0.08	0.14

Table 4. Seasonal percent composition of mule deer, elk, and cattle diets on the Apache-Sitgreaves National Forest, Arizona 1981 and 1982.

Season:	<u>May-June</u>	<u>July-August</u>	<u>Sept-Oct</u>
	(5)	(20)	(21)
<i>Lotus wrightii</i>	-	0.10	0.10
<i>Monarda menthaefolium</i>	-	0.03	0.10
<i>Plantago</i> spp.	-	0.13	-
<i>Silene lacinata</i>	-	-	0.02
<i>Solidago</i> spp.	-	0.05	0.05
<i>Thermopsis pinetorum</i>	0.40	-	-
<i>Vicia americana</i>	-	0.80	0.05
Unk. forbs	0.05	0.08	-
TOTAL	25.70	25.19	19.98
TOTAL PERCENT DIET	99.50	98.92	100.54

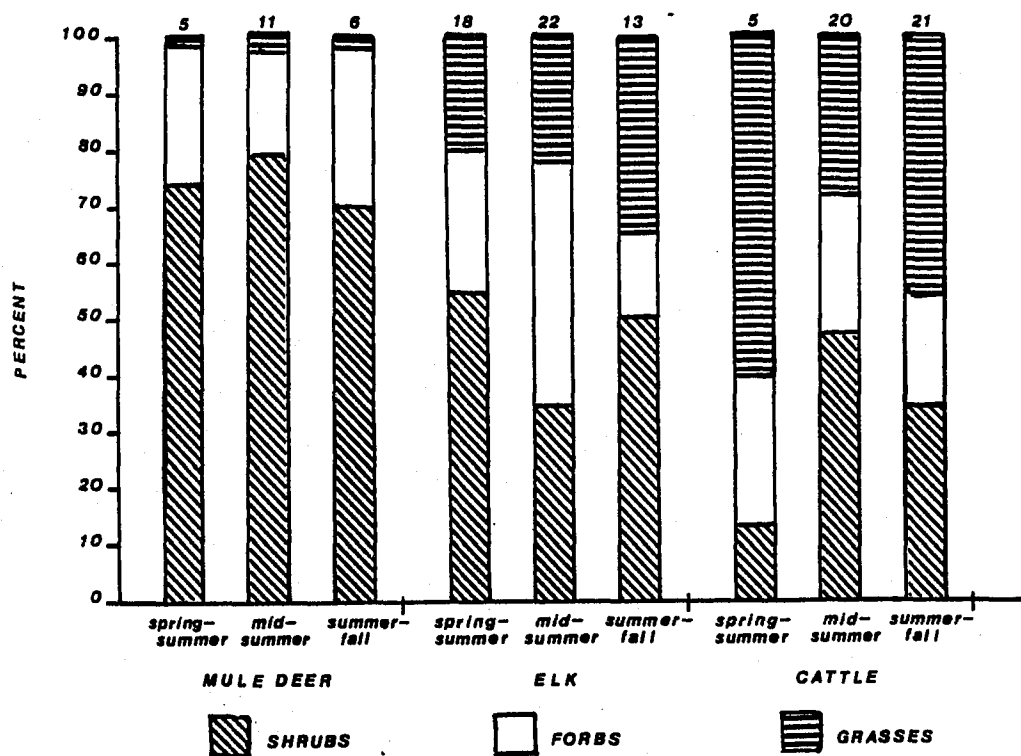


Figure 3. Percent seasonal composition of elk, mule deer, and cattle diets on the Apache-Sitgreaves National Forest in 1981-1982. Determined by fecal analysis.

decreased as phenology advanced and plants cured in late summer and fall. Significantly more forbs were eaten by elk when cattle were excluded ($t = 1.6999$, $0.10 > P > 0.05$).

Cattle were predominantly grazers. Grasses ($X = 44.53\% \pm SE 32.13\%$) and forbs ($X = 23.57\% \pm SE 0.07\%$) constituted most of the diet. Shrubs ($X = 30.09\% \pm SE 47.43\%$) increased in the diet in late summer and fall when cattle were moved to Breed pasture (Figure 3). Much of this pasture was burned in 1956 and 1979 and now supports extensive stands of buckbrush. Increase of shrubs in the cattle diet coincides with this increased availability of buckbrush.

Seasonal patterns of total diet overlap (Figure 4) and overlap within forage classes (Figure 5) indicate that elk and mule deer diet overlap was not biologically significant in 1982. Elk and cattle diet overlap was biologically significant in late summer and fall, primarily due to overlap on the shrub components of the diet (Figure 4). Mule deer and cattle diet overlap was biologically significant in mid-summer, primarily due to use on shrubs and grasses. Overlap on grasses is somewhat misleading. Mule deer ate very little grass but all the species utilized were also heavily used by cattle.

