Population dynamics, food habits, seasonal habitat use, and spatial relationships of bighorn sheep, mule deer, and feral horses in the Pryor Mountains, Montana/Wyoming
by Robert E. Kissell, Jr

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Biological Sciences
Montana State University
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Abstract:
Seasonal habitat use, seasonal food habits, interspecific behavior, and population dynamics of bighorn sheep (Ovis canadensis) mule deer (Odocoileus hemionus) and feral horses (Equus Caballus) in the Pryor Mountains, Montana, centered on the Pryor Mountain Wild Horse Range and adjacent rangelands, were examined during 1993-1995. Bighorn sheep used mountainmahogany, juniper, and mountainmahogany/juniper complexes most frequently at elevations < 2200 m on northeast and southeast aspects. Most slopes used were <45°° and at distances > 100 m from escape terrain.' Mule deer used juniper and mountainmahogany/juniper complexes on the winter range and sagebrush and conifer on the summer range. Elevations used on the winter range were < 1800 m and on the summer range varied from 1400 - 2200 m. Southeast and southwest aspects. dominated use in winter and northeast in summer. Slopes <31°° were commonly used on both summer and winter range. [Feral horses used juniper and grasslands most frequently, and use varied in elevation depending upon the season and portion of the herd. Winter was spent at elevations < 1800 m and summer elevation use included elevations > 2300 m and < 1800] All aspects were used equally, except northwest which was used least.

Bighorn sheep diets were dominated by browse (34.0% - 93.8%) in all seasons except spring, when grass was the dominant (58.6% - 66.0%) forage class. Mule deer diets showed winter to summer seasonal trends, with browse as the major winter, summer, and fall dietary component and forbs as the major spring dietary component. Feral horses consumed primarily grasses (66.95% - 96.35%) during all seasons and exhibited a high level (>20%) of browse use in the fall. Morista's similarity index suggested substantial dietary overlap between bighorn sheep and mule deer during fall and winter and substantial dietary overlap between bighorn sheep and feral horses during spring and summer.

Twenty-one interspecific interactions were observed during the study. Ifhorses were involved in an encounter and there was a dominant species, horses were the dominant species; bighorn sheep and mule deer were not observed exhibiting dominant or subordinate actions towards one another during the study.

The bighorn sheep population peaked at an estimated 211 animals in 1994 and declined in 1996 to an estimated 125 animals. Lamb production by bighorn sheep was sufficient to increase the population size; however, mean recruitment of yearlings was only sufficient to maintain the population in each year except 1995, when recruitment fell below the maintenance level. The mule deer population peaked at an estimated 780 animals during 1995 and decreased to an estimated 143 animals in 1996. Mean mule deer recruitment increased each year from 1994-1996, from 37 fawns: 100 does to 44.8 fawns to 100 does. The feral horse-population peaked at a minimum of 177 animals during 1994. Removal of 51 feral horses yielded a minimum of 143 animals in 1995. Population growth rates for feral horses were estimated at a maximum of 16.5%, 23.8%, and 21.2%, during 1993, 1994,-and 1995, respectively. Population structure of bighorn sheep and mule deer indicated inadequate nutrition for lambs and

fawns, respectively. Feral horse population growth indicated adequate nutrition. -

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A thesis submitted in partial fulfillment
of the requirements for the degree

of

Doctor of Philosophy

in

Biological Sciences

MONTANA STATE UNIVERSITY
Bozeman, Montana

December 1996

D378
.K6434

APPROVAL

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ACKNOWLEDGMENTS

I convey my deepest gratitude to Elizabeth, my wife, who supported and provided me with encouragement throughout my entire degree program. I wish to express my sincere appreciation to Dr. Lynn R. Irby who generously gave of his time when requested and provided advice, encouragement, and freedom during manuscript preparation and with related topics. I am indebted to Drs. Richard J. Mackie, Carl L. Wambolt, Jay J. Rotella, Robert G. White, and Earl Skogley, Montana State University, for reviewing the manuscript. I wish to recognize the many individuals who assisted in capture and collaring animals. I would also like to acknowledge Mr. Keith Iverson, Montana Department of Fish, Wildlife & Parks, Mr. Robert Hawkins, Mr. Rick Sanford, Mr. Rick Schwartz, and Mr. Kent Potter for their excellent flying during relocation and population survey flights. My appreciation is extended to Mr. Mark Thompson and Mr. Toby Swank for summer field assistance. I thank Mr. James T. Peters and Mr. Jack Lindsey for use of office space. I am indebted to the Barton, Carroll, Bassit, Schwend, Snell, Sintec, and Tillet families, and the Crow Tribe Indian Reservation for their hospitality. I thank F. Schwieger for assistance concerning the horse population. I also extend my appreciation to Dr. David E. Worley, Montana State University, for processing and analyzing samples for lungworm larvae counts. I am also grateful to the staff of the Geographic Information and Analysis Center, Montana State University. I wish to express my appreciation to the National Park Service, Bureau of Land Management, National Forest Service, and Montana Department of Fish, Wildlife & Parks for funding the study.

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ABSTRACT

Seasonal habitat use, seasonal food habits, interspecific behavior, and population dynamics of bighorn sheep (Ovis canadensis), mule deer (Odocoileus hemionus), and feral horses (Equus caballus) in the Pryor Mountains, Montana, centered on the Pryor Mountain Wild Horse Range and adjacent rangelands, were examined during 1993-1995. Bighorn sheep used mountainmahogany, juniper, and mountainmahogany/juniper complexes most frequently at elevations < 2200 m on northeast and southeast aspects. Most slopes used were < 45° and at distances > 100 m from escape terrain. Mule deer used juniper and mountainmahogany/juniper complexes on the winter range and sagebrush and conifer on the summer range. Elevations used on the winter range were < 1800 m and on the summer range varied from 1400 - 2200 m. Southeast and southwest aspects dominated use in winter and northeast in summer. Slopes < 31° were commonly used on both summer and winter range. Feral horses used juniper and grasslands most frequently, and use varied in elevation depending upon the season and portion of the herd. Winter was spent at elevations < 1800 m and summer elevation use included elevations > 2300 m and < 1800 m. All aspects were used equally, except northwest which was used least.

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Twenty-one interspecific interactions were observed during the study. If horses were involved in an encounter and there was a dominant species, horses were the dominant species; bighorn sheep and mule deer were not observed exhibiting dominant or subordinate actions towards one another during the study.

The bighorn sheep population peaked at an estimated 211 animals in 1994 and declined in 1996 to an estimated 125 animals. Lamb production by bighorn sheep was sufficient to increase the population size; however, mean recruitment of yearlings was only sufficient to maintain the population in each year except 1995, when recruitment fell below the maintenance level. The mule deer population peaked at an estimated 780 animals during 1995 and decreased to an estimated 143 animals in 1996. Mean mule deer recruitment increased each year from 1994-1996, from 37 fawns:100 does to 44.8 fawns to 100 does. The feral horse population peaked at a minimum of 177 animals during 1994. Removal of 51 feral horses yielded a minimum of 143 animals in 1995. Population growth rates for feral horses were estimated at a maximum of 16.5%, 23.8%, and 21.2%, during 1993, 1994, and 1995, respectively. Population structure of bighorn sheep and mule deer indicated inadequate nutrition for lambs and fawns, respectively. Feral horse population growth indicated adequate nutrition.

INTRODUCTION

According to fossil records (Buechner 1960, Martin and Guilday 1967, Wallmo 1981, McFadden 1992), bighorn sheep (Ovis canadensis canadensis), mule deer (Odocoileus hemionus hemionus), and horses (Equus spp.) were all present on the North American continent prior to 8,000 years ago. Bighorn sheep evolved in Asia, apparently moved across the Bearing land bridge during the Pliestocene (Buechner 1960), and expanded southward throughout the Rocky Mountain range as far south as present day Mexico (Lawson and Johnson 1982). The evolution of mule deer on the continent is unclear and still debated; nonetheless, mule deer have been present in North America for at least 10,000 years and probably evolved from a cervid line that originated in Asia (Wallmo 1981, Mackie et al. 1982, Geist 1994). Equus evolved on the North American continent during the Pliocene (Simpson 1951, McFadden 1992), but along with many other large mammals (Simpson 1951, Martin 1967, Grayson 1989, McFadden 1992) became extinct on the North and South American continents between 8,000 and 13,000 years ago. Prior to that great megafaunal extinction all three genera had distributions encompassing the present day Pryor Mountains (Cowan 1940, Simpson 1951, Buechner 1960, McFadden 1992).

Bighorn sheep were numerous and widely distributed in western North America prior to European settlement (Buechner 1960), occurring in the Pryor Mountains and surrounding area before 1850 (Hamilton 1910). Distribution and numbers of bighorn

sheep in the Pryor Mountains declined from the early 1800's to about 1860, when sheep were extirpated (Gordon et al. 1974). The Montana Department of Fish, Wildlife & Parks (MDFWP) reintroduced a total of 77 bighorn sheep in 1971 and 1974 to the Pryor Mountains (Gordon et al. 1974). In 1973, the Wyoming Game and Fish Department (WGFD) transplanted 39 sheep to the Porcupine drainage (Helms 1973) of the Bighorn Mountains, which empties into the Bighorn River. Genetic profiles (FitzSimmons 1992) and visual observations (Simmons and Stewart 1977, Coates and Schemnitz 1989) indicated sheep from both reintroductions contributed to establishment of the present Pryor Mountain bighorn sheep herd.

Mule deer were a very common ungulate in Montana before European settlement of the area (Burroughs 1961). With growing numbers of settlers, collapse of the fur trade, expansion of the livestock industry, loss of habitat, and unlimited harvest, the mule deer population declined prior to 1900 and did not rebound until the 1940's (Egan 1971). Since the early 1960's, the Pryor Mountain mule deer herd has experienced periodic increases and decreases in harvests (Ellig 1960, Townsend 1964, Foss and Whitney 1966, Foss et al. 1969, Simmons and Stewart 1979) which are assumed to reflect population size (Wood et al. 1989).

Cortez, on March 13, 1519, unloaded 16 horses from his ships near Vera Cruz, Mexico and introduced the first horses to inhabit North America in at least 8,000 years (Wyman 1946, Martin and Guilday 1967, McFadden 1992). During the following 3 centuries numerous other horses were brought to the continent where trading by Native Americans, ranchers, and missions facilitated the expansion of horses throughout the United States

(Simpson 1951). "Wild" horses of today are descendants of horses that escaped or were released by ranchers, missions, or Native Americans to range freely.

The time of arrival of horses in the Pryor Mountains is uncertain. Hamilton (1910) did not mention the presence of free-ranging horses in the Bighorn Basin in 1848 or 1849. Others suggest that free-ranging horses may have occupied south-central Montana since the 1700's (Wyman 1946). Regardless, feral horses occurred in the Pryor Mountains and the surrounding area, apparently in great numbers (Wyman 1946), until the 1930's. In the early 1930's, because of potential competition with livestock, stockmen sponsored round-up efforts. By 1939, these efforts were sufficiently effective that few feral horses were still free-ranging in Montana (Wyman 1946). Feral horses became re-established in the Pryor Mountains (Thomas 1979) prior to or during the 1960's and numbered approximately 200 by 1968 (BLM 1984).

As public support for protection of feral horses grew in the western United States, both national and local pleas for preservation increased. The Pryor Mountain Wild Horse Range (PMWHR) was established in 1968 by the Department of Interior (Federal Register Document 68-11056). Subsequent passage of the Wild Free-Roaming Horses and Burros Act (Public Law 92-195) in 1971 ended commercial exploitation of feral horse herds on public lands in the United States.

Condition of rangeland across the majority of the PMWHR and adjacent areas during the last half of this century has been described as poor or very poor (Firebaugh 1969, Gordon and Coop 1973, Hall 1973, BLM 1984, BLM 1992) with high potential for soil loss (Cleary and MacIntyre 1973). This, together with a steady increase in the bighorn

sheep herd (Coates and Schemnitz 1989), fluctuating mule deer numbers as indicated by highly variable harvests (MDFWP, unpubl. data), and consistent high levels of reproduction of feral horses (Garrott and Taylor 1990), provided impetus for this study.

The study was designed to address the following objectives and hypotheses [given in brackets] on and around the PMWHR: 1) determine seasonal habitat use for bighorn sheep, mule deer, and feral horses [H_o: there is no significant overlap in habitat use among ungulates by season]; 2) determine seasonal diets for bighorn sheep, mule deer, and feral horses [H_o: there is no significant overlap in diets of ungulates by season]; 3) determine if population structure of bighorn sheep, mule deer, or feral horses indicated adequate nutrition [H_o: there is no difference between population structure of healthy populations and population structures of ungulates in the Pryor Mountain Study Area]; 4) estimate the population size trends for bighorn sheep, mule deer, and feral horses during 1993-1995; and, 5) determine if behavioral interactions among bighorn sheep, mule deer, and feral horses influence distribution or habitat use patterns [H_o: there is no difference in distribution given the presence or absence of another species].

STUDY AREA

The Pryor Mountain Study Area (PMSA) is located approximately 75 km south of Billings in Bighorn county, Wyoming, and Bighorn and Carbon counties, Montana (45° 00' N latitude, 108° 15' W longitude). The study area (Figure 1) encompassed approximately 700 km^2 that included the PMWHR and adjacent lands managed by the Bureau of Land Management (BLM), portions of the Bighorn Canyon National Recreation Area (BCNRA), the Custer National Forest (CNF), the Crow Tribe Indian Reservation (CTIR), and privately owned properties.

Topoedaphic Features

Topographic features (Figure 1) consisted of vertical canyon walls, steep talus slopes, and gently rolling hills and meadows intersected by canyons. Elevation varied from 1109 m to 2660 m. Steep slopes (> 45°) were primarily located along the Bighorn and Crooked Creek Canyons. Many creeks traversed the area, but perennial streams were rare and most water courses were intermittent (Figure 2). Soils were composed of sandstone, limestone, shale, dolomite, and alluvial deposits (Richards 1955, Blackstone 1975). Soil depth varied but has been described as severely depleted (Cleary and MacIntyre 1973).

Vegetation

Vegetation (Figure 3) was classified into 9 principal types (Knight et al. 1987, McCarthy 1996). Juniper woodlands were dominated by Utah juniper (Juniperus osteosperma). Mountainmahogany woodlands were dominated by curlleaf mountainmahogany (Cercocarpus ledifolius). Juniper/mountainmahogany woodlands were composed of a mixture of both Utah juniper and curlleaf mountainmahoghany. Riparian habitat was dominated by cottonwoods (Populus spp.) and fragrant sumac (Rhus aromatica). Desert shrubland was characterized by saltbush (Atriplex canescens, A. confertifolia), black greasewood (Sarcobatus vermiculatus), rubber rabbitbrush (Chrysothamnus nauseosus), big sagebrush (Artemisia tridentata), broom snakeweed (Gutierrezia sarothrae), bluebunch wheatgrass (Agropyron spicatum), threeawn (Aristida fendleriana and A. longiseta), and needle-and-thread (Stipa comata). Sagebrush steppe included both big sagebrush and black sagebrush (Artemisia nova) communities, the latter on limestone derived soils. Grasslands were dominated by bluebunch wheatgrass, blue grama (Bouteloua gracilis), needle-and-thread, broom snakeweed, Hooker sandwort (Arenaria hookeri), fringed sagebrush (Artemisia frigida), and Hood phlox (Phlox hoodii), alpine bluegrass (Poa alpinum), alpine timothy (Phleum alpinum), Ross sedge (Carex rossii), bluebunch wheatgrass, annual fescue (Festuca octoflora), silky lupine (Lupinus sericeus), grouse whortleberry (Vaccinium scoparium), paintbrush (Castilleja pulchellum), tufted fleabane (Erigeron caespitosus), tufted phlox (Phlox caespitosa), and goldenrod (Solidago radiata). Coniferous woodlands were characterized by limber pine (Pinus

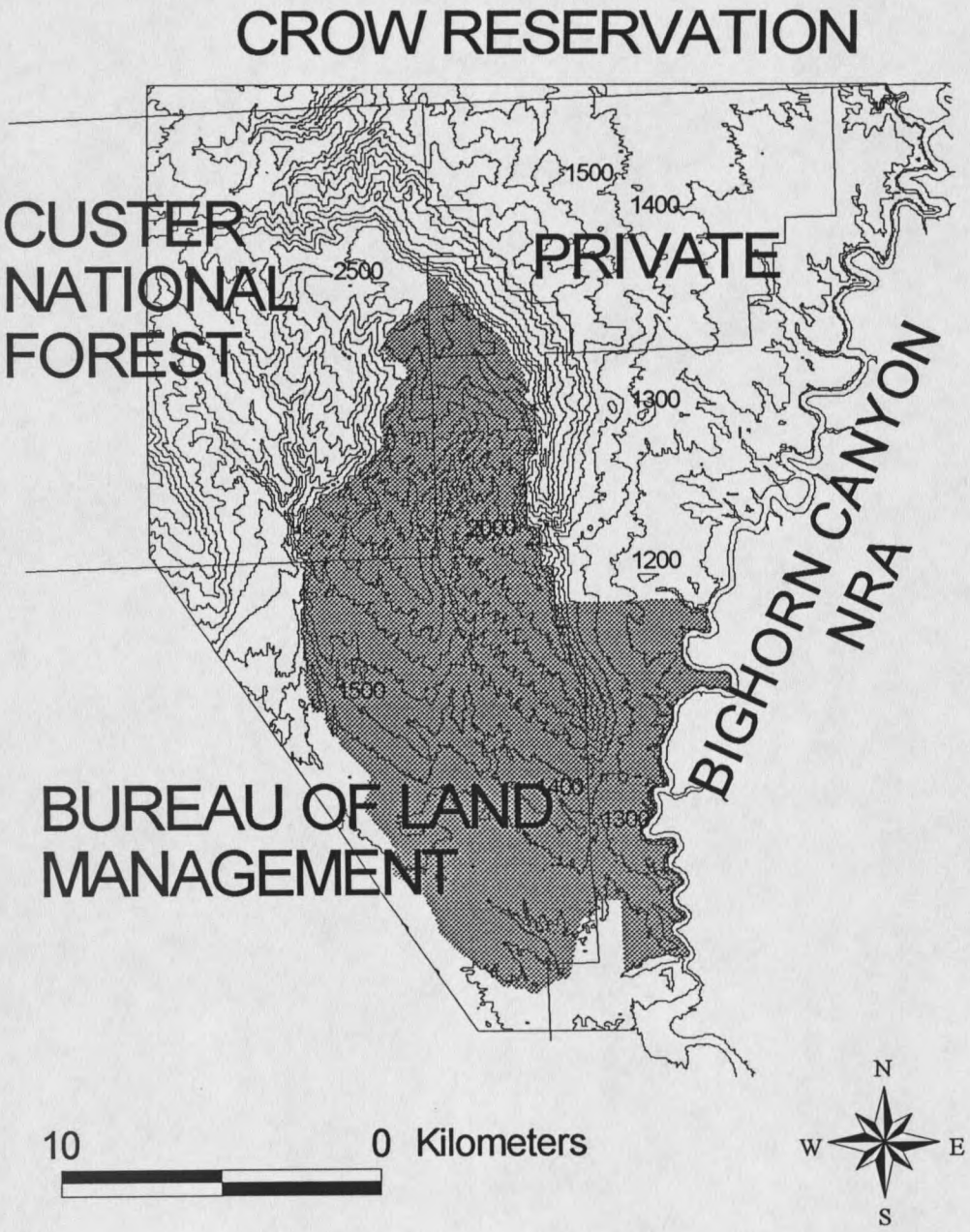


Figure 1. Pryor Mountain Study Area, associated ownership, and topography. The Pryor Mountain Wild Horse Range (shaded area) represents an approximate boundary.

