SPATIAL SEGREGATION OF BIGHORN SHEEP, MULE DEER, AND FERAL HORSES

ROBERT E. KISSELL, JR., Fish and Wildlife Program, Department of Biology, Montana State University,
Bozeman, MT 59717
LYNN R. IRBY, Fish and Wildlife Program, Department of Biology, Montana State University, Bozeman,
MT 59717
RICHARD J. MACKIE, Fish and Wildlife Program, Department of Biology, Montana State University,
Bozeman, MT 59717

Abstract: We examined population size, spatial distribution, and behavioral interactions of Rocky Mountain bighorn sheep (*Ovis canadensis*), mule deer (*Odocoileus hemionus*), and feral horses on the Pryor Mountain Wild Horse Range (PMWHR) and the Bighorn Canyon National Recreation Area (BCNRA) of Montana and Wyoming. The BCNRA winter range is one of the driest, if not the driest, sites occupied by the 3 species in Montana, and the summer range is one of the most heavily forested and rugged areas occupied by feral horses in the northwest. During 1993, we estimated 159 (S.E. 61) sheep, 516 (S.E. 121) deer, and 95 (S.E. 22) horses on the winter range in the study area. Potential for competitive interactions between deer and horses or sheep were low due to habitat segregation in winter and habitat and spatial separation in summer. Horses and sheep used similar cover types in summer and winter and exhibited clumped distributions that could have exacerbated competition for forage if forage were limiting. Spatial segregation reduced the potential for competition at current population levels. The consequences of population increases should be considered by managers in the area. The mule deer population is apparently stable, but the sheep population has increased by approximately 17% annually since 1989, and interest groups supporting feral horses are capable of blocking population reductions in the horse population.

Ecologically similar species co-occur through one or a combination of strategies. These include competition, resource partitioning, and coexistence (Begon and Mortimer 1987). Behavioral domination, one form of interference competition, has been documented for a number of potentially competitive species, such as mule deer and cattle (Kie et al. 1991), burros and bighorn sheep (Seegmiller and Ohmart 1981), and red fox (*Vulpes vulpes*) and coyotes (*Canis latrans*)(Dekker 1983). Resource partitioning allows for coexistence and avoids competition by separating species by habitat or forage use. Moose (*Alces alces*), elk (*Cervus elaphus*) and white-tailed deer (*Odocoileus virginianus*) in northwestern Montana were found to spatially segregate to reduce competition (Singer 1979) and Wydeven and Dahlgren (1985) found competition to be reduced between pronghorn antelope (*Antilocapra americana*) and bison (*Bison bison*) by differences in forages consumed. Coexistence, unlike the other strategies, occurs in landscapes containing unlimited resources supporting sympatric populations. Habitat preferences and preferred food items are utilized without regard to the presence of another species. Kissell and Kennedy (1992) found this to be the case for two generalists, raccoons (*Procyon lotor*) and opossums (*Didelphis virginiana*).

Most co-occurring ungulates possess great opportunity for overlap in habitat use and food habits. Bighorn sheep, mule deer, and horse populations have been shown to compete, partition resources, or coexist (Wishart 1978, Seegmiller and Ohmart 1981, Kie et al. 1991) with another ungulate population when present.

A community of potentially competitive species exists on and around the Pryor Mountain Wild Horse Range (Boyce et al. 1992). The PMWHR was established in 1968 to manage and protect the resident feral horse population (BLM 1984). PMWHR historically supported both mule deer and bighorn sheep. Bighorn sheep were extirpated prior to the turn of the 20th century but recently have recolonized a portion of the PMWHR. During the

past decade, the sheep population has been increasing rapidly (Coates and Schemnitz 1989). The horse population has been maintained at approximately 120 through capture and removal since 1971 (BLM 1984), and the mule deer population has varied about the historical mean (500-600).