Elk and mule deer diet overlap was greater when cattle were excluded in 1981 than in 1982 with cattle

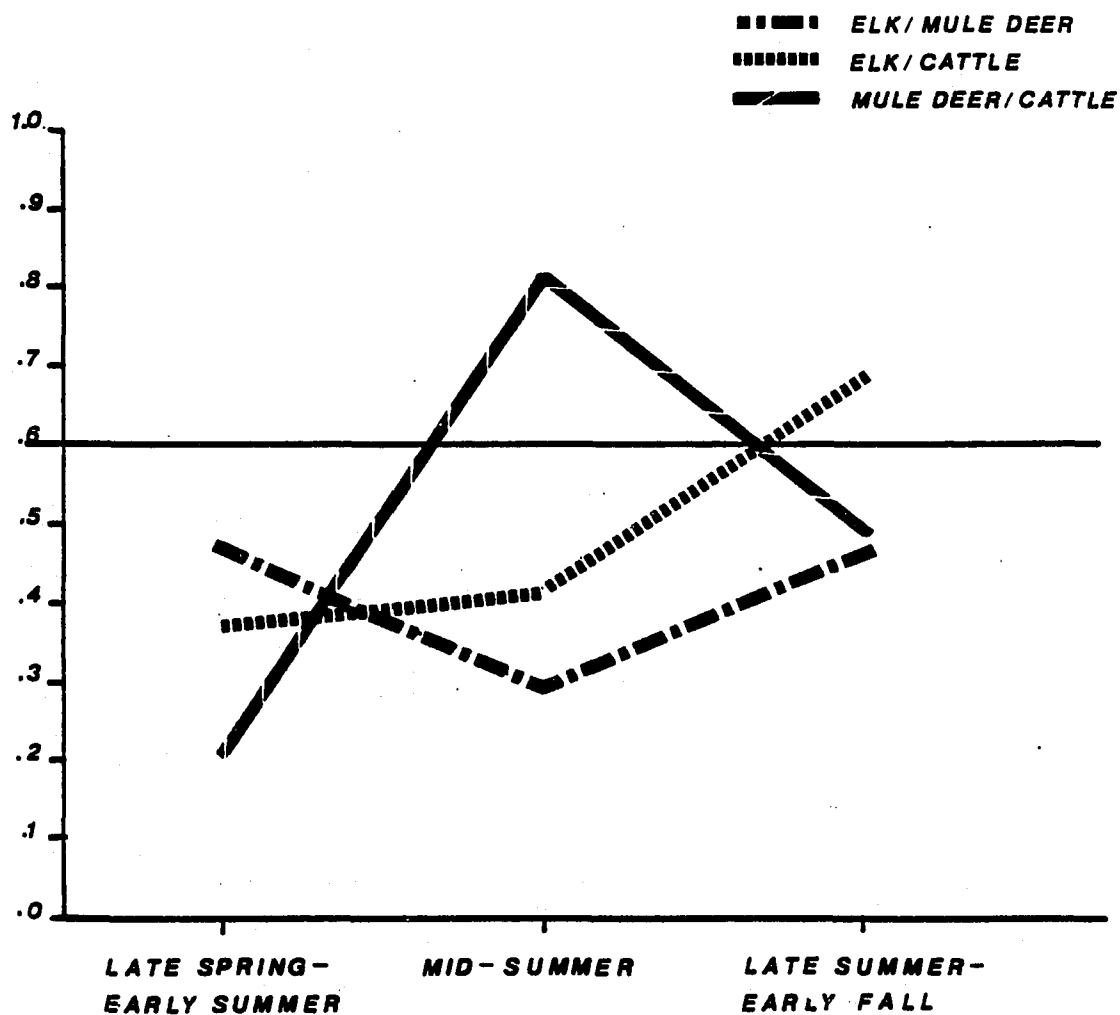


Figure 4. Seasonal patterns of diet overlap for elk, mule deer, and cattle on the Apache-Sitgreaves National Forest in 1982. Values are Moristas' overlap coefficient (C_{xy}). Values greater than 0.60 are biologically significant (Alcoze and Zimmerman 1973).