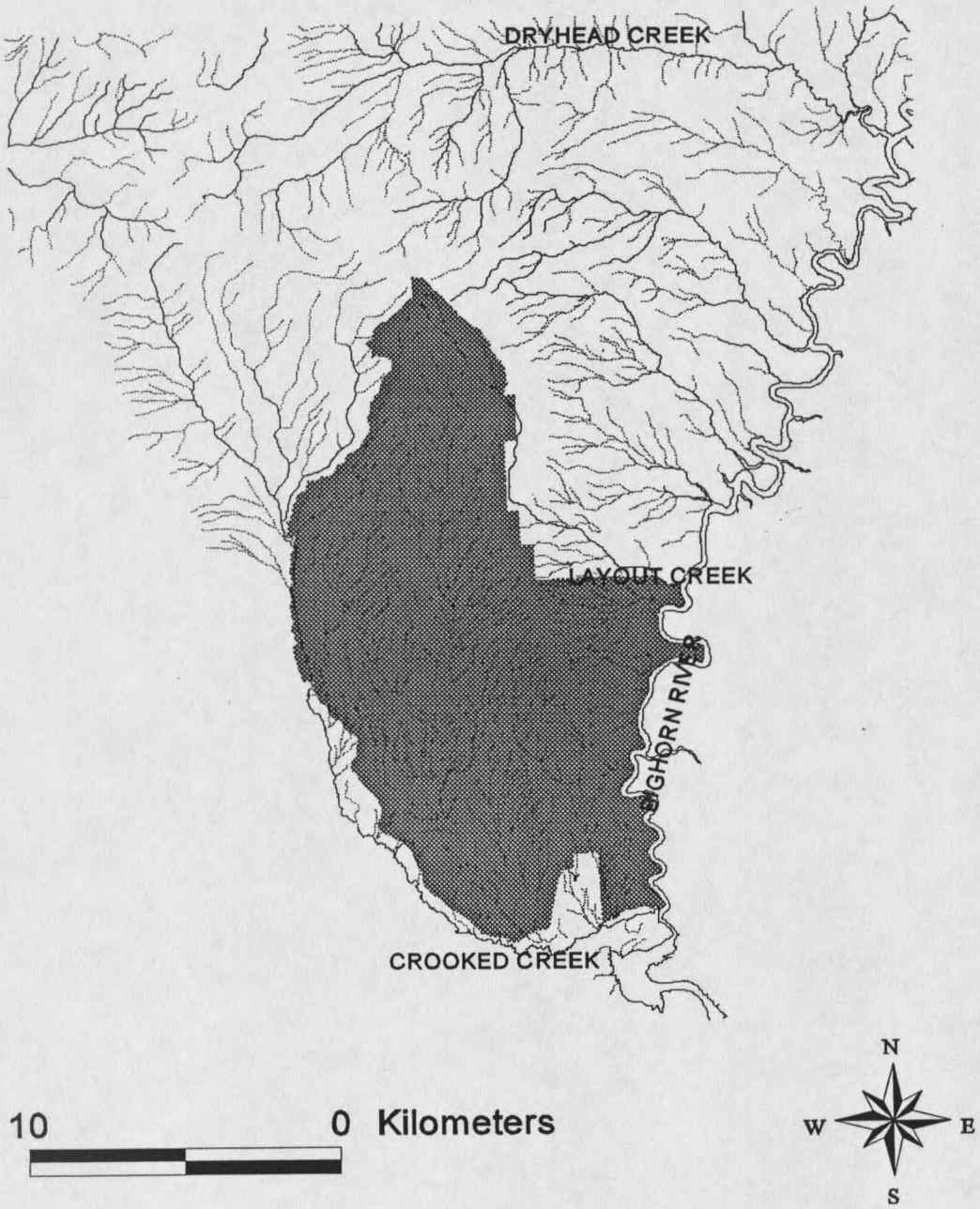


Figure 2. Permanent (solid lines) and ephemeral (dotted lines) streams on the Pryor Mountain Study Area as related to the Pryor Mountain Wild Horse Range (shaded area).

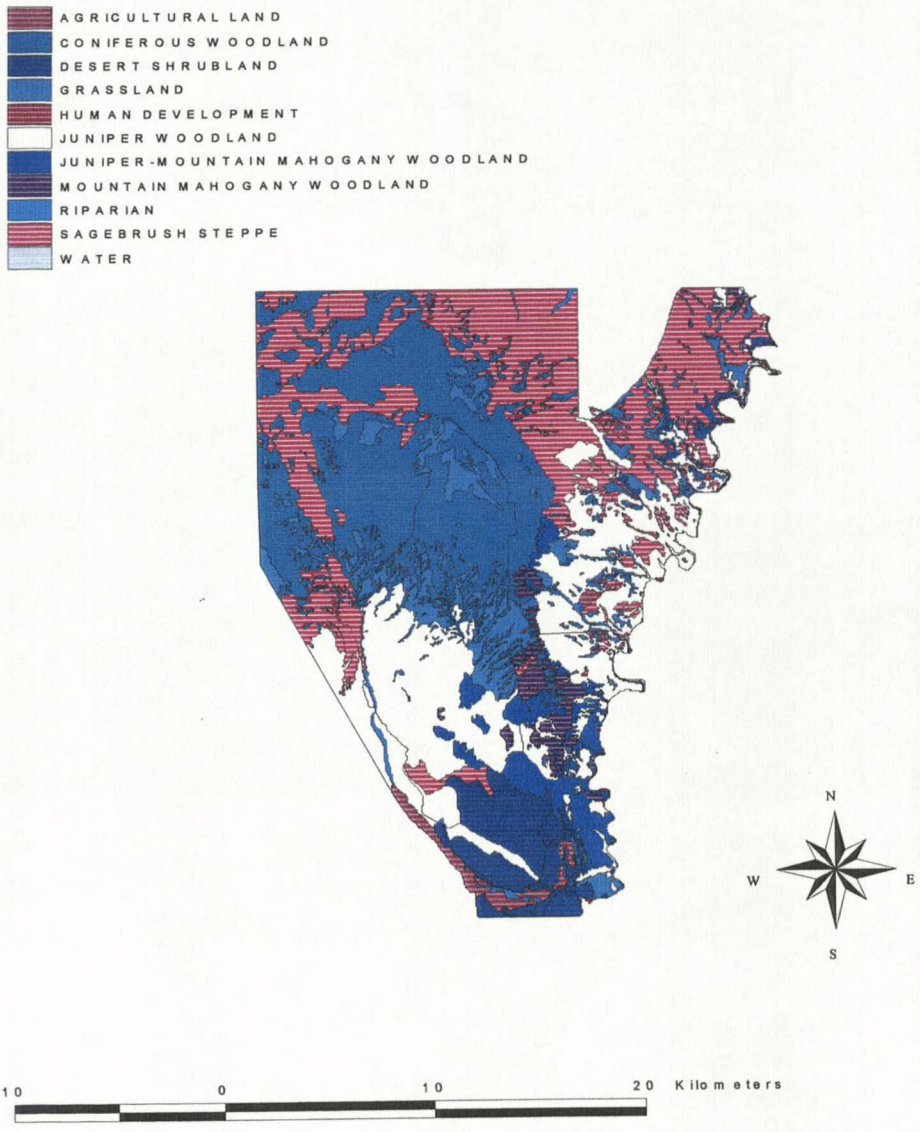


Figure 3. Distribution of vegetation on the Pryor Mountain Study Area. Southern and eastern portions were provided by Knight et al. (1987), and western and northern portions were developed during this study.

flexilis), ponderosa pine (P. ponderosa), Douglas fir (Psuedotsuga menziesii), and a spruce (Picea engelmannii) - fir (Abies lasiocarpa) mix. Agricultural areas were dominated by alfalfa (Medicago spp.).

Climatic Features

Climate varies from hot, dry, semi-arid to cold, dry, mesic conditions. Mean summer temperature in Lovell, WY (approximately 10 km SSW of the study area, measured at the Western Sugar Company (an official National Oceanic and Atmospheric Administration reporting station, recorded since 1920), was 21.1 °C with extremes exceeding 40°C. Mean maximum monthly winter temperature was -6.3 °C with extreme lows exceeding -34°C (Figure 4). December and January were the coldest months with average high temperatures of 0.5 °C and -0.7 °C. July and August were the hottest months with average high temperatures of 29.0 °C and 28.7 °C, respectively. Mean summer precipitation (June - August) was 2.13 cm and mean winter precipitation was 0.74 cm (Figure 5). Precipitation varies monthly with single rainfall events producing amounts ranging from a trace to > 5 cm covering portions or all of the Pryor Mountains.

Land Uses

The BLM, NPS, CNF, and MDFWP properties were most often used for wildlife and horse viewing, hunting, or fishing. Access was limited to a few main roads (Figure 6). Deer hunting was allowed on the study area, and deer were harvested following the regular season regulations of Wyoming and Montana. MDFWP issued 2 bighorn sheep

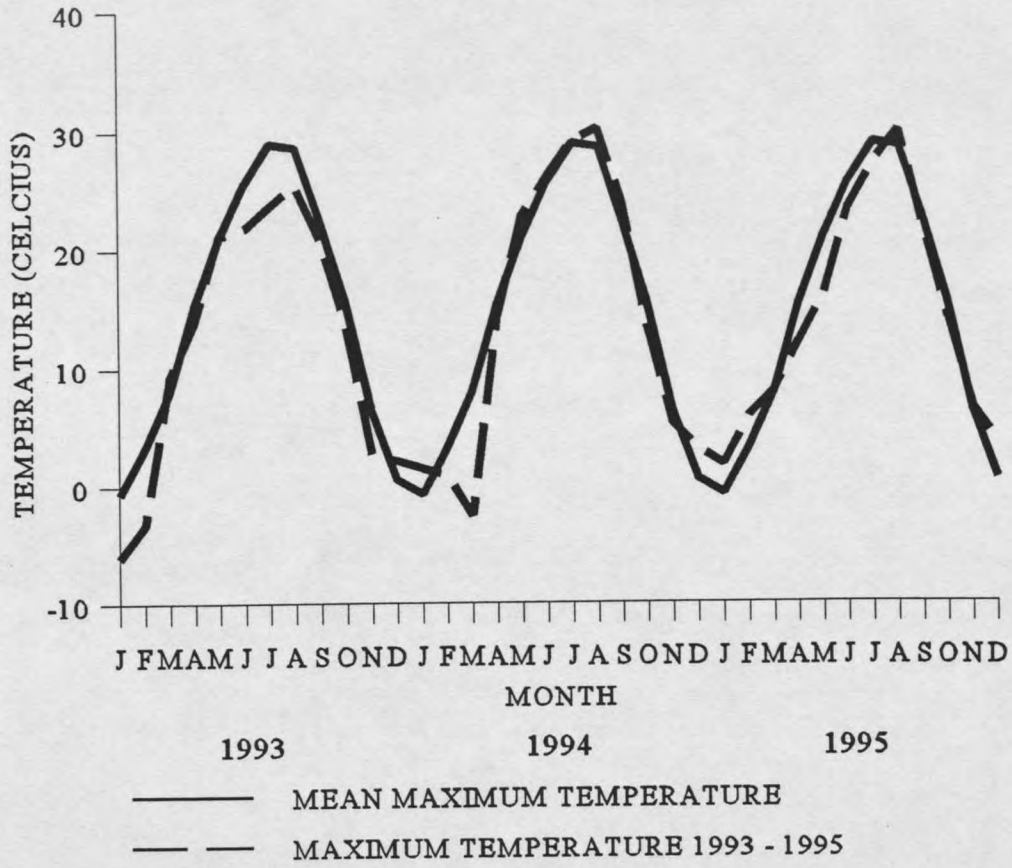


Figure 4. Maximum monthly temperatures for the Pryor Mountain Study Area from 1993 - 1995 in relation to mean monthly maximum temperatures (based on a 20 year average) at Lovell, WY.

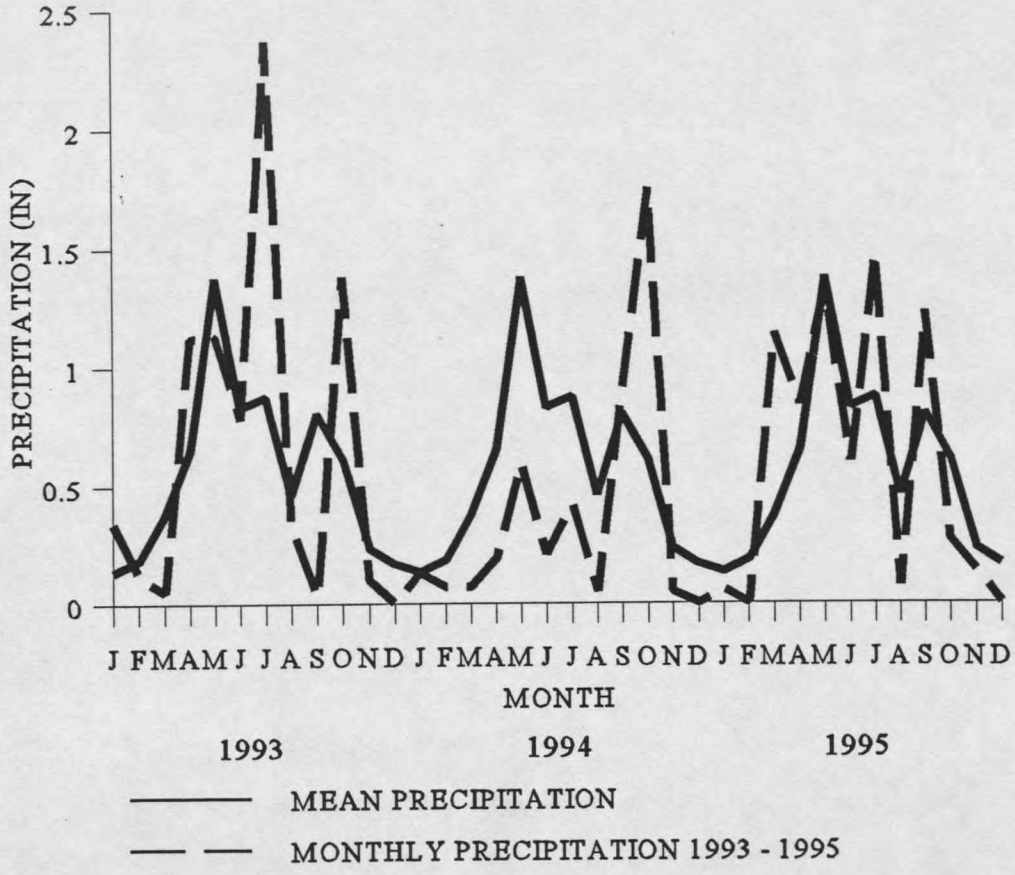


Figure 5. Mean monthly precipitation (based on a 20 year average) for the Pryor Mountain Study Area from 1993 - 1995 in relation to monthly precipitation at Lovell, WY.

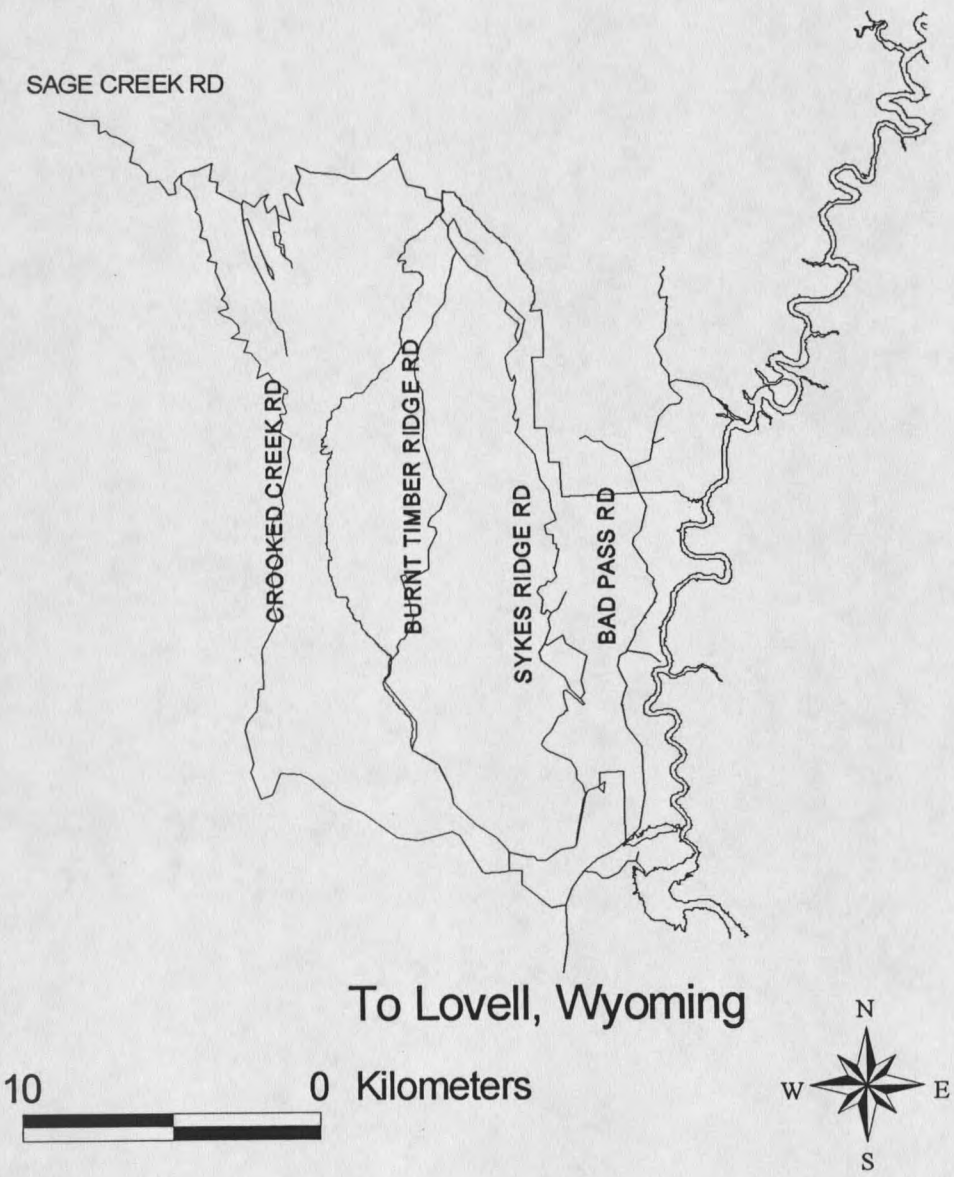


Figure 6. Main roads of the Pryor Mountain Study Area in relation to the Pryor Mountain Wild Horse Range (bold line).

permits annually in 1991 - 1993, and 4 permits were issued annually in 1994 - 1995. There were no bighorn sheep permits issued by WGFD for the area. Horses were gathered and the population was culled in fall 1992 and fall 1994.