Ungulate populations occupying small restricted ranges, such as on the PMWHR, may require intensive management (Wydeven and Dahlgren 1985). Boyce et al. (1992) implied a need to evaluate potential competition between bighorn sheep, feral horses, and mule deer on the PMWHR as a factor in management. Studies directed toward feral horse behavior (Feist 1971), feral horse reproduction (Feist and McCullough 1975), feral horse population dynamics (Garrot and Taylor 1990), and bighorn sheep ecological relationships (Coates and Schemnitz 1989) have been completed; however, no attempt has been made to differentiate use of resources of the area by the three ungulates relative to their ecological requirements. Our objectives were to determine population estimates for mule deer, bighorn sheep, and feral horses, ascertain distributional patterns, and describe behavior regarding the potential for competitive interaction.

STUDY AREA

The study area is located approximately 75 km south of Billings, MT (45°00' N, 108°20' W). The study area encompasses approximately 350 km² and includes the Pryor Mountain Wild Horse Range, portions of the Bighorn Canyon National Recreation Area, and lands managed by the Bureau of Land Management, the Custer National Forest, and the Crow Indian Tribe.

Soils are relatively raw, composed typically of sandstone, limestone, shale, dolomite, and alluvial deposits (Richards 1955, Blackstone 1975). Topographic features consist of vertical canyon walls, steep talus slopes, and gently rolling hills and meadows intersected by canyons. Several spring-fed and some intermittent creeks traverse the area.

Habitat on the BCNRA and surrounding area has been classified into 6 principal types (Knight et al. 1987). Juniper/mountain mahogany woodlands are dominated by Utah juniper (Juniperus osteosperma) and mountain mahogany (Cercocarpus ledifolius). This type is further broken down into juniper woodland, mountain mahogany shrubland, and juniper/mountain mahogany woodland, depending upon the dominant species. Riparian habitat is dominated by cottonwoods (Populus spp.). Desert shrubland is dominated by saltbrush (Atriplex spp.), greasewood (Sarcobatus vermiculatus), big sagebrush (Artemisia tridentata), and mixed desert shrubland communities. Rubber rabbitbrush (Chrysothamnus nauseosus), shadscale (Atriplex confertifolia), big sagebrush, broom snakeweed (Gutierrezia sarothrae), bluebunch wheatgrass (Agropyron spicatum), Fendler three-awn (Aristida fendleriana), and needle-and-thread (Stipa comata) comprise the major components of mixed desert shrubland. Sagebrush steppe includes both big sagebrush and black sagebrush (Artemisia nova) communities. Basin grasslands are dominated by bluebunch wheatgrass, blue grama (Bouteloua gracilis), needle-and-thread, broom snakeweed, Hooker sandwort (Arenaria hookeri), fringed sagewort (Artemisia frigida), and Hoods phlox (Phlox hoodii). Coniferous woodlands are characterized by limber pine (Pinus flexilis), ponderosa pine (P. ponderosa), douglas fir (Psuedotsuga menziesii), and a spruce-fir (Picea-Abies spp.) mix.

Climate varies from near desert to subalpine with the elevation ranging from 1109 m to 2675 m. Mean summer temperature at the lower elevation in Lovell, WY, is 21.1 C and mean summer precipitation is 2.13 cm. Mean winter temperature

is -6.3 C and mean winter precipitation is 0.74 cm (Western Sugar Company, recorded since 1920).

Adjacent land uses include cattle ranching and agriculture. Cattle are maintained on portions of the study area throughout spring and summer. Agricultural crops primarily consist of alfalfa. Hunting is allowed on the study area. Deer are harvested through regular season regulations in Wyoming and Montana and two bighorn sheep permits have been issued annually by Montana since 1991.

METHODS

Population Estimation

Bighorn sheep and mule deer were captured and marked 21-22 September 1992 and 14-15 January 1993 using a net gun fired from a Hughes 500-C helicopter (Barrett et al. 1982, Andryk et al. 1983). Age was estimated for bighorn sheep and mule deer using tooth wear and replacement (Cowan 1940, Deming 1952; Robinette et al. 1957). Each animal was fitted with an uniquely marked radio collar (150.000-151.999 MHz). Horses were not radio-collared, but 20 readily recognizable horses distributed among various bands were used as "marked" animals. Sixteen female and 4 male bighorn sheep, 14 female and 3 male mule deer were radio-collared, and 14 female and 6 male horses were used as "marked" animals.