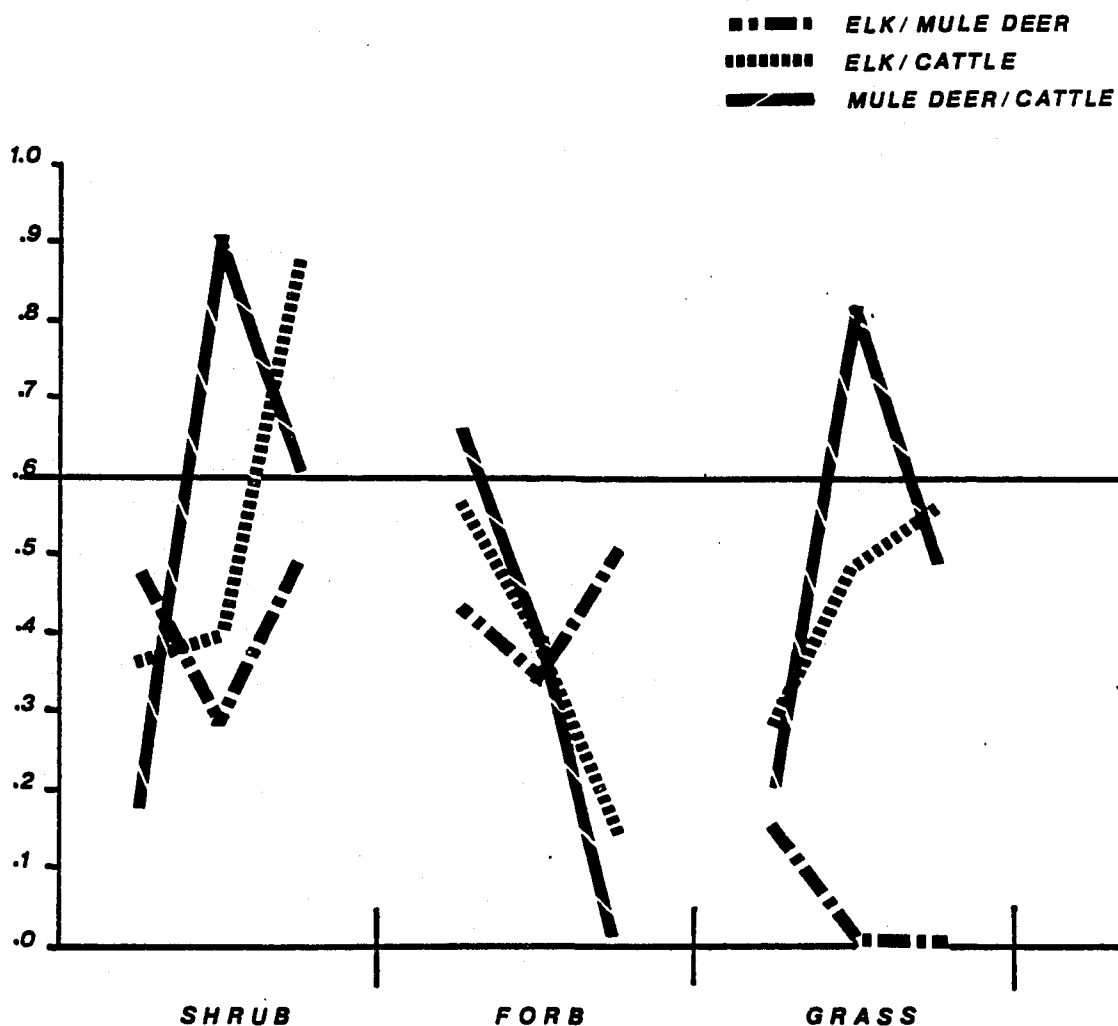


Figure 5. Diet overlap within forage classes for elk, mule deer, and cattle on the Apache-Sitgreaves National Forest in 1982. Values are Mortistat's overlap coefficient (C_{xy}). Values greater than 0.60 are biologically significant overlap (Alcoze and Zimmerman 1973).

(Table 5). Overlap was biologically significant on the shrub and grass-grasslike forage classes most used by cattle in 1982.

Habitat Use

Elk were most frequently associated with sites where the dominant shrub was gambel oak (42.1% of observations in 1981 and 27.5% of observations in 1982). Mule deer were most commonly associated with buckbrush dominated sites (66.7% in 1981 and 81.3% in 1982). Chi-squared values were 8.68 (4 d.f. $P < 0.10$) and 13.35 (5 d.f. $P < 0.05$) for 1981 and 1982 respectively.

In 1982 the dominant forb on elk sites was western yarrow (31.4%), while spreading fleabane (Erigeron divergens) was the dominant forb (22.2%) associated with mule deer sites ($\chi^2 = 32.38$, 23 d.f. $P < 0.10$). Animal sightings were independent of dominant forb species in 1981 ($P > 0.10$) and independent of dominant tree or grass species in both years ($P > 0.10$).