Adjacent land uses included cattle ranching and farming. Cattle were maintained on portions (< 25%) of the study area throughout the spring and summer months on the CNF, the CTIR, and adjacent private lands. Alfalfa was the only agricultural crop grown during the study, occurring only in fields along the southern boundary of the study area.

METHODS

Animal Capture and Marking

Bighorn Sheep

Twenty-two female and 4 male bighorn sheep were captured and marked in September 1992, January 1993, April 1994, and June and July 1995 (Appendix, Table 14). Bighorn sheep were captured using a hand-held net gun fired from the ground or from a Hughes 500C helicopter following techniques described by Andryk et al. (1983). A concerted effort was made to distribute radiocollars among different bands to sample the population as broadly possible. Upon capture, the time and location were noted, the animal was blindfolded, and its legs were bound. Blood samples, nasal and pharyngeal swabs, and fecal samples were taken. Age was estimated for bighorn sheep using tooth wear and replacement (Cowan 1940, Deming 1952). Bighorn sheep males ≥ 4 years of age and females > 2 years of age were considered adults, male bighorns > 1 year and < 4 years of age were considered juveniles, and bighorns of both sexes < 1 year of age were considered young of the year (YOY) (Geist 1971). Thirteen of 22 (59%) ewes were adults at the time of capture and 3 of 4 (75%) rams were adults at the time of capture. Each bighorn sheep was fitted with an individually recognizable radiocollar (150.000-151.999 MHz) and tagged in each ear with a numbered, metal tag provided by MDFWP. Handling time was < 10 minutes per animal, and animals were released at the site of capture.

Mule Deer

Twenty-five mule deer, 19 does and 6 bucks, were captured and marked during January 1993 and January and February 1994 (Appendix Table 15). Mule deer were captured using a net gun fired from a Hughes 500C helicopter following techniques described by Barrett et al. (1982) or with Clover traps (Clover 1954) baited with alfalfa hay. An effort was made to distribute radiocollars as broadly as possible across the deer population. Upon capture, the time and location were noted, the animal was blindfolded, and its legs were bound. Only blood samples were taken from mule deer. Age of each individual was estimated to the nearest 6 months using tooth wear and replacement (Robinette et al. 1957). Mule deer ≥ 2 years of age were considered adults, deer > 1 year and < 2 years of age were considered yearlings, and deer < 1 year of age were considered YOY (Wallmo 1981). At the time of collaring, 2 of 6 (33%) bucks were adults, 3 (50%) were yearlings, and 1 (15%) was a YOY. Sixteen of 19 (84%) does were adults and 3 of 19 (16%) does were YOY at the time of capture. Each mule deer was also fitted with an uniquely marked radiocollar (150.000-151.999 MHz) and tagged in each ear with a numbered, metal tag provided by MDFWP. Handling time was < 10 minutes per animal, and animals were released at the site of capture.

Horses

Feral horses were not captured or radiocollared and no tissue samples or other biological materials were taken from horses prior to or during the study. Based on coat color and pattern, 20 readily recognizable horses, 14 females and 6 males, were used as

"marked" animals (Appendix Table 16). At the time of identifying marked females, only 1 was a juvenile (7%).

Radiotracking and Visual Observation

Locations were determined for 3 time periods: morning (0500-0959 hrs); midday (1000 - 1559 hrs); and evening (1600-2300 hrs). Aerial locations of radiocollared bighorn sheep and mule deer were obtained using a portable TR-2 receiver (Telonics, Inc., Mesa, AZ) and 2, 2-element H-antennas attached to the wing struts of a Super Cub, or 1 pivotal, 3-element yagi antenna mounted beneath the fuselage. Aerial locations were typically obtained during the morning time block. Aerial locations were recorded on 1:24000 United States Geological Survey (USGS) topographic maps from January 1993 to January 1994; thereafter, a Garmin 95XL geographic positioning system (GPS) or a Garmin 45 Personal Navigator™ GPS unit (Garmin Inc., Lenexa, KS) was used to record aerial locations.

Radiocollared mule deer and bighorn sheep were located from the ground using a portable receiver and a hand-held, 2-element H-antenna for triangulation. Two bearings were obtained from routinely used telemetry stations (Nams and Boutin 1991), or by homing in on the marked animal. All locations were recorded from a 1:24000 USGS topographic map or determined by a Garmin 45 Personal Navigator™ GPS unit. Additional locations obtained by chance were recorded in a similar manner.

An attempt to locate radiocollared animals was made once each week from the ground and twice per month from the air between 15 February 1993 and 30 June 1993. From 1

July 1993 to 30 August 1995, radiocollared animals were aerially located once per month if conditions permitted. An attempt was also made to locate all radiocollared animals from the ground 3 times every 2 weeks during field seasons (Table 1). To obtain independence of observations within seasons, days and time blocks were randomly assigned to species and individual radiocollared animals, respectively. Feral horses were located during weekly ground surveys.

Usable telemetry or visual locations for bighorn sheep, mule deer, and feral horses totaled 2,512 (Table 2) from January 1993 through February 1996.

Table 1. Field seasons during which data were collected on the Pryor Mountain Study Area.

	YEAR		
SEASON	1993	1994	1995
WINTER	X	X	
SPRING	X	X	
SUMMER	X	X	X
FALL	X		

Coordinate Transformation

Universal Transverse Mercator (UTM) coordinates were obtained from telemetry data for each estimated location using a program written in SAS (SAS Inst., Inc. 1987). Locations determined using bearings having a difference of $< 30°$ or $> 150°$ were omitted, as these data resulted in unacceptable error polygons (White and Garrott 1990). Telemetry locations were transferred into ARC/INFO using the GENERATE

subcommand. Visual locations recorded on 1:24000 USGS topographic maps were digitized and projected into real world coordinates using PROJECTDEFINE,

Table 2. Number of usable locations by season and species recorded from January 1993 - August 1995.

SEASON	SPECIES		
	BIGHORN SHEEP	MULE DEER	FERAL HORSES
WINTER	227	179	122
SPRING	322	199	165
SUMMER	492	132	276
FALL	226	95	77

PROJECT, and TRANSFORM subcommands in ARC/INFO. All locations were attributed in ARC/INFO.

Bearing Error

Bearing error was quantified by locating transmitters placed in unknown locations (n = 44) at varying distances (400, 600, 800, and 1500 m) from routinely used telemetry stations. The difference between observed and true bearings was recorded for each bearing taken.

An analysis of variance was used to determine if there was a difference between mean bearing error at different distances. Confidence intervals were calculated for each distance to determine if error was $\leq 5°$. A standard deviation of $\leq 5°$ was considered acceptable. Any deviation $> 5°$ would have resulted in error polygons being unacceptably large.

No significant differences were found in bearing errors (Table 3) at different distances (Table 4); therefore, error was assumed to remain the same at any distance. The mean error across all distances was 0.636° ± 2.96° and the average arc between bearings was 71.4°.

Table 3. Mean bearing error in degrees and the associated standard deviation for bearings taken for radiocollars placed at unknown locations at varying distances from routinely used telemetry stations on the Pryor Mountain Study Area.

Distance (m)	Mean (degrees)	Standard deviation (degrees)
400	0.727	2.91
600	0.455	2.40
800	0.727	1.03
1500	0.636	1.12

Table 4. Analysis of variance results testing the effect of distance (400 m, 600 m, 800 m, and 1500 m) on bearing error from routinely used telemetry stations on the Pryor Mountain Study Area from 1993-1995.

Source	D.F.	Sum of Squares	Mean Square	F-Value	Pr > F
Model	3	0.5454545	0.1818182	0.02	0.9963
Error	40	375.63636	9.3909091		
Total	43	376.18182			

Error Polygons Based on Telemetry, GPS, and Visual Data

Using the standard deviation calculated from the bearing error trials, degrees were added to and subtracted from the observed bearing, such that 97.5% error arcs were

obtained about each bearing. The intersection of the 2 error arcs provided the 95% error polygon (Nams and Boutin 1991) for each location. UTM coordinates were obtained from telemetry data for each error polygon.

Locations recorded by GPS units were presumed to be within 100 m 100% of the time (Garmin Int. 1994). To account for this GPS error, a circle with a radius of 100 m around recorded locations was created using the BUFFER subcommand in ARC/INFO. Visual locations recorded on 1:24000 USGS topographic maps were treated in the same manner.

Average distance from telemetry stations to estimated locations determined by telemetry was 1,869 m. The average error polygon size, based on distance from test collars and the standard deviation of bearings, was 6.92 ha. Error polygon size was 3.14 ha for visual or GPS locations.

Seasonal Habitat Use

Determining Use of Habitat Variables

Seasons were defined as winter: 23 December - 20 March; spring: 21 March - 21 June; summer: 22 June - 23 September; and, fall: 24 September - 22 December. Habitat was defined by the following variables: elevation, slope, aspect, vegetative type, distance to permanent water, distance to main roads, and distance to escape terrain (for sheep only). Elevation was partitioned into 100 m intervals (1000 m - 2600 m). Slope was segregated into 5 categories ($\leq 15°$, 16°-30°, 31°-45°, 46°-60°, $> 60°$). Aspect was divided into 9 categories (flat, NNW, NNE, ENE, ESE, SSE, SSW, WSW, WNW). Vegetation was separated into 9 types (see Study Area for description). Distance to permanent water and

distance to main roads were arranged into 8 intervals (0 - 50 m, 50 - 100 m, 101 - 300 m, 301- 500 m, 500 - 750 m, 750 m -1 km, 1km - 1.5 km, and > 1.5 km). Because escape terrain is considered an important parameter aiding in predator avoidance and evasion for bighorn sheep (Geist 1971), it was defined as areas having slopes > 30° (Fairbanks et al. 1987, Tilton and Willard 1982). Distance from escape terrain was divided into the same intervals as distance to permanent water and main roads. Use was determined by telemetry and visual locations.

Analytical Procedures

For each habitat variable, a chi-square test was used to determine distributional differences among ungulates. To assess spatial overlap, the study area was divided into 25 ha (500 m X 500 m) cells (Figure 7). The number of grid cells common to 2-species pairs was used to determine the minimum percent overlap (Porter and Church 1987, Wood et al. 1989, Fritzen 1995). Spatial overlap of one species by another was relative to the number of cells occupied by the other. For instance, if bighorn sheep occupied 100 cells, horses 50, and there were 25 cells common to each, bighorn sheep overlapped horses 50% and horses overlapped sheep 25%.

Seasonal Diets

Field Procedures

Pellet groups observed to be dropped by bighorn sheep and mule deer were collected within 1-48 hrs after defecation. The time delay was sometimes necessary to avoid



Figure 7. Grid cells overlaying the Pryor Mountain Study Area used to assess spatial overlap among bighorn sheep, mule deer, and feral horses during winter 1993 - summer 1995.

behavioral disturbance. Entire, or nearly entire, pellet groups were collected for bighorn sheep and mule deer; only one pellet from each fecal deposit from horses was collected. Samples were air-dried before being analyzed by an independent laboratory (Wildlife Habitat Lab, Washington State University). Two composite samples, each containing pellet groups from 10-20 individuals of the same species, were collected during winter, spring, summer, and fall during 1993, winter, spring, and fall during 1994, and winter and summer 1995.

Diet composition was determined using microhistological techniques to identify epidermal fragments to species when possible; otherwise, identification was made to the most detailed level possible (e.g., genus). Eight slides and 25 views per slide were used to determine percent diet composition. Nomenclature of all dietary items followed Scott and Wasser (1980).

Analytical Procedures

Food habits of each species were presented seasonally as percent occurrence by plant species or genera within 4 major forage classes or groups (grasses, forbs, browse, and other). Grasses included grasses and grass-like plants; forbs were non-woody, non-grass or grass-like plants; browse included leaves, current annual growth, buds and stem tissues from trees, shrubs, and half-shrubs; and, other included unknown items. For each season, comparisons of each forage class between years was performed using a Wilcoxon 2-sample test if 2 years were represented and a Kruskal-Wallis test if 3 years were represented. Only major food items ($\geq$ 3%) were used as data for each comparison. If no

differences existed, the data were pooled to represent annual food habits.

Interspecific similarity of diets was determined using Morista's (1959) similarity index as modified by Hardin (1966). This was not a statistical test but yielded the percent overlap in the diet. Dietary overlap of > 50% during any season was considered substantial.

Behavioral Interspecific Interactions

Field Procedures

An attempt was made to observe each marked animal and its associates twice per season, once during morning and once during afternoon hours. Randomly chosen days within a season and randomly chosen individual radiocollared animals were selected for observation. Observations of horses were conducted by chance. An observation consisted of a 1-hour session during which behavior (feeding, bedded, standing, moving) was recorded every 5 minutes for both the focal animal and the majority (> half of the group) of animals present. Observations were made using a 15-60 X spotting scope or 7-21 X 50 binoculars. During each session, the number of hetero- and conspecifics visible in the area, estimated distance of hetero- and conspecific groups from the focal group, estimated distances moved at 15-minute intervals by the focal animal and the group associated with it, and social responses (dominant, submissive, or indifferent) of an encounter (i.e., when different species were in close proximity (<200 m) to one another) were noted. Dominant behavior included displays, such as head bowing by horses or horn displays by sheep, chases, or usurping of an area. Submissive behavior was characterized

by vacating an area with the approach of another species or a change of behavior when near another species; for instance, walking slowly until within a given distance of a heterospecific individual or group and running past until at a tolerable distance, then returning to a walk. Indifference was recorded when neither species exhibited dominant or submissive behavior.

Analytical Procedures

Behavioral data by season were pooled across years and percentages of different categories of behavior recorded were presented by hour and season. An analysis of variance was performed to assess differences in timing of interspecific behaviors. Data were arcsine-square root transformed to achieve homogeneity of variance, and hours were used as replicates for both the morning and afternoon time periods.

Population Structure and Population Size Estimation

Field Procedures

Population structure was described in terms of the numbers of young of the year (YOY; lambs, fawns, or foals) and numbers of adult males (rams, bucks, or stallions) per 100 adult females (ewes, does, or mares) observed from ground or aerial surveys. Age and sex ratios were obtained during the first 3 flights of winter population surveys during 1993-1994, 1994-1995, and 1995-1996. The ratio of YOY:100 adult females during winter was used as an indicator of recruitment of young to adult population based on the assumption that no differential mortality of young occurred during the remainder of winter

or spring.

To estimate population sizes, I counted numbers of marked and unmarked animals observed during aerial transect surveys (Figure 8) flown in a Hiller 12-E or a Bell 47 helicopter during winter, 1993-1995 (Table 5), with each transect replicated 5 times. Four flights were conducted during January and February 1996, in a Hiller 12-E or a Hughes 500C. These included 2 complete area coverage surveys and 2 replicate transect flights.

In all years, transects varied in length (0.8 km - 10.8 km), were separated by approximately 0.8 km, and were typically flown during morning hours (Table 5). Transects were flown ≥ 40 m above the ground and at 40 - 60 km/hr using geographic landmarks and compass bearings for guidance. The date, time, species, number of animals, number of marked animals, the identification of each marked animal, sex, age (adult, juvenile, or YOY), and location were noted during each survey. To prevent double counting, bighorn sheep and mule deer groups were hazed in the opposite direction of the progression of the survey; feral horses were not intentionally disturbed. During surveys conducted in the winters of 1992-1993 and 1993-1994, locations were recorded on 1:24000 USGS topographic maps using landmarks and the flight path to determine locations. During the winters of 1994-1995 and 1995-1996, locations were recorded using a Garmin 95XL™ GPS unit (Garmin Inc., Lenexa, KS).

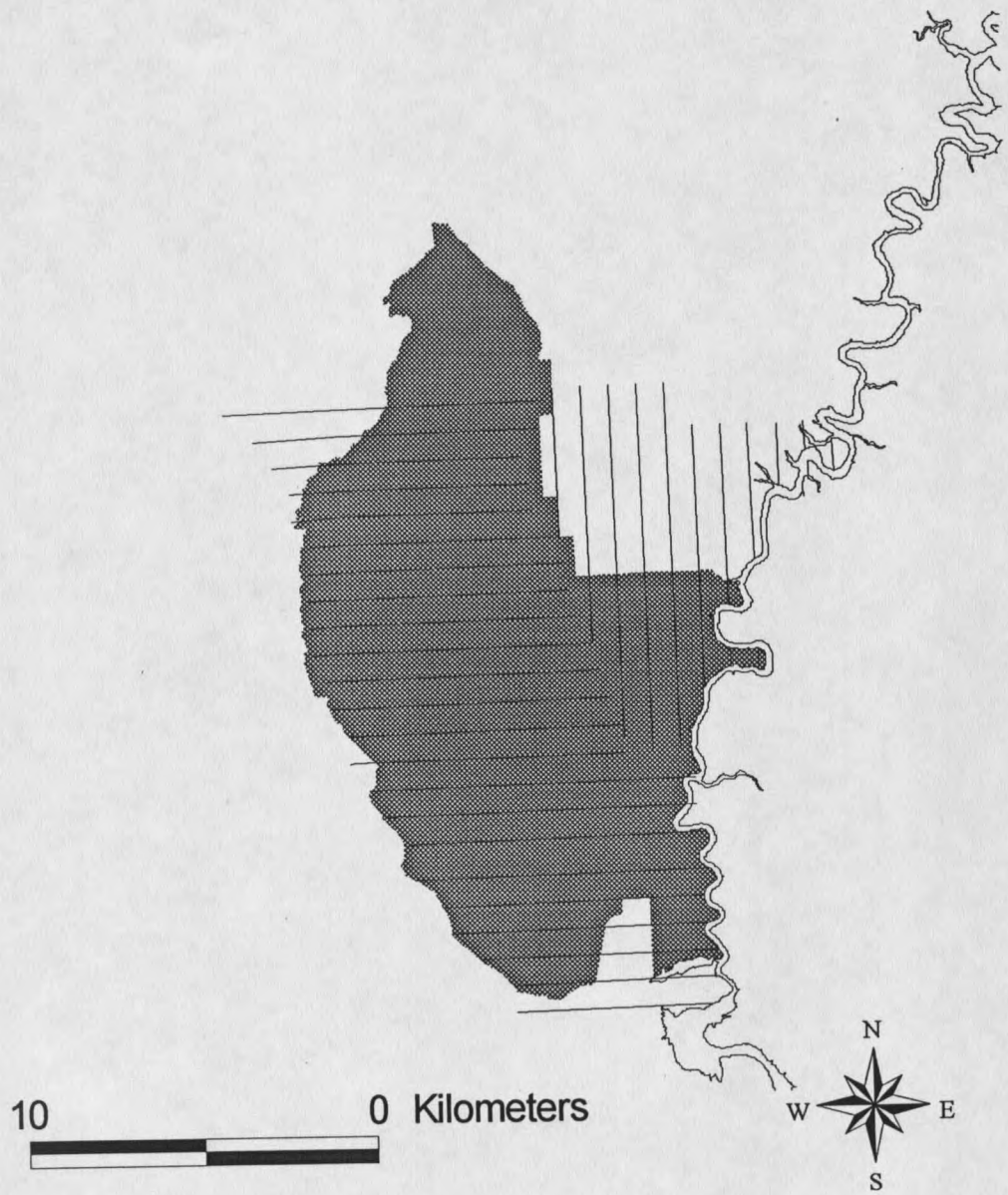


Figure 8. Transects flown during winter population surveys in relation to the Pryor Mountain Wild Horse Range (shaded area).