To estimate population size, approximately 30 aerial transects were flown in a Hiller 12-E at approximately 1-week intervals from 10 February to 8 March 1993, with each transect replicated 5 times. Transects were separated by approximately 0.5 km and typically were flown during the morning (0700-1200 hrs). Transects were flown 20 - 40 m above the terrain at 40 - 50 km/hr. The date, time, location, species, number of animals, sex, age category (adult or juvenile) when possible, and the number of marked animals in the group were noted. Chapman's (1951) estimator and Lincoln-Peterson index techniques were used to estimate population size. Chapman's estimate corrects for surveys in which no marked animals of a species were observed. Each estimate derived was used to determine a mean population estimate. Mean estimates were compared with results of previous studies by Coates and Schemnitz (1989) using a t-test to evaluate population growth rates between 1985-1988 and 1988-1993.

Distribution

Distribution was determined by radio locations and casual observations during ground and aerial surveys. Locations were determined for 3 time periods: morning (0500-0959 hrs); midday (1000 - 1559 hrs); and evening (1600-2300) hrs. Aerial locations were obtained using a portable receiver and 2, 2-element directional antennas attached to the wing struts of a Super Cub or 1 pivotal 3-element directional antenna mounted beneath the fuselage. Aerial locations were made typically during the morning time block. Ground locations were obtained using a portable receiver and hand-held, 2-element, directional antenna. Additional locations were obtained by chance observations. To obtain independence of observations, days and time blocks were randomly assigned to species and individual animals, respectively. Feral horses were located by a weekly ground search. All locations were plotted on 1:24000 USGS topographic maps and Universal Transverse Mercator (UTM) coordinates were obtained. Overall distribution of marked animals was determined by lumping all the locations of one species for a season. Distributional ranges were overlayed to determine common areas of use.

Behavior

An attempt was made to observe each marked animal and the group associated with it twice/season; once during the morning and once during afternoon hours. An observation consisted of an 1-hour session during which behavior type (feeding, bedded, standing, moving) was recorded every 5 minutes for both the focal animal and the majority of the animals present in a group. Observations were made using a 15-60 X spotting scope. Days and individual radio-collared animals to be observed were determined randomly. Observations of horses were conducted by chance. At each session, we noted the number of hetero- and conspecifics visible in the area, the estimated distance from the focal group, estimated distances moved at 15-minute intervals by the focal group, and aggressive or submissive behaviors observed during the session. Homogeneity of behavior across seasons for each species was examined using chi-square. Due to small sample sizes, sexes were lumped.

RESULTS AND DISCUSSION

Population Estimation

Table 1. Population estimation for bighorn sheep, mule deer, and feral horses, on the Pryor Mountain Wild Horse Range during winter, 1993.

Date	Bighorn sheep				Mule deer				Feral horses			
	n_i[a]	m_i[b]	N_i[c]	N_2[d]	n_i	m_i	N_i	N_2	n_i	m_i	N_i	N_2
11 February	39	3	260	209	244	7	593	550	54	14	77	75
17 February	44	3	293	235	155	5	527	467	48	10	96	93
22 February	6	0	0	146	142	4	604	514	42	6	140	128
1 March	20	3	133	109	191	4	812	690	39	10	78	75
8 March	22	4	110	96	139	6	394	359	48	9	107	10
Total N_1	199 ± 91				586 ± 151				100 ± 26			
Total N_2	159 ± 61				516 ± 121				95 ± 22			

[a] Total number of animals observed.
[b] Total number of marked animals observed.
[c] Lincoln-Peterson population estimator.
[d] Chapman's population estimator.

Population estimates for 1993 are given in Table 1. Coates and Schemnitz (1989) reported the bighorn sheep population to be increasing at an exponential rate of $r = 0.18$ during 1985-88. We found the population increased at the same exponential rate ($r = 0.172$; $p > 0.05$) since 1988. This high growth rate is characteristic of colonizing populations of other ungulates (Eberhardt 1987, Gogan and Barret 1987).

Estimated mule deer population size was in the range typical of the study area during 1986-1990 (MDFWP 1990) when the population generally increased. Our estimates suggest the population size may have stabilized during 1990-1993. The minimum number of mule deer known to be alive following the hunting season of 1990 (MDFWP 1990), 565, was similar to our estimate.