The order of inclusion of stepwise selected variables and the magnitude of the standardized discriminant function coefficients (Table 6) revealed the most useful variables for discerning differences in ungulate habitats. Each coefficient represents the relative contribution of its associated variable to the discriminant function. The sign denotes whether the variable is making a positive or

Table 5. Elk and mule deer mid-summer diet overlap coefficients. Apache-Sitgreaves National Forest, Arizona 1981 and 1982.

	1981 (No Cattle Present) -----	1982 (Cattle Present) -----
Forage Class		
Shrubs	0.6626*	0.2796
Forbs	0.4350	0.3387
Grass-grasslikes	0.7003*	0.0102
Total Diet	0.5682	0.2819

* An overlap greater than .60 indicates a biologically significant overlap (Alcoze and Zimmerman 1973).

Table 6. Standardized canonical discriminant function coefficients for functions discriminating elk and mule deer habitat use along survey routes, Apache-Sitgreaves National Forest, Arizona 1981 and 1982.

VARIABLE	1981 (Cattle Excluded)	1982 (Cattle Excluded)	1982 (Cattle Graze Areas)
<u>Relative Frequency of</u>			
<u>litter</u>	-0.75132	-0.27789	-
<u>Conyza canadensis</u>	1.04649	-	-
<u>Lupinus spp.</u>	-	0.49961	-
<u>Muhlenbergia montana</u>	-	0.47329	-1.07597
<u>Rumex spp.</u>	0.41702	-	-
<u>Sitanion hystrix</u>	-1.43782	-	-
<u>Rosa spp.</u>	-0.66912	0.38007	0.41923
<u>Relative Density of</u>			
<u>Trifolium spp.</u>	0.60561	-0.30062	-
<u>Relative Dominance of</u>			
<u>litter</u>	-	-	1.80422
<u>Antennaria aprica</u>	-	-0.37462	-0.80422
<u>Carex spp.</u>	0.46376	-0.39734	-
<u>Ceanothus fendleri</u>	-0.41591	0.75122	0.43125
CANOPY COVER	-0.42391	-	-1.08548
<u>Distance to</u>			
DRAW	0.46405	-	0.80865
COVER	-	-0.32519	-
MEADOW	-	-0.39164	0.49436

negative contribution (Klecka 1975). It is, therefore, practical to name the functions on that basis (Sensu Hanley 1980).

Canonical correlation is a measure of the function's ability to discriminate among the groups. It tells how closely the function and the group are related (Klecka 1975). Observed elk and mule deer habitat use in 1981 was significantly ($P < 0.01$) different. The discriminant function is well correlated (canonical correlation = 0.86) with the groups and group memberships of 94.23% of the observed cases were classified correctly (Figure 6). Elk habitat had low percent overstory canopy cover, high relative frequency of clovers (Trifolium spp.), sedges (Carex spp.), and sheep sorrels (Rumex spp.). Elk were seen in the open farther from draws than mule deer. Mule deer habitat was characterized by greater percent canopy cover, more forest litter, high relative frequencies of bottlebrush squirreltail (Sitanion hystrix) and rose (Rosa spp.), and high relative dominance of buckbrush. This discriminant function gradient separates elk sites (open mesic and disturbed areas) from mule deer sites (dense overstory with shrubs but little other understory vegetation).

Discriminant analysis of 1982 elk and mule deer sites in the control area and in Circle-Bar and Breed