Table 5. Date, time, pilot, aircraft, flight time, and type of coverage used during population surveys conducted on the Pryor Mountain Study Area during winters of 1993-1996.

SURVEY YEAR	DATE	PILOT	AIRCRAFT	FLIGHT TIME	COVERAGE
1993	11 FEB	HAWKINS	HILLER	0700-1200	TRANSECT
1993	17 FEB	HAWKINS	HILLER	1230-1630	TRANSECT
1993	22 FEB	HAWKINS	HILLER	0800-1100	TRANSECT
1993	1 MAR	HAWKINS	HILLER	0745-1230	TRANSECT
1993	8 MAR	HAWKINS	HILLER	0745-1115	TRANSECT
1994	29 NOV	IVERSON	BELL 47	0815-1345	TRANSECT
1994	6 DEC	IVERSON	BELL 47	0800-1315	TRANSECT
1994	13 DEC	IVERSON	BELL 47	0745-1245	TRANSECT
1994	11 FEB	IVERSON	BELL 47	0730-1100	TRANSECT
1994	17 MAR	IVERSON	BELL 47	0700-1130	TRANSECT
1995	24 FEB	IVERSON	BELL 47	0845-1330	TRANSECT
1995	1 MAR	IVERSON	BELL 47	0900-1415	TRANSECT
1995	3 MAR	IVERSON	BELL 47	0845-1215	TRANSECT
1995	26 MAR	SANFORD	HILLER	1000-1400	TRANSECT
1995	6 APR	SANFORD	HILLER	0915-1345	TRANSECT
1996	23 JAN	SANFORD	HILLER	0930-1515	TOTAL AREA
1996	6 FEB	SANFORD	HILLER	0815-1315	TOTAL AREA
1996	13 FEB	SANFORD	HUGHES	0745-1130	TRANSECT
1996	17 FEB	SANFORD	HUGHES	0745-1100	TRANSECT

Analytical Procedures

A Wilcoxon 2-sample test was used to compare median age ratios for bighorn sheep and mule deer populations against other populations described as increasing, and therefore thought to have adequate nutrition (Keating 1982). Comparison of the feral horse population with other feral horse populations was made using population growth rates, as

age and sex ratios were not common statistics reported for this species. While age ratios for bighorns and deer or population growth rates for horses were the only data available to use as a measure of adequate nutrition, it should be noted the relationship between these factors is not known. Other possible methods of assessing this relationship include urinary indicators of nutritional status (DelGiudice 1995; however, see Saltz et al. 1995), measurements of kidney fat, marrow fat, and blood related indices (Harder and Kirkpatrick 1996).

Estimates of population size were calculated using the joint hypergeometric maximum likelihood estimator (Bartmann et al. 1987, Bear et al. 1989, White and Garrott 1990, Neal et al. 1993, White 1996) from the NOREMARK program (White 1996). If the minimum number known alive (MNKA) was greater than the lower confidence interval bound, the MNKA was used as the lower bound. This method is a modified form of the Lincoln-Peterson mark-recapture model based on the hypergeometric distribution (Chapman 1951, Chapman 1952). The model has 5 assumptions (White and Garrott 1990, White 1996): 1) marking of animals is by simple random sampling without replacement; 2) the population is closed, both geographically and demographically; 3) equal sighting probability for each animal, but sighting probabilities can vary from one survey to another; 4) the correct number of marked animals is known; and, 5) double counting does not occur.

Assumptions were reasonably met in the study. Radiocollared bighorn sheep did not have consistent associations with other radiocollared bighorn sheep, and I assumed this same random association extended to the entire population. Marked bighorn sheep,

therefore, were considered to represent a random sample. Radiocollared mule deer live in matriarchal family and bachelor groups (Mackie et al. 1982) and were assumed to be marked in a simple random fashion as no matriarchal groups had > 1 radiocollar.

The process used to "mark" feral horses violated the assumption of simple random sampling with replacement. Feral horses have a patriarchal social system (Klingel 1974), and in some cases more than one "marked" animal occurred in a social unit, indicating simple random sampling with replacement. Given the unique markings of the feral horses and low sightability (LeResche and Rausch 1974, Bartmann et al. 1986), the MNKA was determined during ground surveys (Frei et al. 1979).

In winter, bighorn sheep and mule deer populations were assumed to be both demographically and geographically closed. No lambing occurred during this time of year, and no known deaths of bighorn sheep were recorded. Geographically, bighorn sheep show strong site fidelity (Geist 1971) and, based on radiocollared animals, did not disperse to new areas during winter. Mule deer were not fawning at this time of year, and even though some carcasses were discovered during the winter, these were few in number and not likely to significantly affect the population estimation. The winter range for mule deer was well defined by climatic, vegetative, and topographic features which limited mule deer movements to a given area, thereby providing geographic closure.

Sightability is known to affect population estimation of large mammals (Samuel et al. 1987, Neal et al. 1993, Bodie et al. 1995). Equal sighting probabilities were assumed to exist among animals but not confirmed. Bighorn sheep favor steep terrain in areas with high visibility (Geist 1971, Wakelyn 1987), and locations in which bighorn sheep were

observed were represented by such features. Likewise, in this study, mule deer favored and were observed occupying outcropping terrain in association with curlleaf mountainmahogany or juniper.

Prior to surveys in each year, I determined the number of marked animals available by days or weeks of ground coverage of the study area using telemetry and visual reconnaissance. Marked animals with non-functioning radiocollars that were not observed during this period were not included in marked samples.

RESULTS

Seasonal Habitat Use

Bighorn Sheep

Bighorn sheep were located at lower elevations (< 1500 m) yearround (Figure 9), with a majority of the locations occurring between 1300 - 1400 m. Less steep slopes (< 31°) contained a majority (> 75%) of locations during each season examined (Figure 10), and only a small percentage of all locations were recorded in very steep terrain. Eastern aspects were used most frequently in all seasons (Figure 11) followed by southern aspects; completely flat aspects were used least. Locations were most often in the mountainmahogany and/or juniper vegetative type during all seasons (Figure 12). Little use of agricultural and desert shrubland was noted. Distance of locations from permanent water varied (Figure 13), but consistent peaks at distances > 500 m were common for each season. Bighorns were often observed along the roads, but frequency of occurrence related to distance to main roads (Figure 14) varied by season and more than 50% were > 200 m during all seasons. Distribution of locations in relation to escape terrain (Figure 15) indicated more than 50% of locations were within 400 m of cliffs or steep slopes regardless of season. However, more than 20% of all seasonal locations occurred at distances > 500 m from escape terrain.

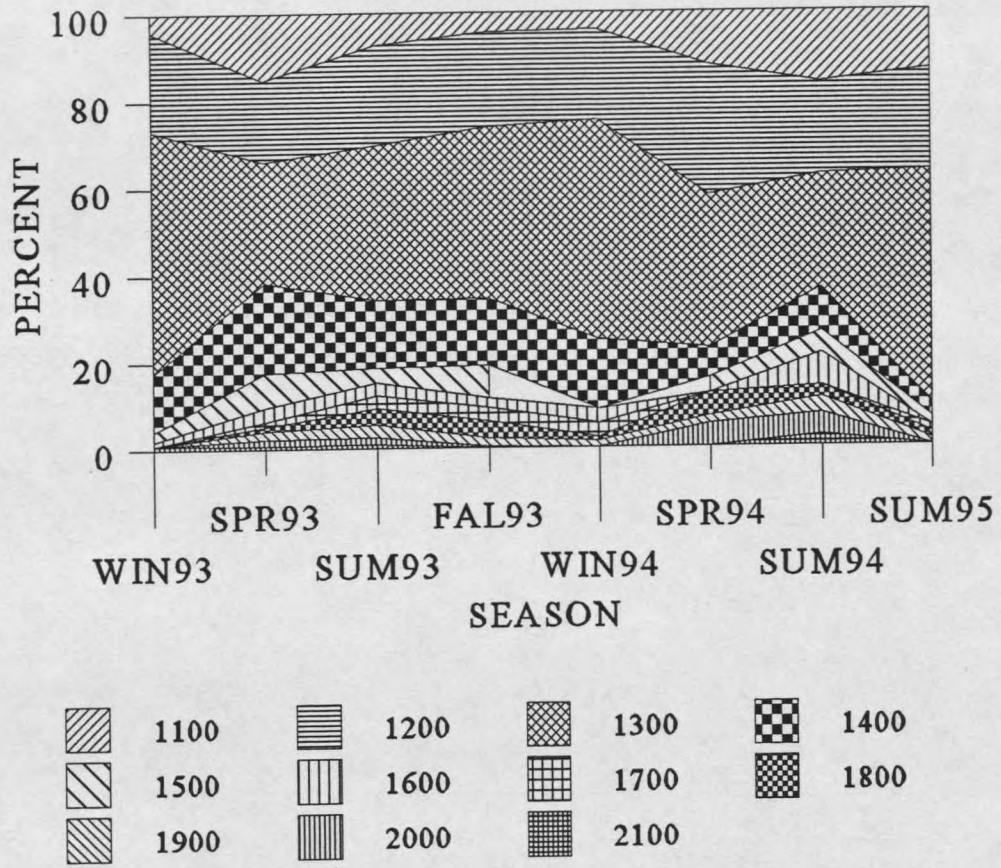


Figure 9. Percent of all locations of bighorn sheep that occurred at various elevations (< 1100 m - > 2100 m) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

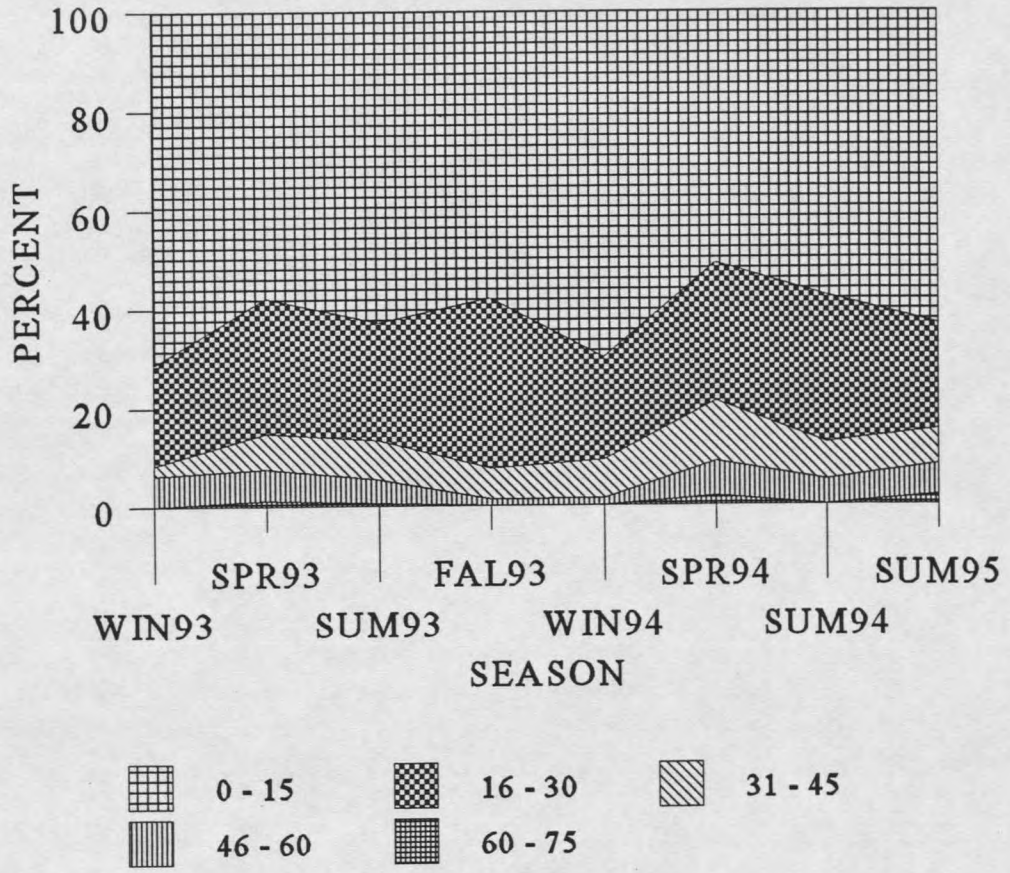


Figure 10. Percent of all locations of bighorn sheep that occurred at various slopes (0 - 60°+) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

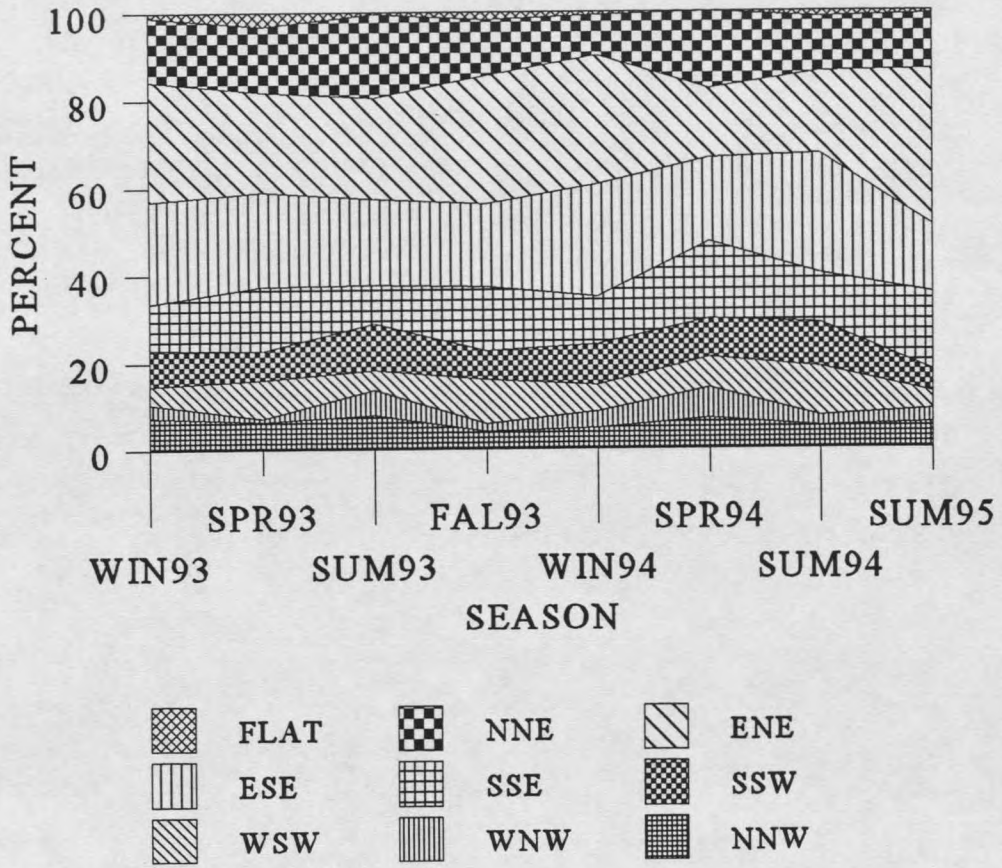


Figure 11. Percent of all locations of bighorn sheep that occurred on various aspects (flat, NNE, ENE, ESE, SSE, SSW, WSW, WNW, NNW) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

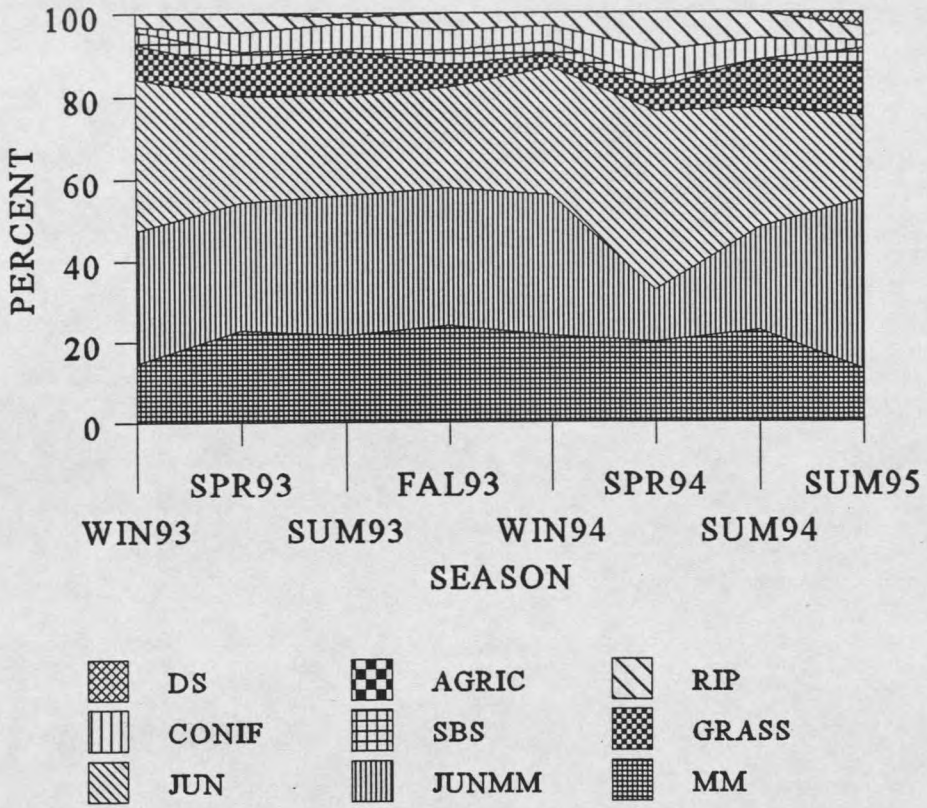


Figure 12. Percent of locations of bighorn sheep that occurred in various vegetative types (MM = Mountain Mahogany Woodland, JUNMM = Juniper-Mountain Mahogany Woodland, GRASS = Grassland, SBS = Sagebrush Steppe, CONIF = Coniferous Woodland, RIP = Riparian, and AGRIC = Agricultural Land) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