The horse population was estimated to be approximately 100 based on helicopter surveys during winter 1993. Another, possibly more accurate, estimate based on sightings of uniquely marked individuals during spring and summer 1993 indicated approximately 180 feral horses, including 1993 foals. Garrot and Taylor (1990) reported the population to be this high only twice during an 11-year period from 1976 to 1986. If foals were deleted from the summer ground population estimate, a downward adjustment of 17%, our helicopter surveys estimated approximately 50% of the actual population size. Stoll et al. (1991) briefly reviewed studies in which ungulate populations are underestimated 33% - 66%. Given the terrain, vegetative cover, and the nature of the technique, our estimates are much more likely to underestimate than overestimate population size.

Distribution

The 3 species were spatially segregated throughout the year (Fig. 1a-b). Through winter and early spring, bighorn sheep were distributed primarily along the edge of Bighorn Canyon. Rams and ewes remained together until mid-late winter. Thereafter, rams moved to a portion of the study area inaccessible to horses and seldom frequented by ewes. Horses ranging in close proximity to the sheep population showed very strong fidelity to the southern and east-central portions of the PMWHR. Distribution of these horses was similar in each season, probably as a result of limited water sources. Other bands of horses used the southern portions of the study area for winter range. Deer were distributed along the southern portion of the study area during winter and early spring.

In spring, sheep were distributed similar to late winter while horses occupying the south-central and southwestern portions of the study area began a migration northward on the East Pryor Mountain. Deer also began migrating northward during the spring.