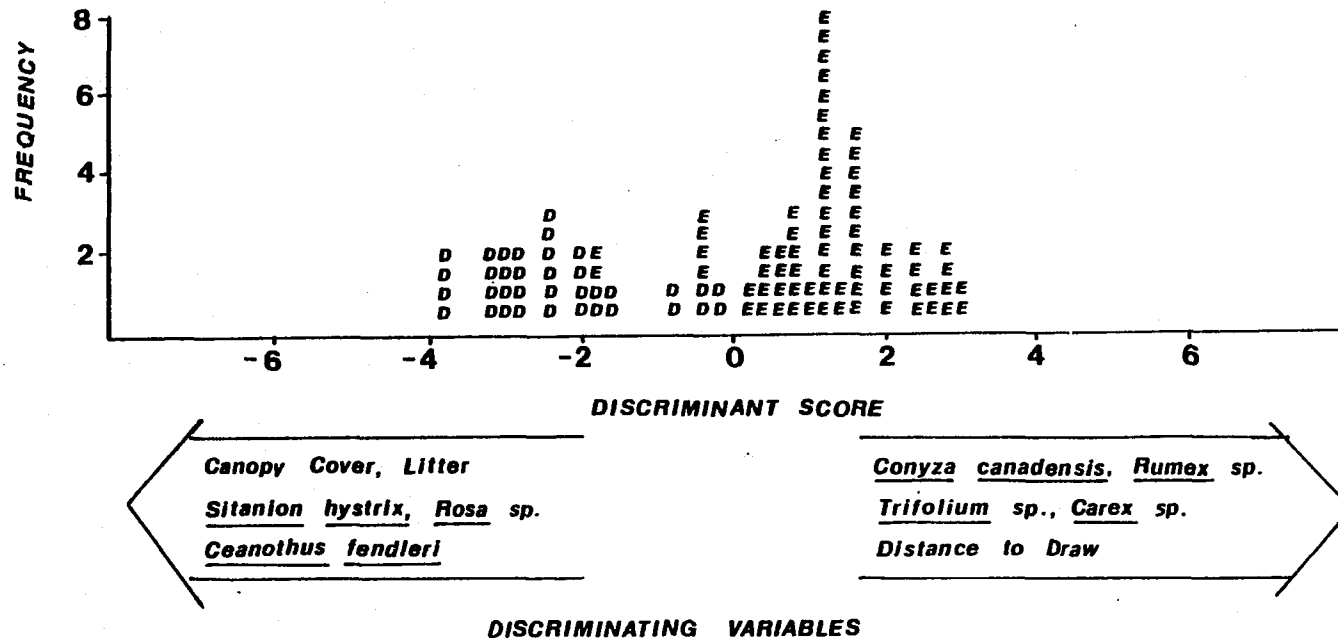


Figure 6. Discriminant classification of 1981 elk and mule deer sightings on the Apache-Sitgreaves National Forest, Arizona.

group centroids: mule deer -2.32, elk 1.23
 significance: ($P < 0.001$)
 canonical correlation: 0.86
 percent cases correctly classified: 94.2

pastures when cattle were excluded indicated that elk and mule deer habitat use was significantly ($P < 0.01$) different. The discriminant function is also well correlated (canonical correlation = 0.60) with the groups and group membership of 83.12% of the cases were correctly classified (Figure 7). Elk habitat was again characterized by high relative frequency of clovers and high relative dominance of sedges. Elk sites also had greater relative dominance of pussytoes (Antennaria aprica) and litter, common to xeric open understory, and were farther from large open meadows and hiding cover than mule deer sites. Mule deer were observed in sites characterized by high relative dominance of buckbrush, and greater relative frequencies of lupines (Lupinus sp.), mountain muhly (Muhlenbergia montana) and rose. The gradients again separated elk sites (mesic to xeric open areas within the forest) from mule deer sites (best represented by the mid-successional Dudley burn).

Elk proximity to large open meadows differed between 1981 and 1982. In 1982 there was a marked decrease of elk sightings in large meadows after mid-June. DelGuidice and Rodiek (1982) observed a similar decrease on other elk ranges in Arizona. Precipitation in 1981 was greater than normal (Figure 2) and elk may have utilized some open meadow sites later in 1981 as plant phenology was slightly retarded.