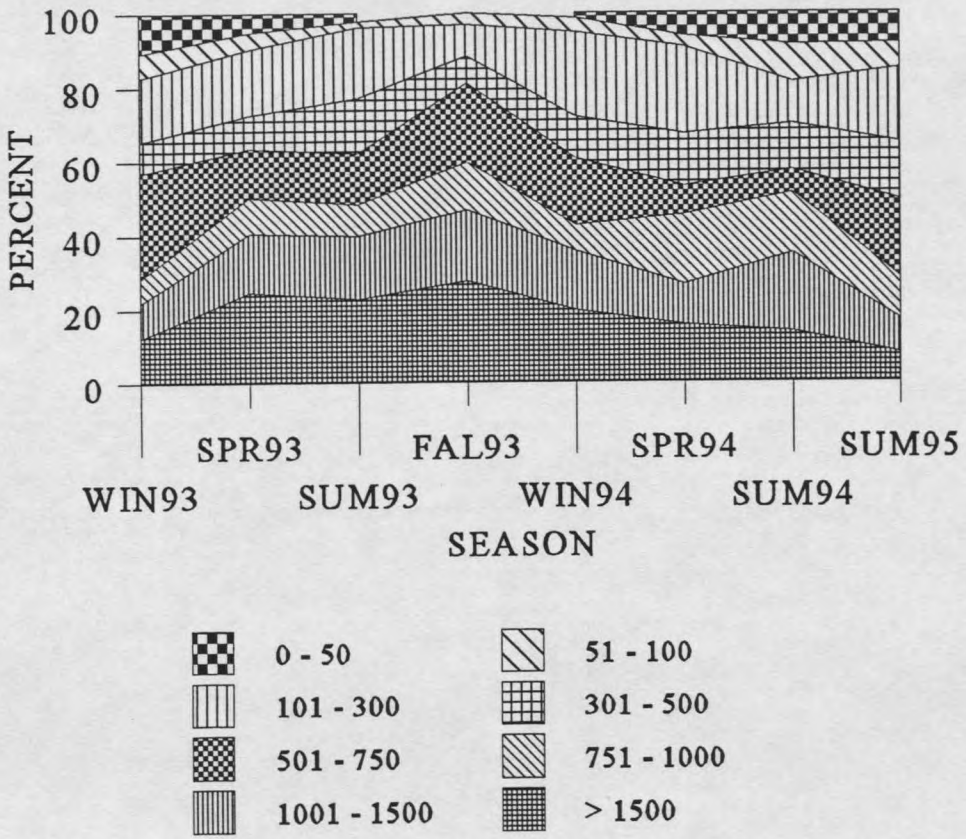


Figure 13. Percent of all locations of bighorn sheep that occurred at various distances to permanent water (0 - 50 m, 51 - 100 m, 101 - 300 m, 301 - 500 m, 501 - 750 m, 751 - 1000 m, 1001 - 1500 m, > 1500 m) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

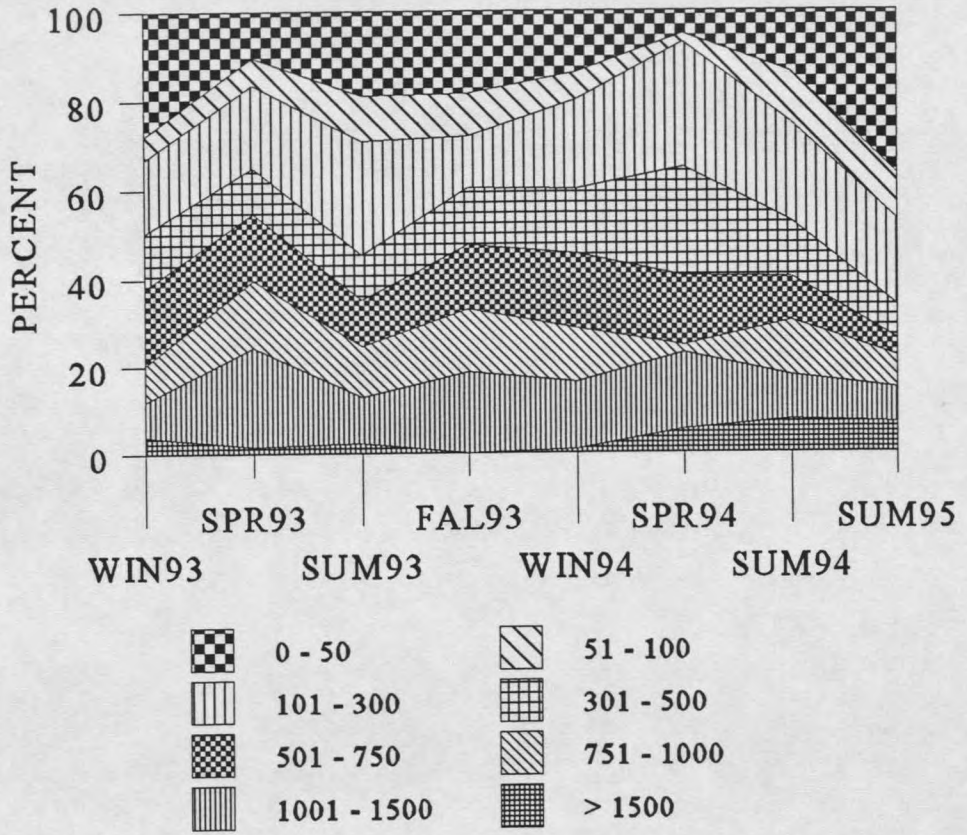


Figure 14. Percent of all locations of bighorn sheep that occurred at various distances to main roads (0 - 50 m, 51 - 100 m, 101 - 300 m, 301 - 500 m, 501 - 750 m, 751 - 1000 m, 1001 - 1500 m, > 1500 m) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

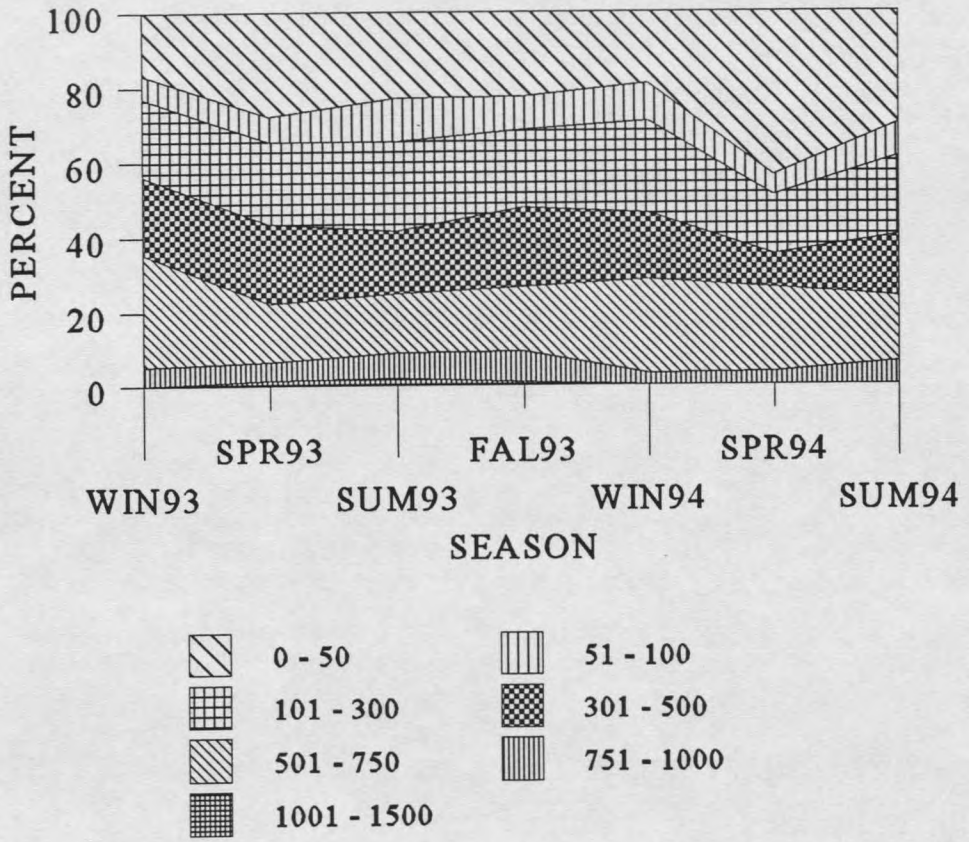


Figure 15. Percent of all locations of bighorn sheep that occurred at various distances to escape terrain (0 - 50 m, 51 - 100 m, 101 - 300 m, 301 - 500 m, 501 - 750 m, 751 - 1000 m, 1001 - 1500 m, > 1500 m) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

Mule Deer

Mule deer occurred over a wide range of elevations (Figure 16), but were most often found at elevations < 1500 m on the PMSA. More than 80% of all locations of mule deer were on slopes < 31°; and slopes > 45° were seldom used (Figure 17). Eastern, southern, and northeastern aspects (Figure 18) were used most regardless of season and completely flat aspects were seldom used. Within the study area, juniper and/or juniper-mountainmahogany vegetation types were used often, as were mountainmahogany, coniferous woodlands, sagebrush steppe, and desert shrubland (Figure 19). Use changed by season with the juniper and mountainmahogany complexes used most in winter and the coniferous woodlands, sagebrush and juniper used in summer. Distance to permanent water (Figure 20) varied depending upon season, but deer appeared to occur at greater distances from water during winter and spring. A majority (> 50%) of locations during fall were within 200 m of main roads (Figure 21). Otherwise, distance to main roads varied depending upon season.

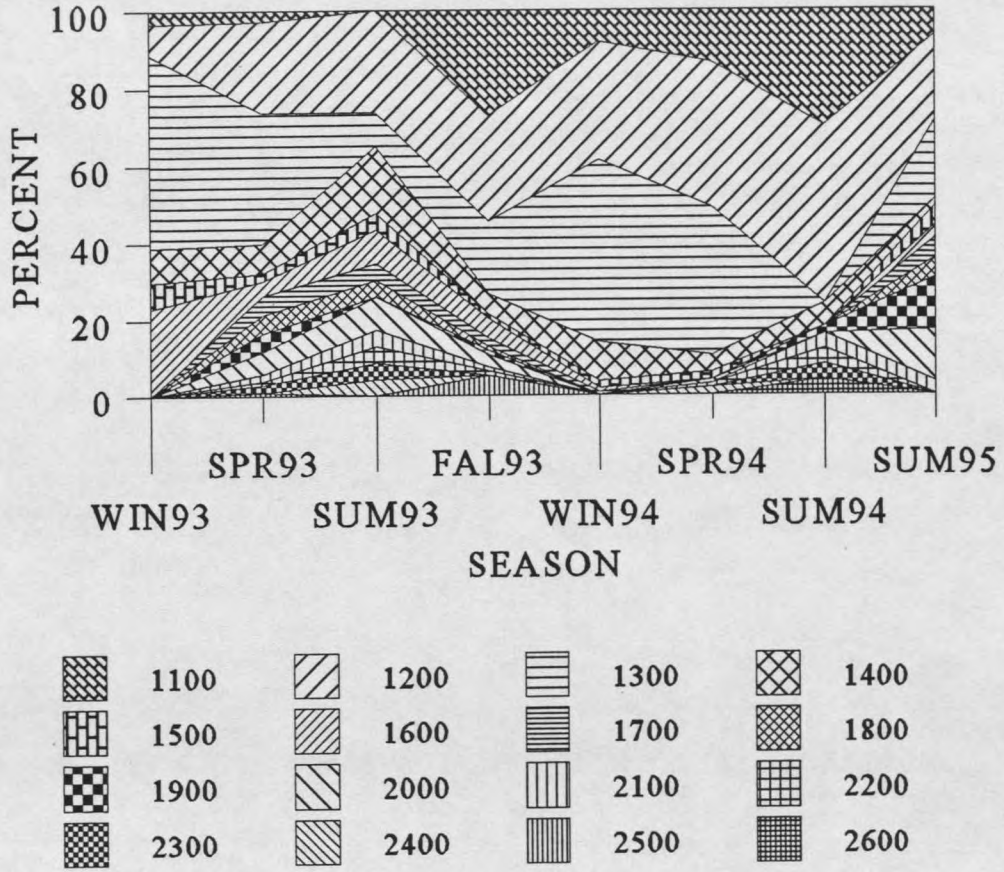


Figure 16. Percent of all locations of mule deer at various elevations (< 1100 - > 2600 m) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

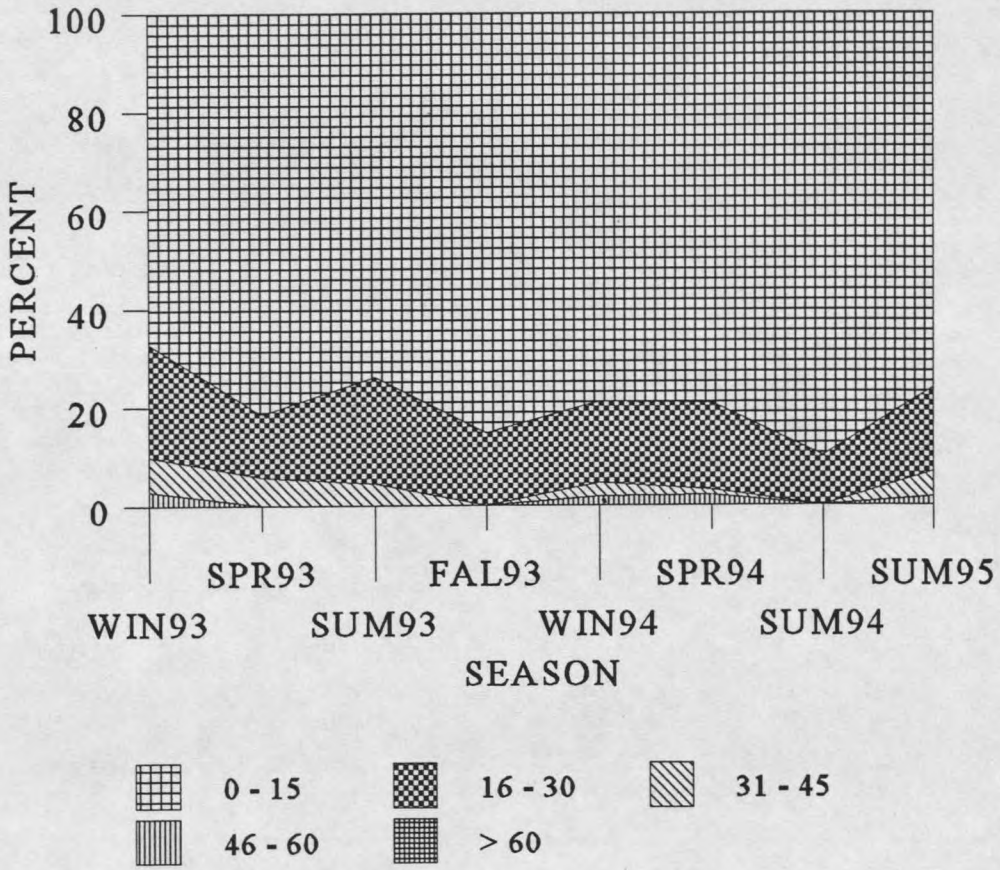


Figure 17. Percent of all locations of mule deer at various slopes (0 - 15°, 16 - 30°, 31 - 45°, 45 - 60°, > 60°) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

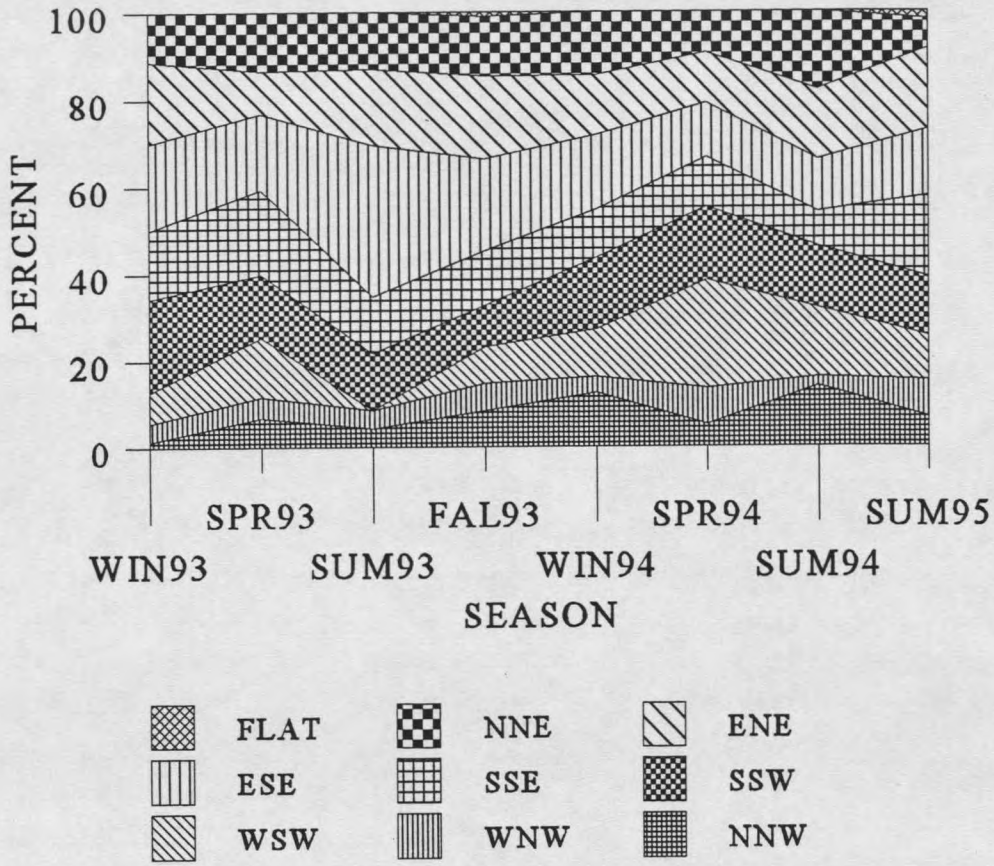


Figure 18. Percent of all locations of mule deer at various aspects (flat, NNE, ENE, ESE, SSE, SSW, WSW, WNW, NNW) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

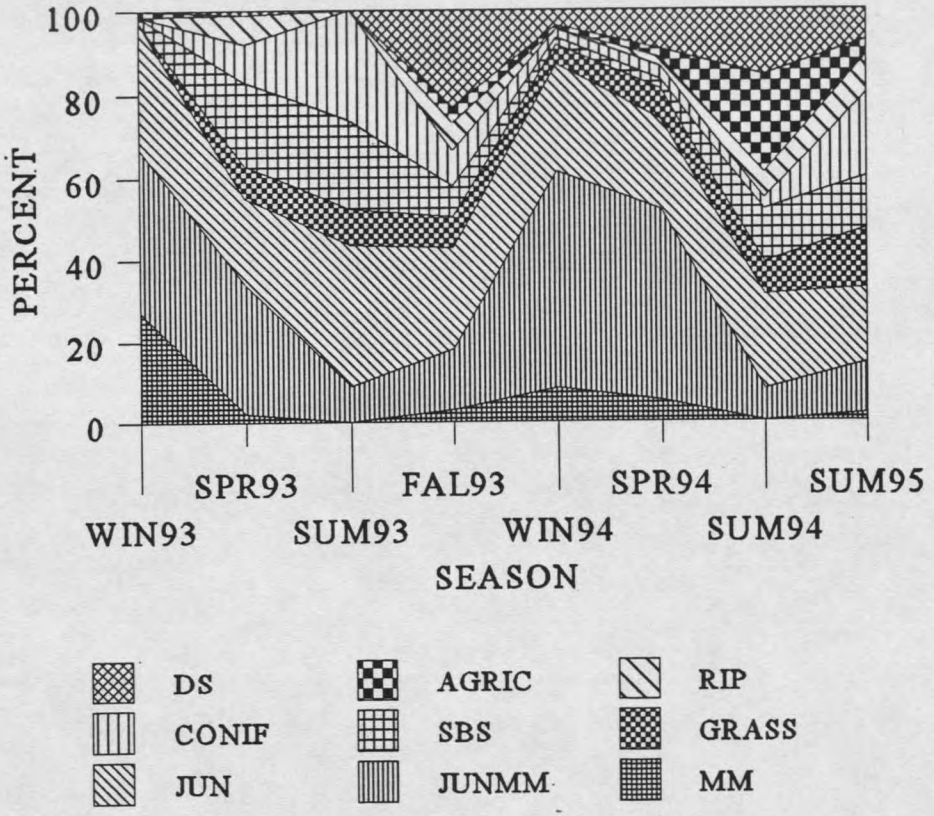


Figure 19. Percent of all locations of mule deer in various vegetation types (MM = Mountain Mahogany Woodland, JUNMM = Juniper-Mountain Mahogany Woodland, GRASS = Grassland, SBS = Sagebrush Steppe, CONIF = Coniferous Woodland, RIP = Riparian, and AGRIC = Agricultural Land) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area. .