Summer distributions provided extreme examples of spatial segregation. During lambing, ewes spent considerable time near or in the Bighorn Canyon. Two ewes were observed lambing in Crooked Creek Canyon, approximately
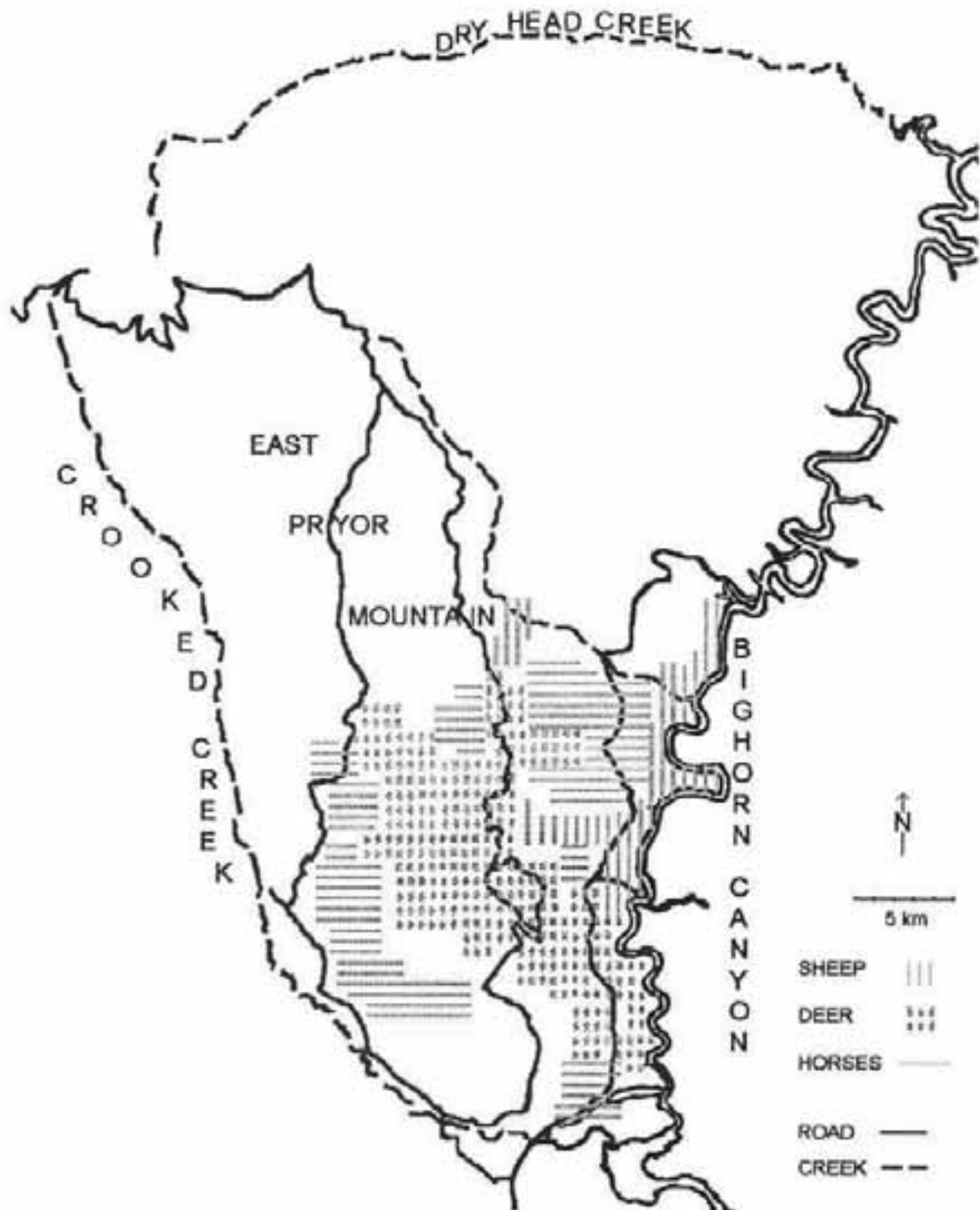
Figure 1a. Distribution of bighorn sheep, mule deer, and feral horses on and surrounding the Pryor Mountain Wild Horse Range during winter 1993.
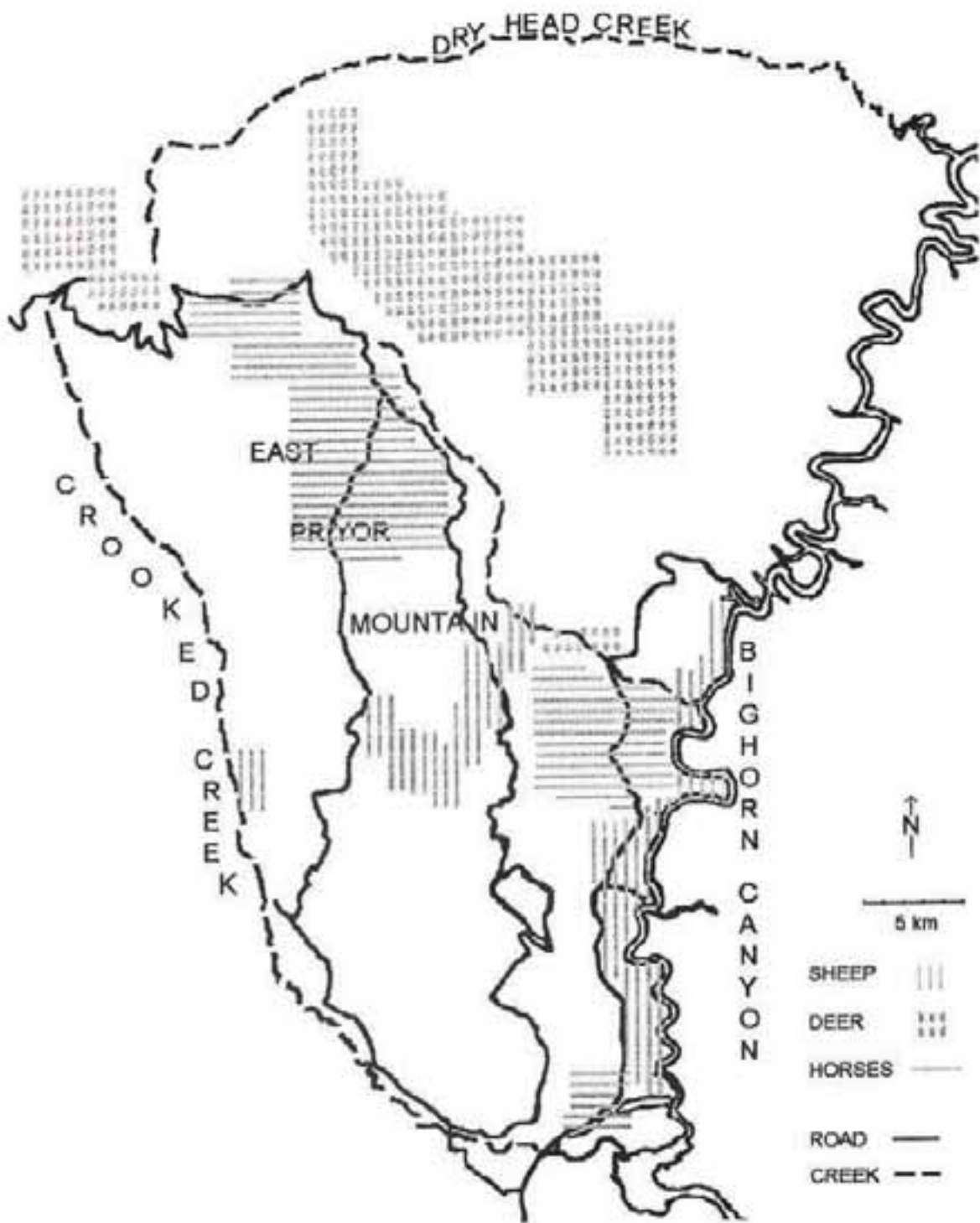
Figure 1b. Distribution of bighorn sheep, mule deer, and feral horses on and surrounding the Pryor Mountain Wild Horse Range during summer 1993.