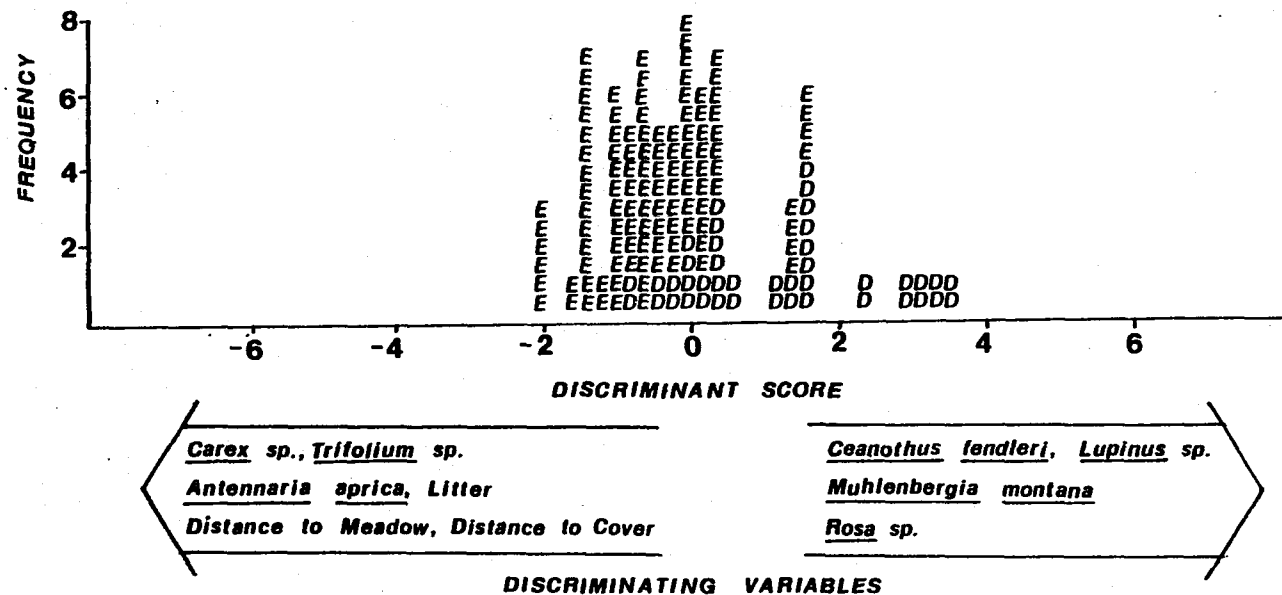


Figure 7. Discriminant classification of 1982 elk and mule deer sightings in cattle excluded areas on the Apache-Sitgreaves National Forest, Arizona.

group centroids: elk -0.45, mule deer 1.21
 significance: (P < 0.001)
 canonical correlation: 0.60
 percent cases correctly classified: 83.1

Elk and mule deer habitat use was significantly different ($P < 0.01$) in Circle-bar and Breed pastures when cattle grazed in 1982 (Figure 8). The canonical correlation was 0.78 and 87.10% of the cases were correctly classified. However, variables discriminating elk habitat use were different. Elk sites had higher percent canopy cover, greater relative frequency of mountain mahogany, and greater relative dominance of pussytoes. Mule deer sites were farther from draws and meadows than elk sites, with greater relative dominance of litter and buckbrush, and greater relative frequency of rose. Elk habitat use apparently shifted from mesic open areas to those with a more xeric closed canopy and the associated understory plants on the grazed pastures after cattle were introduced. Mule deer habitat use remained similar to before; away from open mesic meadows in areas with rose and buckbrush shrub components still important.

The addition of cattle as a third group enables us to use 2 discriminating functions in the analysis. The first discriminant function (horizontal axis, Figure 9) accounted for 62% of the variation explained, the second function (vertical axis) accounted for 38%. Canonical correlations were 0.53 and 0.44 for the first and second functions respectively and 68% of the cases were correctly classified. Habitat use by cattle was discriminated from

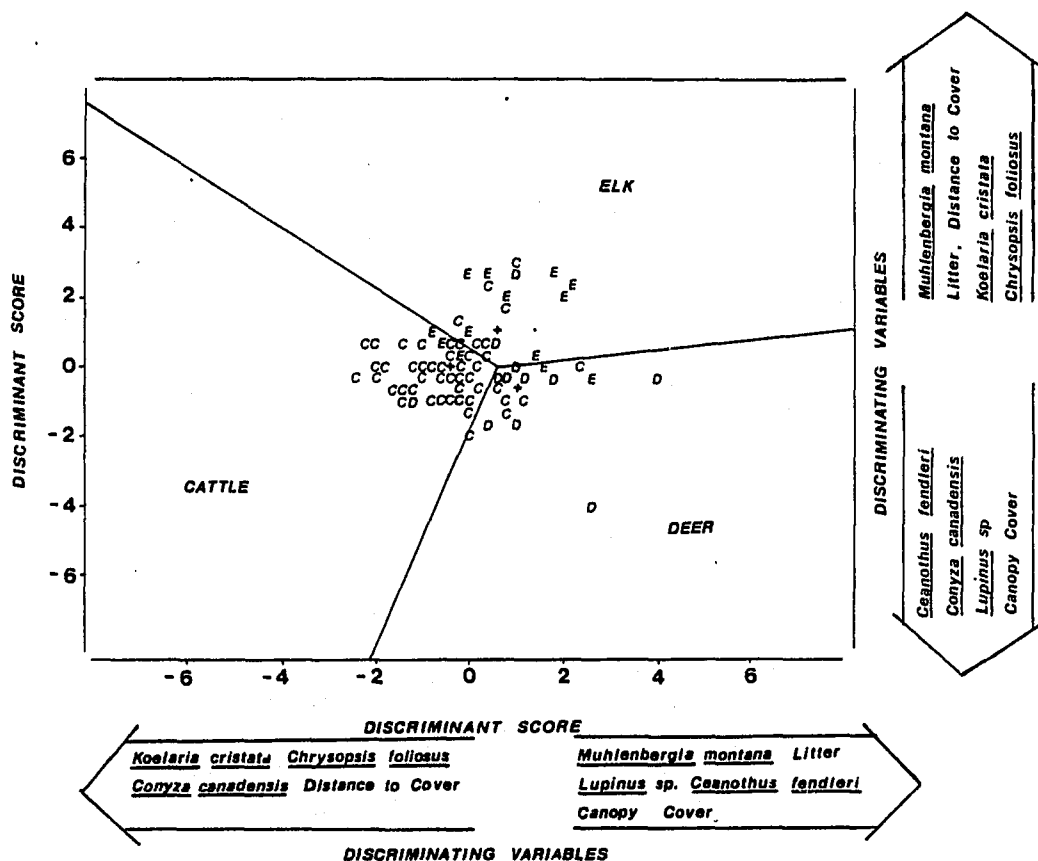


Figure 9. Discriminant classification of 1982 elk, mule deer, and cattle sightings on the Apache-Sitgreaves National Forest, Arizona.