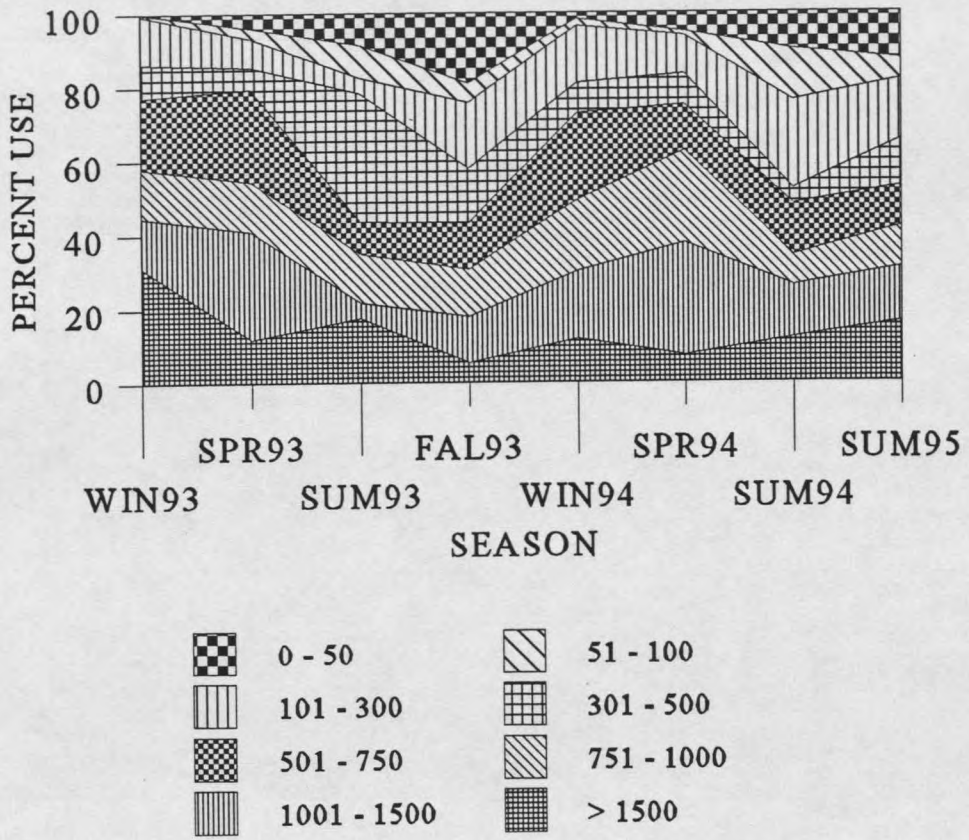


Figure 20. Percent of all locations of mule deer at various distances to permanent water (0 - 50 m, 51 - 100 m, 101 - 300 m, 301 - 500 m, 501 - 750 m, 751 - 1000 m, 1001 - 1500 m, > 1500 m) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

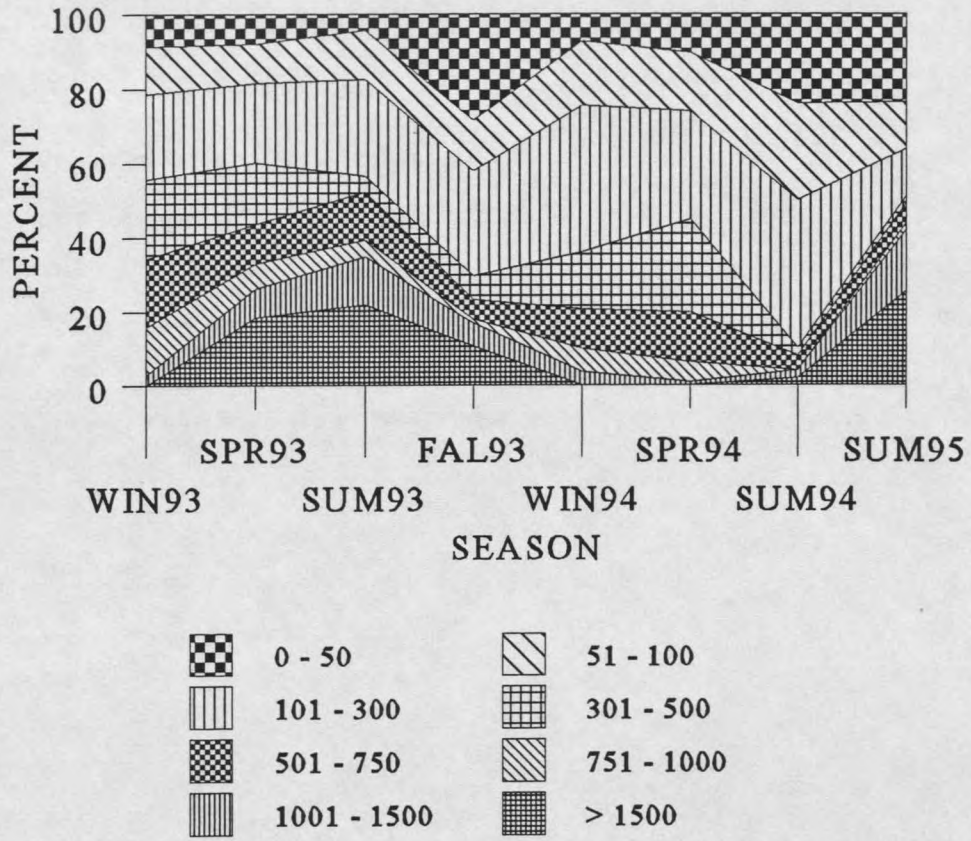


Figure 21. Percent of all locations of mule deer at various distances to main roads (0 - 50 m, 51 - 100 m, 101 - 300 m, 301 - 500 m, 501 - 750 m, 751 - 1000 m, 1001 - 1500 m, > 1500 m) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

Feral Horses

Frequency distribution of feral horses at various elevations was bimodal (Figure 22). Most locations were at lower elevations during all seasons, but important use of upper elevations occurred in summer. Most horse locations (> 75%) were on slopes ≤ 15° during any season (Figure 23). No use of slopes > 45° was observed. Although all aspects were used, eastern, southern, and northeastern aspects were used most (Figure 24); completely flat aspects were seldom exploited. Juniper, grassland, and desert shrubland were all used a majority of the time, differing by season (Figure 25). Regardless of season, juniper was the vegetative type used most and riparian and agricultural areas were used least. The majority (> 50%) of locations were at distances > 500 m from permanent water during each season (Figure 26), and the proportion of locations at various distances to main roads (Figure 27) varied by season but appeared to decrease with distance beyond 750 m.

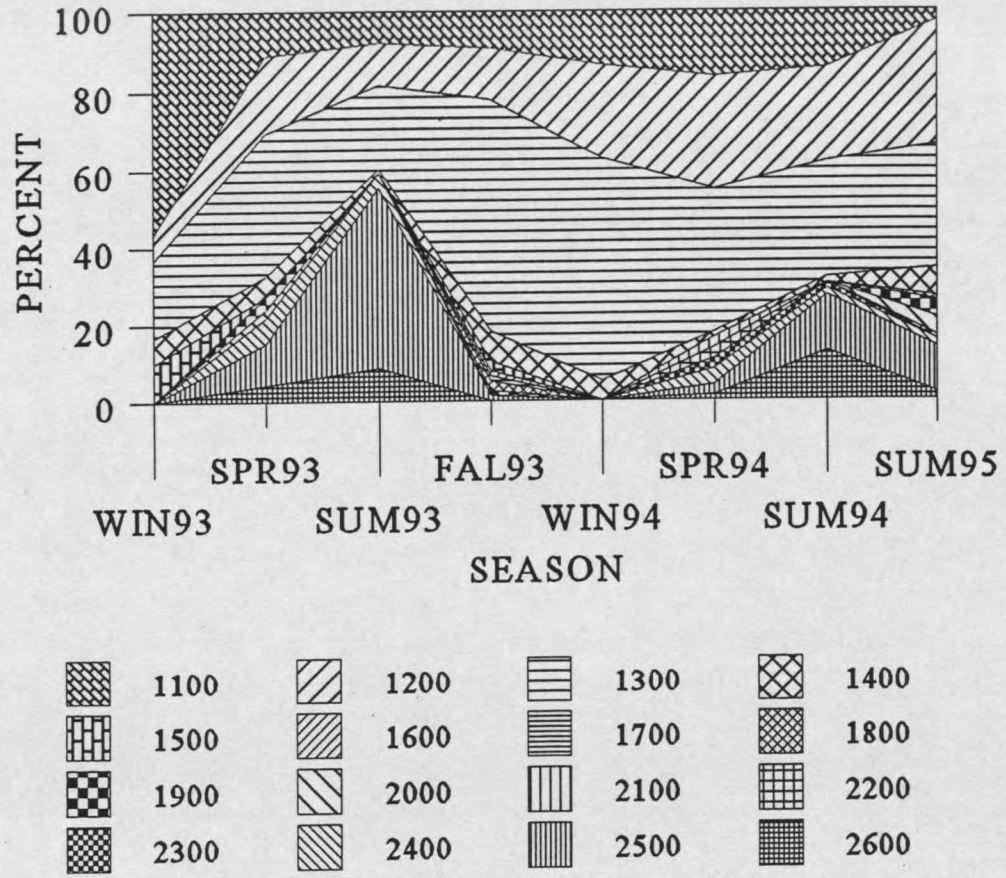


Figure 22. Percent of all locations of feral horses at various elevations (<1100 - > 2600 m) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

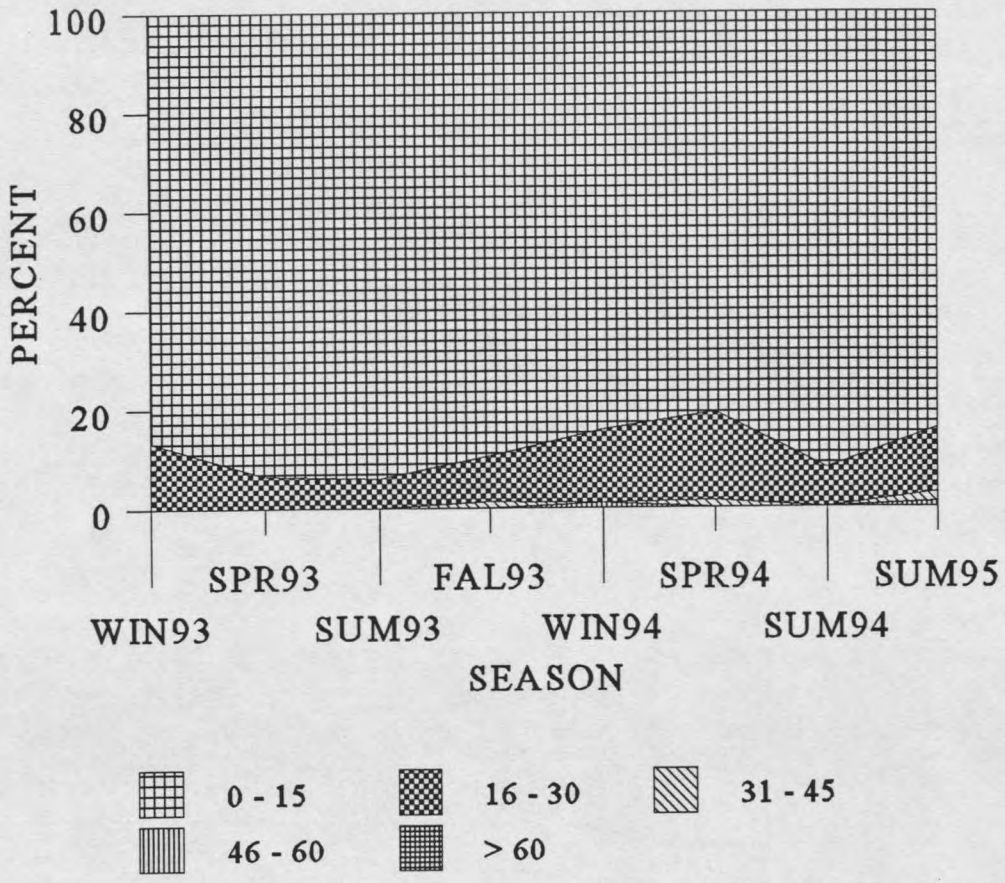


Figure 23. Percent of all locations of feral horses at various slopes (0 - 15°, 16 - 30°, 31 - 45°, 45 - 60°, > 60°) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

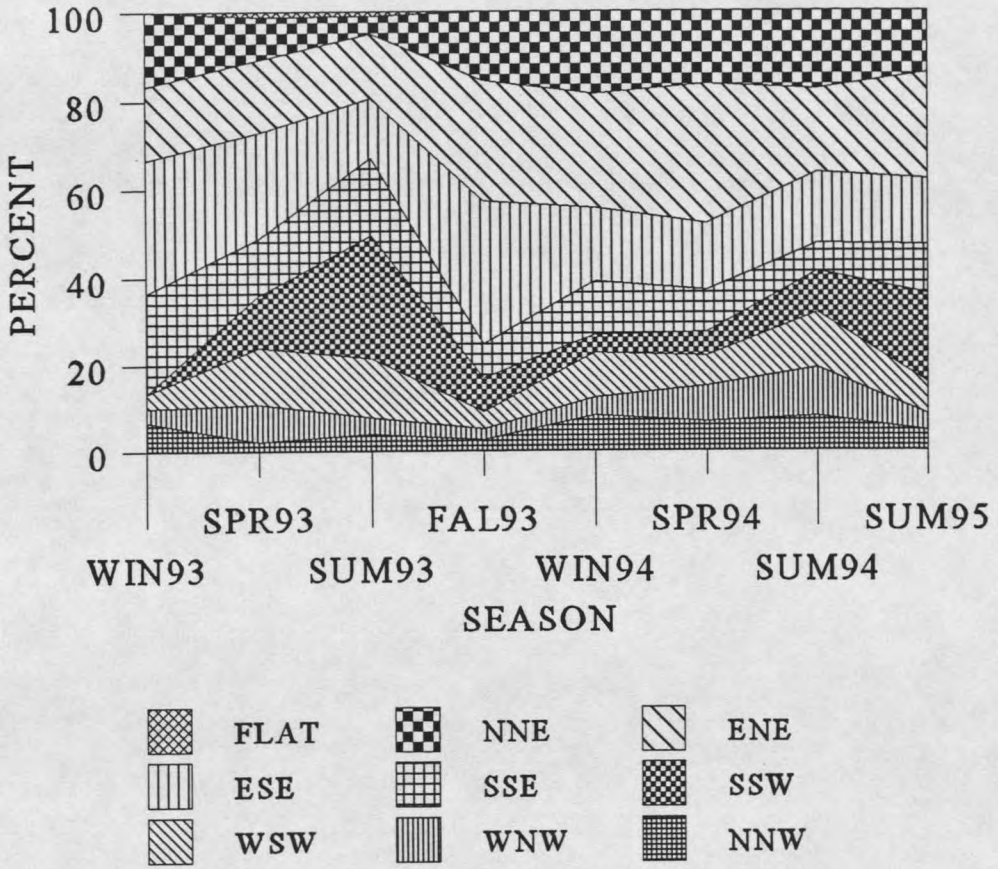


Figure 24. Percent of all locations of feral horses at various aspects (flat, NNE, ENE, ESE, SSE, SSW, WSW, WNW, NNW) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

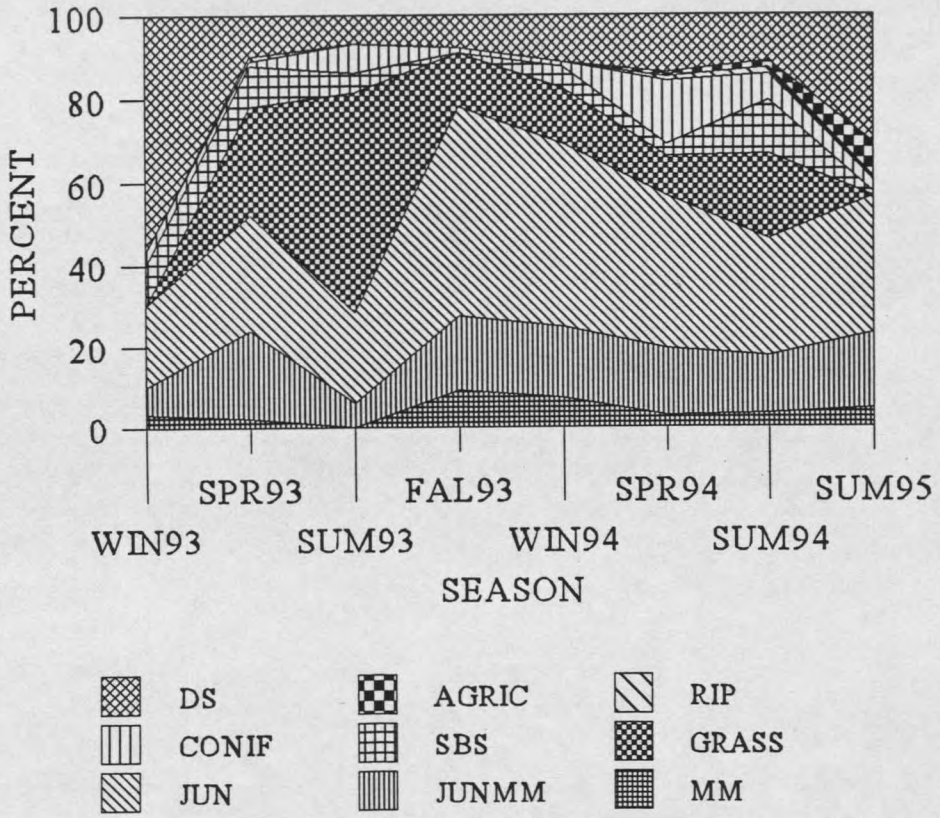


Figure 25. Percent of all locations of feral horses that occurred in various vegetation types (MM = Mountain Mahogany Woodland, JUNMM = Juniper-Mountain Mahogany Woodland, GRASS = Grassland, SBS = Sagebrush Steppe, CONIF = Coniferous Woodland, RIP = Riparian, and AGRIC = Agricultural Land) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area..