10 km west of the primary lambing area. These ewes returned to the primary lambing area, the Bighorn Canyon, within 6 weeks. Rams occupied a large area of little topographic relief and a considerable distance (>3 km) from permanent water in the center of the study area during the summer and fall. Leslie and Douglass (1979) also reported that ewes occupied areas of greater topographic relief and closer to water than areas used by rams. The majority of the horse herd spent the summer and fall seasons at the top of East Pryor Mountain. Most deer summered along the base of the mountain on the northern and northeastern sides. Only one radio-collared deer summered on top of the East Pryor Mountain. Additionally, very few deer were seen on top, or on the southern aspect, of the East Pryor Mountain during summer and most of fall.

Rams returned to the lower elevations of the study area during late fall and early winter where ewes spent summer and fall. Horses and deer also returned to the winter range during this time. Snow and the onset of more severe winter conditions appeared to be factors initiating fall/winter migration.

Ungulates typically separate spatially or temporally to avoid competition (Hirst 1975). Though there was insufficient evidence to support the existence of competition between feral horses, bighorn sheep, and antelope, Berger (1986) invoked habitat separation and food habit preferences as the strategies used in the Great Basin to avoid competition. Seasonal distributions of the 3 species on our study area were indicative of spatial segregation suggesting that it is at least one tactic being used to avoid competition.

Behavior

No difference in frequency of behavior (feeding, moving, standing, bedded) between seasons was observed for mule deer (X^2 = 15.4, p > 0.5). Differences between fall and summer (X^2 = 14.4, p < 0.005), fall and spring (X^2 = 14.85, p < 0.005), and fall and winter (X^2 = 10.06, p < 0.05) for frequency of behaviors were indicated for bighorn sheep. Differences in frequency of behaviors were observed for feral horses between fall and summer (X^2 = 9.7, p < 0.05), and fall and spring (X^2 = 14.1, p < 0.005).

Very few (N < 6) interspecific interactions were observed during 1993. All occurred in the winter or early spring, when the three species were on winter ranges and all included horses as the dominant species when horses were present. Like Berger (1986), we found that encounters between species were rare as a result of different habitat preferences and seasonal use patterns. Coates and Schemnitz (1989) also reported few interactions (n = 9) between sheep and horses; where they occurred, horses were the dominant species.

MANAGEMENT RECOMMENDATIONS

Greatest opportunity for competition existed during winter when the three species were in close proximity. However, given present population sizes, distributions, movements, and the infrequent encounters between species, little or no interspecific interaction of population consequence appears to be occurring. Therefore, we recommend that the three species be managed independently at this time. Berger (1986) noted that interspecific conflicts between feral horses and native species almost always resulted in submission of the native species. With this in mind, we suggest that these ungulate populations be monitored closely to determine if the increasing sheep population is influenced by the feral horse herd or if the sheep population expands its range further to maintain the reduced potential for competition with horses.

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