group centroids: elk x axis 0.70 y axis 1.17
 mule deer x axis 0.96 y axis -0.57
 cattle x axis -0.40 y axis -0.13

significance: ($P < 0.05$)

canonical correlation: function 1: 0.53
 function 2: 0.44

percent cases correctly classified: 0.68

native ungulate habitat use by variables representing moderately open canopy with understory grasses to open and disturbed areas (Figure 9). Habitat use was significantly different ($P < 0.05$) between ungulates.

Cattle were excluded from the large open meadows all of which have been fenced for big game spring habitat use. Cattle readily used these meadows when they gained access but observations of cattle illegally using these fenced meadows were excluded from this analysis. June grass (Koeleria cristata) common under moderately open pine overstory and horseweed (Conyza canadensis) common in silviculturally disturbed and burned areas were the most important variables (had the largest standardized coefficients describing cattle use, Table 7) for discriminating habitats used by cattle from those used by the other ungulates.

Table 7. Standardized canonical discriminant function coefficients for functions discriminating elk, mule deer, and cattle habitat use along survey routes on the Apache-Sitgreaves National Forest, Arizona in 1982.

VARIABLE -----	FUNCTION 1 -----	FUNCTION 2 -----
<u>Relative Frequency of</u>		
litter	0.39258	0.42301
<u>Chrysopsis foliosus</u>	-0.39695	0.11369
<u>Conyza canadensis</u>	-0.13225	-0.38243
<u>Koeleria cristata</u>	-0.52955	0.18615
<u>Lotus wrightii</u>	0.35433	0.08178
<u>Lupinus</u> spp.	0.19162	-0.16401
<u>Muhlenbergia montana</u>	0.65533	0.48275
 <u>Relative Dominance of</u>		
<u>Ceanothus fendleri</u>	0.04957	-0.61407
 CANOPY COVER	 0.32961	 -0.36018
 <u>Distance to</u>		
COVER	-0.10916	0.40723

CHAPTER 4

DISCUSSION AND CONCLUSIONS

Julander and Jeffery (1964) and Sivinski (1979) studied summer habitat partitioning by elk and mule deer where topographic features such as elevation, slope, and exposure were the major factors distinguishing habitats selected. This study sampled an area with relatively homogeneous topographic features. Habitat use was discriminated at the finer levels of vegetative structure and floristic composition. Habitats represented on the study area were primarily open ponderosa stands with understory production interspersed with natural and man-made openings. Selective cutting, pulpwood harvest, and commercial thinning have not created the large openings or dense regrowth common under other silvicultural management schemes. Exceptions are the large burns which are open or in dense mid-successional regeneration.

Habitat use by elk, when cattle were excluded, was discriminated by variables which characterized open mesic and silviculturally disturbed areas. Reynolds (1962, 1966, 1969), Clary and Larsen (1971), Sivinski (1979), Neff (1980), and DelGuidice and Rodiek (1982) report similar summer habitat use by elk in the southwest.

Discriminating variables characterized mule deer habitat as a more closed overstory with a high relative dominance of buckbrush or rose. Reynolds (1962, 1966) indicated that mule deer use under ponderosa pine was nearly equal to use of openings and deer preferred small clearings over large ones. Skovlin et al. (1968) also observed that deer used forest more than openings. Neff (1980), Carpenter and Wallmo (1981), and Leckenby et al. (1982) stress that mule deer use of openings is dependent on the proximity of cover.

Variables discriminating elk and mule deer habitat use changed when cattle grazed, showing an apparent shift in elk habitat use. Mule deer use was still characterized by shrub cover. Elk sites were characterized by greater canopy cover and more shade tolerant understory plants. Habitat use by elk shifted from mesic forest openings and silviculturally disturbed sites to less open forest sites after cattle were introduced.

Further evidence of this change is apparent in the forage consumption by ungulates. Hansen and Reid (1975) reported that elk-mule deer diet overlaps reach yearly maxima during the summer growing season when foods are abundant. Mid-summer elk-mule deer diet overlap observed during this study decreased from $C_{xy} = 0.5682$ when cattle were excluded to $C_{xy} = 0.2819$ when cattle grazed. Elk ate

more forbs and mule deer ate more forbs and grasses when cattle were excluded. Elk and mule deer diets were constricted and overlap decreased when forage availability decreased due to the added grazing pressures of cattle.