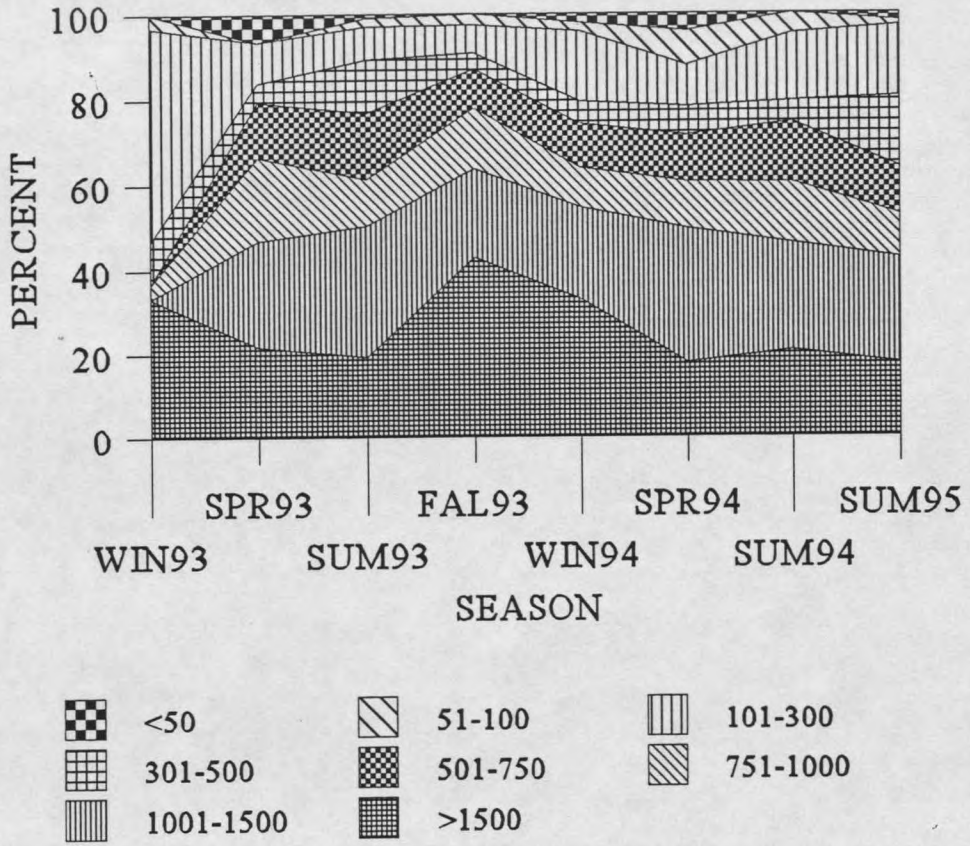


Figure 26. Percent of all locations of feral horses that occurred at various distances to permanent water (0 - 50 m, 51 - 100 m, 101 - 300 m, 301 - 500 m, 501 - 750 m, 751 - 1000 m, 1001 - 1500 m, > 1500 m) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

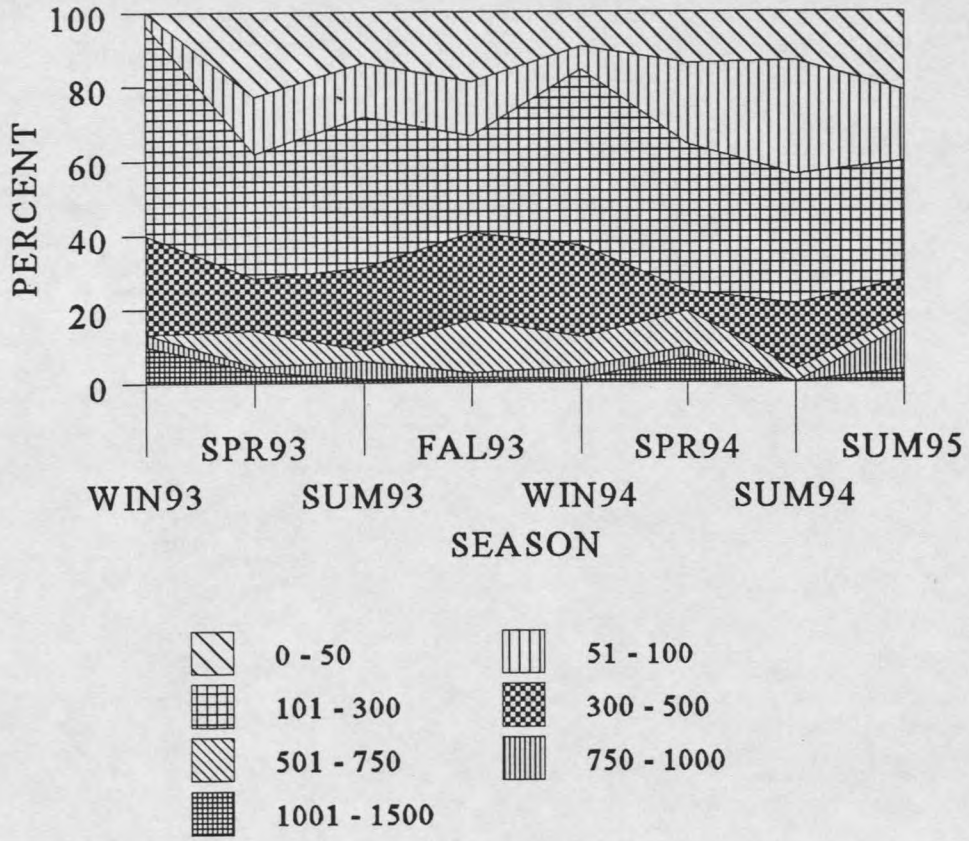


Figure 27. Percent of all locations of feral horses that occurred at various distances to main roads (0 - 50 m, 51 - 100 m, 101 - 300 m, 301 - 500 m, 501 - 750 m, 751 - 1000 m, 1001 - 1500 m) by season and year, winter 1993 - summer 1995, in the Pryor Mountain Study Area.

Interspecific Habitat and Spatial Relationships

Except for elevation and slope in winter 1993, and aspect in fall 1994, seasonal use of all other habitat components significantly differed among species (Appendix, Table 23). The spatial overlap of one species on another varied by season (Table 6). Spatial overlap of bighorns on horses was least in spring and summer, and significant during fall; overlap of horses on sheep was most during fall and least during summer. Mule deer spatially overlapped bighorns most during winters and least during summers, and bighorns spatially overlapped deer most during fall and least during spring and summer. Deer overlapped horses and horses overlapped deer spatially most in fall and not at all in summer 1993 and 1994.

Table 6. Percent spatial overlap of ungulate species combinations by year and season in the Pryor Mountain Study Area determined using 25-ha cells.

		SPECIES PAIRS					
YEAR	SEASON	BIGHORNS OVERLAP HORSES	BIGHORNS OVERLAP DEER	DEER OVERLAP HORSES	HORSES OVERLAP BIGHORNS	DEER OVERLAP BIGHORNS	HORSES OVERLAP DEER
1993	WINTER	23.0	29.3	0	5.8	23.1	0
1993	SPRING	14.5	9.1	14.5	6.9	6.0	10.4
1993	SUMMER	4.8	4.3	0	2.0	1.0	0
1993	FALL	60.6	20.6	54.5	25.6	16.7	29.0
1994	WINTER	29.2	27.4	33.3	25.5	30.9	25.8
1994	SPRING	5.0	3.6	25.0	6.1	6.1	17.9
1994	SUMMER	13.2	2.8	0	10.4	2.1	0
1995	SUMMER	46.2	23.9	15.4	26.1	12.0	17.4

Seasonal Diets

Bighorn Sheep

Tissues of 50 genera and 24 species of plants were identified in bighorn sheep pellet groups (Appendix, Table 17). Major (occurring ≥ 3%) dietary items varied from season to season (Table 7). Winter, spring, summer, and fall were represented by 12, 11, 9, and 8 major species, respectively. The only forbs eaten seasonally as major items were yucca (Yucca glauca) and wallflowers or gromwell (Erysimum spp. and Lithospermum spp. could not be distinguished from epidermal characteristics). Winterfat and curlleaf mountainmahogany were major browse species in all seasons. Wheatgrass, needle-and-thread, and bluegrass were the major grass taxa identified in each season.

Table 7. Major plant genera or species consumed seasonally by bighorn sheep in the Pryor Mountains during 1993-1995.

WINTER	SPRING	SUMMER	FALL
Yucca glauca	Erysimum spp. /Lithospermum spp.	Ceratoides lanata	Artemisia spp.
Artemisia spp.	Artemisia spp.	Cercocarpus ledifolius	Ceratoides lanata
Ceratoides lanata	Ceratoides lanata	Salix spp./Populus spp.	Cercocarpus ledifolius
Cercocarpus ledifolius	Cercocarpus ledifolius	Agropyron spp.	Agropyron spp.
Juniperus spp.	Agropyron spp.	Festuca idahoensis	Bromus japonicus
Salix spp./Populus spp.	Festuca idahoensis	Poa spp.	Poa spp.
Agropyron spp.	Koeleria macrantha	Stipa spp.	Stipa spp.
Bromus japonicus	Poa spp.	Carex spp.	
Poa spp.	Stipa spp.		
Stipa spp.	Carex spp.		
Carex spp.			

Winter bighorn sheep diets were dominated by browse during 1993 and 1994 (Figure 28). Curlleaf mountainmahogany was most important, comprising 43.0% on average of the winter diet. Grass, primarily Agropyron spp. and Stipa spp., was the next most frequently used forage, accounting for an average of 28.4% of the winter diet. Forbs composed 7.8% of the winter diet on average.

Spring bighorn sheep diets were dominated (54% - 65%)by grasses (Figure 28), with Agropyron spp., Poa spp., Stipa spp., and Festuca idahoensis most heavily represented. Browse accounted for 19.3% of the spring diet on average, with Artemisia spp. and Cercocarpus ledifolius the major species. Forbs comprised 16.1% of the spring diet on average, with Erysimum spp./Lithospermum spp., Phlox hoodii, Erigeron spp., and unknown forbs occurring most often.

Summer diets of bighorn sheep, on average, were dominated (52.7%) by browse (Figure 28). Curlleaf mountainmahogany and winterfat were the 2 most frequently eaten browse species during all summers. Grasses represented 41.5% of the summer diet. Agropyron spp., Stipa spp., and Poa spp. were most commonly represented each summer. Forbs collectively comprised 5.8%, though most items only occurred in trace amounts.

Fall diets of bighorn sheep were also dominated (67.7%) by browse (Figure 28), specifically curlleaf mountainmahogany. Grass, primarily bunchgrass and needle-and-thread, was the second most common forage class represented. Forbs represented only 4.2% of the fall diet on average, and most species occurred only in trace amounts.

Annual difference in diet patterns were also observed. In winter, browse use changed from a high average of 93.8% in 1993 to 34.0% in 1995. Use of browse in spring almost

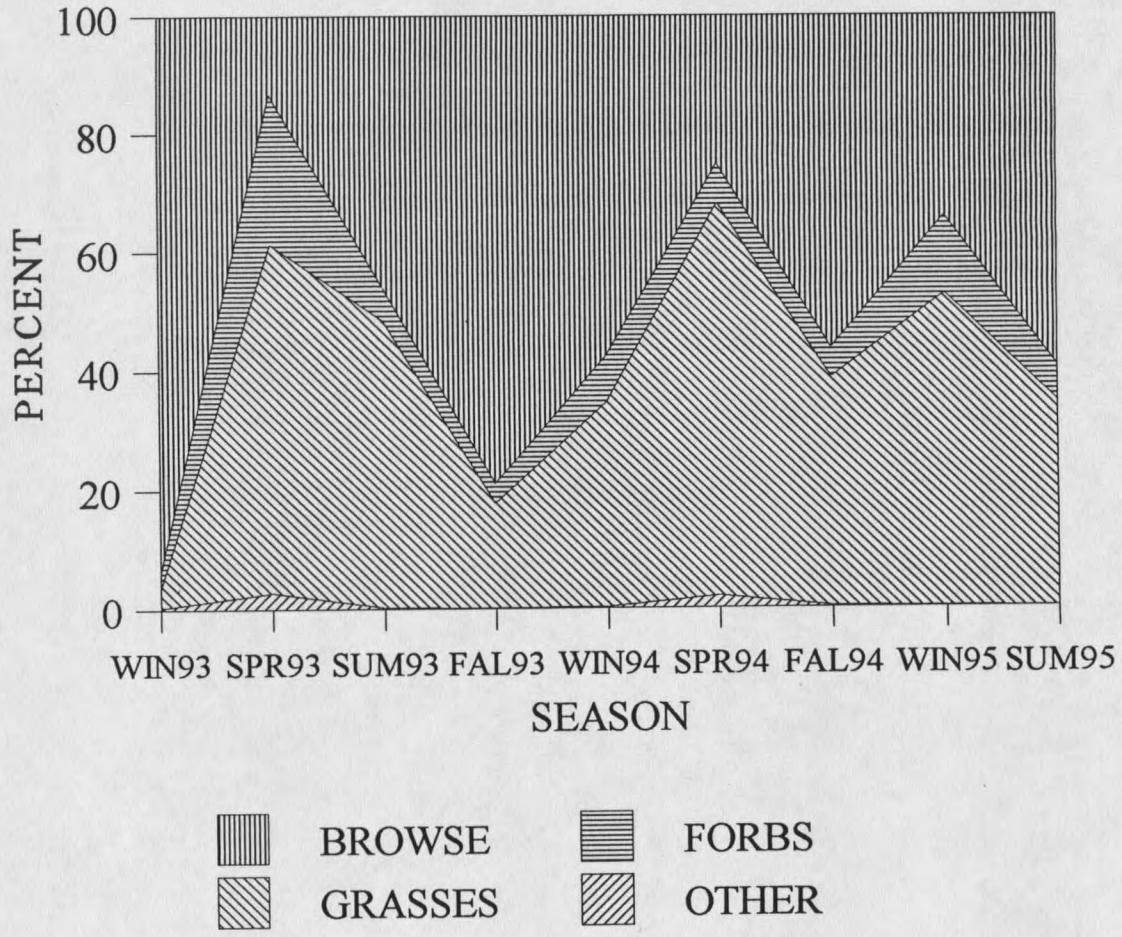


Figure 28. Percent of browse, forbs, grasses, and other items of seasonal food habits of bighorn sheep in the Pryor Mountain Study Area by season and year. Data were from microhistological analysis of epidermal fragments from fecal samples collected during 1993-1995 (see text for further description).

doubled from spring 1993 (13.3%) to spring 1994 (25.3%). Browse made up more of the diet in summer 1995 (59.5%) compared to summer 1993 (46.0%), while a difference in browse occurrence of more than 20% (79.0% to 56.5%) was observed between fall 1993 and fall 1994. The proportion of grass in winter 1993 and winter 1995 averaged 3.3% to 52.1%, respectively. Grass was represented slightly more in spring 1994 (66.0%) as compared to spring 1993 (58.6%). Grasses occurrence in the diet was slightly higher in summer 1993 (48.3%) than summer 1995 (34.6%). The proportion of grass in the fall 1993 (17.6%) was half that of fall 1994 (38.4%). Forb use in winter changed from an average of 2.7% in 1993 to 13.0% in 1995. Forbs were represented less during spring 1993 (25.4%) compared to spring 1994 (6.7%). Forb use remained relatively consistent in each year during summer (5.6%-5.9%) and fall (3.4%-5.0%).

Mule Deer

There were 58 plant genera and 23 species identified as food items of mule deer (Appendix, Table 18). Major mule deer dietary items varied from season to season (Table 8). Winter, spring, summer, and fall were represented by 3, 11, 15, and 3 major species, respectively. Juniperus spp. were major browse items eaten in each season. Significant use of grass species was only observed during summer. Wallflowers or gromwell, milkvetch, lupine, beebalm, and clover were the major forb species.

Winter mule deer diets were dominated by browse (98.85%). Curlleaf mountainmahogany accounted for ≥ 66% of dietary items each year (Figure 29). Sagebrush species were the next most common item in the winter diets in 1993 (13.8%),

and Juniperus spp. ranked second in 1994 and 1995 (6.4% and 19.35%, respectively). The mean percent of grasses and forbs over all years were 0.25% and 0.68%, respectively.

Forbs made up over 55% of spring diets (Figure 29). Wallflowers or gromwell and clover (Trifolium spp.) occurred most frequently. Browse was the second most common forage class represented in spring (31.0%). Fragrant sumac was the most common browse species in 1993, but douglas fir, juniper, and limber pine were most prevalent in

Table 8. Major plant genera and species consumed seasonally by mule deer in the Pryor Mountains during 1993-1995.

WINTER	SPRING	SUMMER	FALL
Artemisia spp.	Astragalus oreganus	Erysimum spp. /Lithospermum spp.	Artemisia spp.
Cercocarpus ledifolius	Erysimum spp. /Lithospermum spp.	Artemisia frigida	Cercocarpus ledifolius
Juniperus spp.	Lupinus spp.	Artemisia spp.	Juniperus spp.
	Monarda spp.	Juniperus spp.	
	Trifolium spp.	Pinus flexilis	
	Abies spp.	Salix spp. /Populus spp.	
	Berberis spp.	Shepherdia spp.	
	Juniperus spp.	Agropyron spp.	
	Pinus flexilis	Bromus japonicus	
	Rhus aromatica	Dactylis glomerata	
	Shepherdia spp.	Festuca idahoensis	
		Oryzopsis hymenoides	
		Phleum spp.	
		Poa spp.	
		Stipa spp.	

spring 1994. Grasses comprised 11.1% of the spring diet on average. No one grass species occurred in 1993 in an amount greater than 2%, but Carex was the most common (12.8%) genus present in 1994.

Summer mule deer diets (Figure 29) were dominated by browse (46.5%). Buffaloberry (Shepherdia spp.) was the most common (37.2%) browse species in 1993, and Artemisia frigida and other Artemisia spp. were the most common (11.6% and 9.3%, respectively) dietary items occurring in summer 1995. Grasses and forbs occurred in similar amounts, 27.1% and 24.1%, respectively. Stipa spp. and Agropyron spp. were the grasses that occurred with the greatest frequency (7.8% and 7.4%, respectively), and wallflowers/gromwell was the commonly identified forb item.

Mule deer diets in fall were dominated by browse (97.9%), specifically curlleaf mountainmahogany, in both 1993 and 1994 (Figure 29). Juniperus spp. was the second most heavily used browse item in fall. Forbs, grasses, and other food items occurred only in trace amounts both years.

Differences between years in seasonal diets were also observed for mule deer. Browse use was consistently high each winter (> 98%). All other forage classes comprised only trace amounts in winter. The occurrence of forbs and browse in the diet in spring 1993 changed little compared to spring 1994. Grasses were consumed less in summer 1993 compared to summer 1995. Browse was eaten slightly less during summer 1993 compared to summer 1995.