High diet overlap for sympatric animals indicates that both species are eating many of the same foods (Alcoze and Zimmerman 1973). It may also imply that those foods are not in short supply. Hutchinson's (1965) competitive exclusion principle suggests that co-evolved species have developed mechanisms to reduce overlap when resources become scarce. Domestic herbivores have not evolved with native herbivores and are unlikely to show such mechanisms. High diet overlap between cattle and native elk and mule deer was evident in this study.

Elk-cattle diet overlap increased as the season progressed. Shrub and grass components increase in both species diets as plant phenology advances. Malechek (1966), Kufeld (1973), and Korfage et al. (1980) report similar increases. Biologically significant elk-cattle diet overlap in late summer and fall was dominated by the shrub and grass forage classes. Hansen and Reid (1975) found the same pattern of diet similarity.

Biologically significant mid-summer mule deer-cattle diet overlap was influenced by cattle management practices. The diet overlap was dominated by shrubs and

grasses. Mule deer ate very little grass. The grass species utilized, however, were also heavily used by cattle. Cattle diet shrub component increased dramatically when cattle were moved to Breed pasture in mid-summer. Breed pasture is dominated by burned areas with large amounts of buckbrush. Mule deer-cattle diet similarity in Colorado was also greatest between June and August (Hansen and Reid 1975).

Distributional changes attributable to the effects of cattle grazing also were found. Fewer elk and mule deer were seen when Circle-bar pasture was grazed in 1982 than when it was ungrazed in 1981, while the numbers seen on the adjacent ungrazed control areas remained unchanged between years. Skovlin et al. (1968), Mackie (1970), Burbridge and Neff (1976), Nelson and Burnell (1976), and Knowles and Campbell (1982) also indicated elk use decreased when cattle grazed. Skovlin et al. (1968), Mackie (1970), Knowles (1975) and McIntosh and Krausman (1982) documented altered mule deer distributions in response to cattle grazing.

When we combine an apparent elk habitat shift, changes in diet composition and overlap, and significantly fewer elk and mule deer seen after cattle introduction it becomes evident that cattle grazing can effect elk and mule deer summer range use. On areas where ungrazed

habitat is available elk and mule deer distribution changes. Where elk and deer use grazed areas elk use apparently shifts from preferred open high forage production habitats to closed and less productive areas. Elk and mule deer exhibited changes in food habits during this study on good range with only moderate cattle use under a rest-rotation grazing system. If cattle grazing increases on this summer range reducing ungrazed habitats and altering condition of grazed areas, elk and mule deer populations may be adversely affected.

Survival and productivity are tied to animal nutrition. The ratio of resource availability to animal numbers decreases when livestock are added. Food and habitat acquired by each animal can be diminished by prior cattle use, by increased animal density on ungrazed areas, or by shift or compression of diet and habitat selected causing greater inter- or intra-specific overlap.

Reduction of summer range resources acquired by elk and mule deer on the Apache-Sitgreaves National Forest can depress the condition of animals entering their already critical (Adams et al. 1979) winter ranges. Animals in poor condition are more vulnerable to predation (Connolly 1978). Nutritional plane of cows and does significantly effects growth and survival of their young (Robinette et al. 1973, Thorne et al. 1976, Clutton-Brock

et al. 1982). Robinette et al. (1955) also report that summer range is more important than winter range in determining fertility.

Cattle grazing may also affect calf/fawn survival directly. Effective hiding, the anti-predator strategy used by neonate ungulates, is dependent upon the availability of hiding cover (Geist 1982). Johnson (1951) and Altmann (1952) found elk calf sites were associated with brush cover. Waldrip and Shaw (1979) found calf bedsites were consistently associated with cover provided by boulders and woody vegetation. On this study area 5 neonate bedsites were found. Forage plants (Arizona fescue, golden pea, gambel oak, and rose) were the major cover components in this limited data set. Cattle grazing on and trampling of these species in elk calving areas could cause increased neonatal mortality due to predation.

The habitats encompassed by this study provide ideal breeding and calving areas for elk (Adams et al. 1979). Elk calving habitat and the effects of cattle grazing on it requires further study.

In summary, cattle grazing did affect elk and mule deer distribution and caused shifts in diet and habitat selection. Where insufficient areas are left ungrazed, elk forced to share ranges with cattle use less preferred foods and habitats, and mule deer diets

are constricted. Survival and productivity of populations will decrease where excessive cattle grazing limits the availability of summer range resources to elk and mule deer.

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