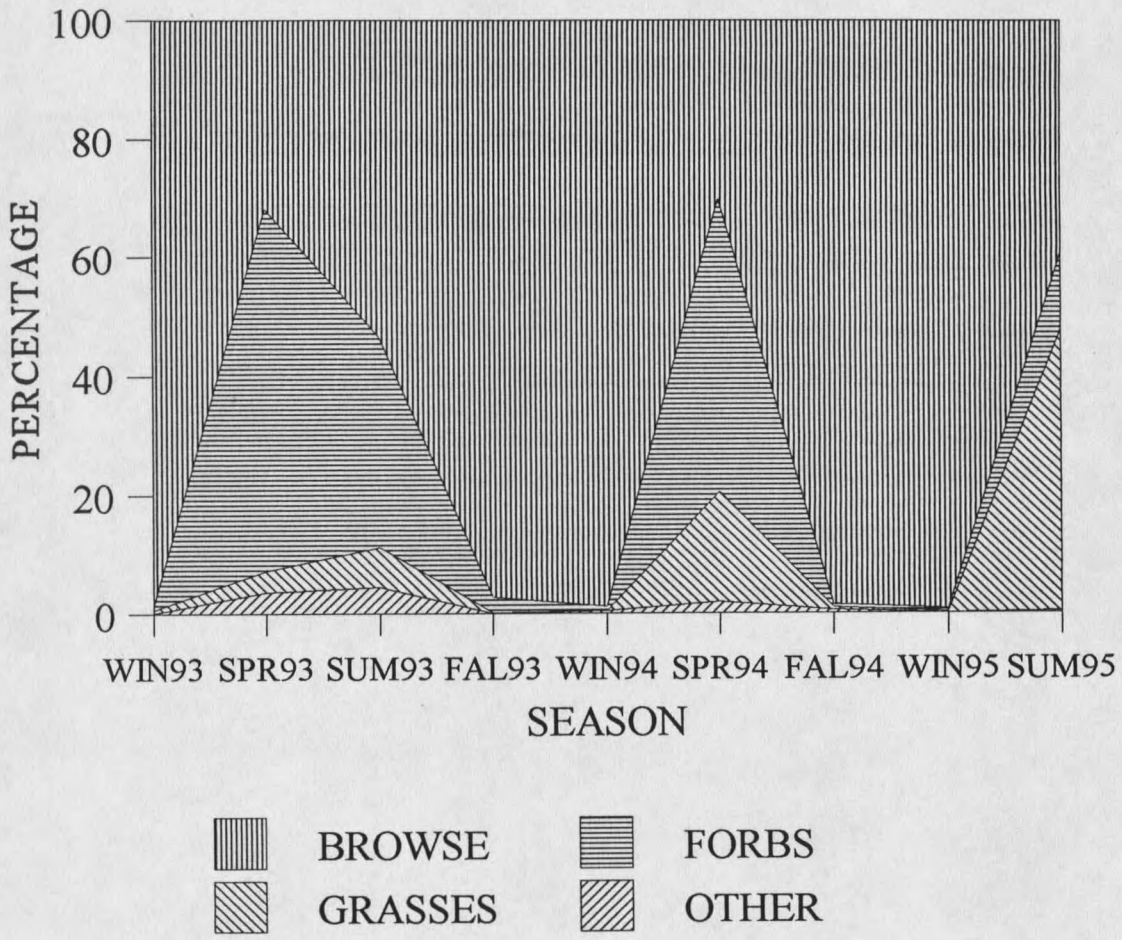


Figure 29. Percent of browse, forbs, grasses, and other items of seasonal food habits of mule deer in the Pryor Mountain Study Area by season and year. Data were from microhistological analysis of epidermal fragments from fecal samples collected during 1993-1995 (see text for further description).

Feral Horses

There were 45 plant genera and 23 species identified as food items of feral horses. Only 2 items occurred as major forages in every season: Agropyron spp. and Stipa spp. (Table 9). The seasonal diets of feral horses consisted of 83%, 96%, 79%, and 73% grasses, 7%, 2%, 13%, and 22% browse, and 9%, 2%, 8%, and 5% forbs in the winter, spring, summer, and fall, respectively. Graminoids were the major dietary component throughout the year in all years.

Table 9. Major plant genera and species consumed seasonally by feral horses in the Pryor Mountains during 1993-1995.

WINTER	SPRING	SUMMER	FALL
Phlox hoodii	Agropyron spp.	Artemisia frigida	Phlox hoodii
Artemisia spp.	Bouteloua spp.	Artemisia spp.	Artemisia frigida
Ceratoides lanata	Festuca idahoensis	Ceratoides lanata	Ceratoides lanata
Agropyron spp.	Poa spp.	Agropyron spp.	Agropyron spp.
Aristida purpurea	Stipa spp.	Festuca idahoensis	Bromus japonicus
Bouteloua spp.	Carex spp.	Poa spp.	Festuca idahoensis
Bromus japonicus	Juncus spp.	Stipa spp.	Koeleria macrantha
Festuca idahoensis		Carex spp.	Poa spp.
Oryzopsis hymenoides			Schizachyrium spp.
Poa spp.			Sitanion hystrix
Stipa spp.			Stipa spp.
Carex spp.			Carex spp.

Winter diets of feral horses were dominated by grasses (82.7%) (Figure 30). Agropyron spp. and Stipa spp. were the most common grass species eaten each winter. Browse and forbs occurred in similar percentages, 7.4% and 8.7%, respectively. Most

browse species occurred only in trace amounts, and Hood phlox was the only forb species to occur as a major dietary species.

Horse diets in spring were comprised of 96% grasses, 2.5% forbs, and 1.6% browse (Figure 30). Agropyron spp. and Stipa spp. were the most common grass species in spring diets. Forbs and browse species typically occurred in trace amounts.

Summer diets of horses contained 79.3% grasses, 12.7% browse, and 8.1% forbs (Figure 30). Agropyron spp. and Stipa spp. were the most prevalent grass species. Winterfat was the most common browse species, and Hood phlox was the forb represented most frequently.

Fall diets of horses were also dominated (72.8% on average) by grasses (Figure 30). Browse, on average, comprised 22.4% and forbs 4.8%. Agropyron spp. and Stipa spp. were the most common grass species. Fringed sagebrush and winterfat were the major browse species, and most forbs only occurred in trace amounts.

Differences between years in seasonal diets of horses varied. Each season of each year was dominated by grasses; forbs and browse never comprised more than 33% in any one season. There were approximately equal amounts of browse each fall (21.2 - 23.6%). During winter 1994, horses ate less grass and more browse than winter 1993 or 1995. Approximately equal amounts of grass were consumed in spring 1993 and spring 1994 (95.1% and 96.4%, respectively). More grass and less forbs were eaten during summer 1993 (91.4%) compared to summer 1995 (67.0%). Forbs were represented slightly more in the fall 1993 (8.1%) compared to fall 1994 (1.6%).

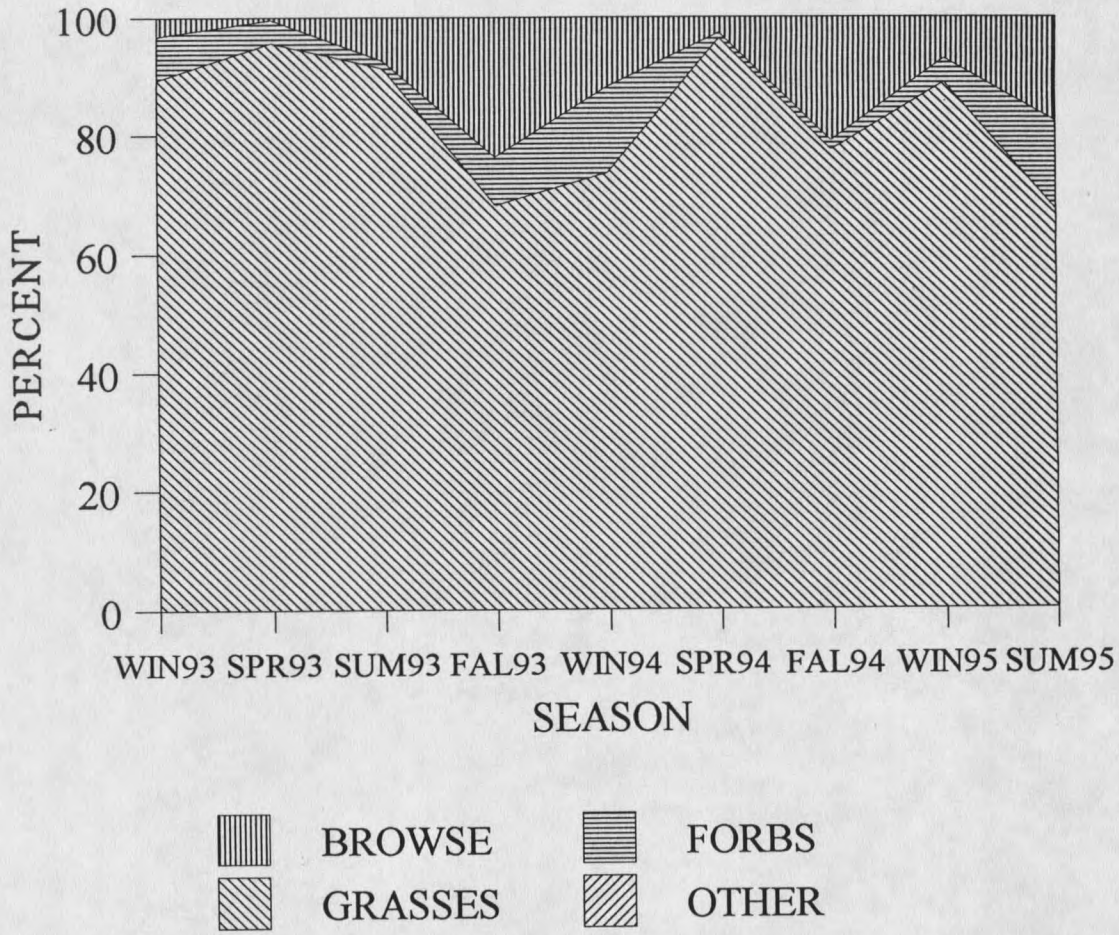


Figure 30. Percentage of browse, forbs, grasses, and other items in seasonal food habits of feral horses in the Pryor Mountain Study Area by season and year. Data were from microhistological analysis of epidermal fragments from fecal samples collected during 1993-1995 (see text for further description).

Interspecific Forage Relationships

Considerable dietary overlap was observed among all species (Table 10) during one or more seasons. Substantial dietary overlap occurred between bighorn sheep and feral horses during spring and summer each year, except summer 1995. Substantial overlap in seasonal diets of bighorn sheep and mule deer was recorded each fall and winter. Considerable dietary overlap was recorded between feral horses and mule deer only during summer 1995.

Table 10. Morista's similarity index, as modified by Hardin (1966), for bighorn sheep-mule deer (BS-MD), bighorn sheep-feral horse (BS-FH), and feral horse-mule deer (FH-MD) combinations representing dietary overlap. Values of 0 = no overlap and values of 1.0 = complete overlap.

	BS-MD	BS-FH	FH-MD
WINTER 1993	**0.983**	0.020	0.005
SPRING 1993	0.313	**0.851**	0.050
SUMMER 1993	0.194	**0.621**	0.313
FALL 1993	**0.934**	0.137	0.003
WINTER 1994	**0.649**	0.479	0.037
SPRING 1994	0.288	**0.843**	0.061
FALL 1994	**0.797**	0.402	0.021
WINTER 1995	**0.561**	**0.597**	0.000
SUMMER 1995	0.263	0.417	**0.596**

Interspecific Behavioral Interactions

Twenty-one interspecific encounters (i.e., when 2 species came within 200 m of each other and were in visual contact) were observed during the study (Table 11). Of those encounters , only 6 resulted in interactions (i.e., when one species exhibited a dominant or submissive behavior). When feral horses were involved, they were either dominant or indifferent to the other species present. Bighorn sheep and mule deer, when not indifferent to the presence of horses, were subordinant. All interactions occurred on the winter range with one exception, which occurred on the summer range in June 1994 between mule deer and feral horses.

Bighorn sheep were submissive in 33% of all encounters involving interactions with feral horses, and the other 67% of bighorn sheep-feral horse encounters resulted in no obvious aggression or submission by either species. Mule deer were subordinate in 60% of the observed encounters with feral horses, while no interaction was evident in the other 40%. Neither bighorn sheep nor mule deer showed dominant or subordinant behavior in interspecific encounters between these 2 species. All 3 species were observed in close proximity (< 100 m) to one another on only one occasion, and this did not result in any obvious interaction. None of the encounters observed exhibited physical contact between species.

The percentages of time devoted to specific activities differed by species for some of the seasons during the morning or evening time periods (Figures 31 - 34). In winter, bighorn sheep bedded significantly more ($X^2 = 10.71$, $p = 0.0047$) during morning hours

than either mule deer or feral horses. Even though bighorn sheep bedded more than the other ungulates in the morning, bighorn sheep spent a majority of the morning and afternoon feeding, with an increase in time spent bedded around the noon hour. There was also an increase in feeding during the last hours of daylight by bighorns. Feral horses fed significantly ($X^2 = 11.017$, $p = 0.0041$) more than mule deer or bighorn sheep during morning hours in winter. Feral horses fed throughout the daylight hours while the ruminants alternately fed and bedded during the day. Mule deer were observed bedding only during morning hours; most observations were made while mule deer were feeding or standing. This pattern may have been a response to the observer rather than a normal behavior pattern of the species.

In spring, bighorn sheep also were observed bedded significantly more ($X^2 = 11.69$, $p = 0.0029$) than mule deer or feral horses in the morning. Bighorn sheep exhibited a similar pattern in spring as winter. A large portion of time was spent bedded in the morning hours, and feeding increased during the afternoon hours. Mule deer were observed feeding during the morning and late afternoon hours. Observations of mule deer were limited in early afternoon when most individuals probably were bedded. Feral horses fed a large percentage of the time during early morning, less through midmorning, and increased the amount of time feeding throughout the afternoon.

In summer, feral horses were observed feeding ($X^2 = 9.476$, $p = 0.0088$) more during morning hours than bighorn sheep or mule deer. Horses spent > 50% of time feeding during morning in summer. The percentage of time spent feeding decreased during early afternoon and increased again during the last hours of daylight. Mule deer and bighorn

Table 11. Number of individuals per species observed during behavioral interspecific interactions and the subordinate species as determined by the interaction. NONE refers to no subordinate species. If a subordinate species is given, the other species observed was dominant.

DATE	BIGHORN SHEEP	MULE DEER	FERAL HORSES	SUBMISSIVE
27 JAN 1993	0	2	4	DEER
29 JAN 1993	5	1	0	NONE
30 JAN 1993	4	4	0	NONE
08 FEB 1993	0	18	1	DEER
08 FEB 1993	7	0	3	NONE
20 FEB 1993	27	9	0	NONE
10 APR 1993	0	7	4	NONE
17 APR 1993	8	1	2	NONE
12 OCT 1993	3	0	2	NONE
16 OCT 1993	14	0	1	BIGHORNS
07 DEC 1993	9	2	0	NONE
15 JAN 1994	12	3	0	NONE
25 JAN 1994	1	0	2	NONE
27 JAN 1994	8	16	0	NONE
01 FEB 1994	24	0	5	BIGHORNS
02 FEB 1994	19	0	5	NONE
02 APR 1994	0	3	5	NONE
09 APR 1994	19	0	5	NONE
17 APR 1994	5	0	8	NONE
14 JUN 1994	0	1	6	DEER
20 JUL 1994	9	0	4	BIGHORNS

sheep exhibited patterns similar to those observed during spring.

In fall, bighorn sheep were observed moving significantly (X^2 =9.423, p = 0.009) more

during the evening hours than were mule deer or feral horses. Bighorn sheep exhibited a similar pattern of feeding during the morning hours, showing a peak in bedding during the midday and increasing feeding during the late afternoon hours. Mule deer decreased the percentage of time feeding during morning hours and increased time feeding during late afternoon hours. Feral horses spent less time feeding from morning into early afternoon and more time feeding as late afternoon progressed. The pattern was similar to the pattern of horse behavior exhibited during summer.

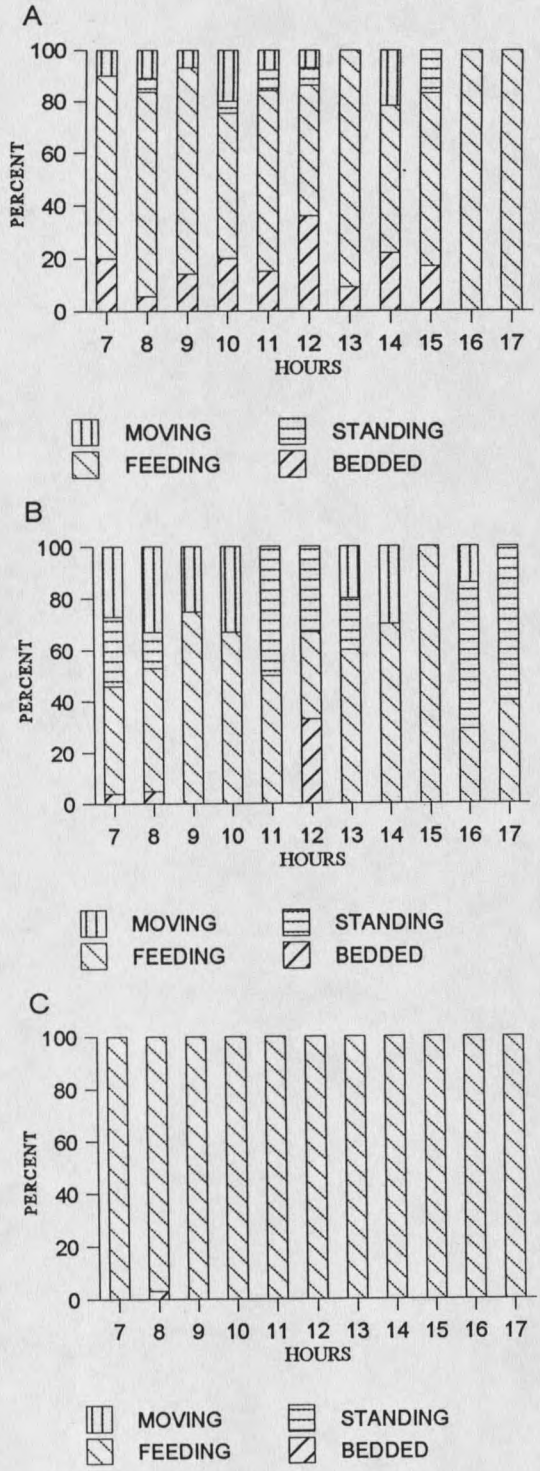


Figure 31. Percent of observations by hour of day in which animals were moving, standing, feeding, or bedded during winter on the Pryor Mountain Study Area. A = bighorn sheep, B = mule deer, C = feral horses.

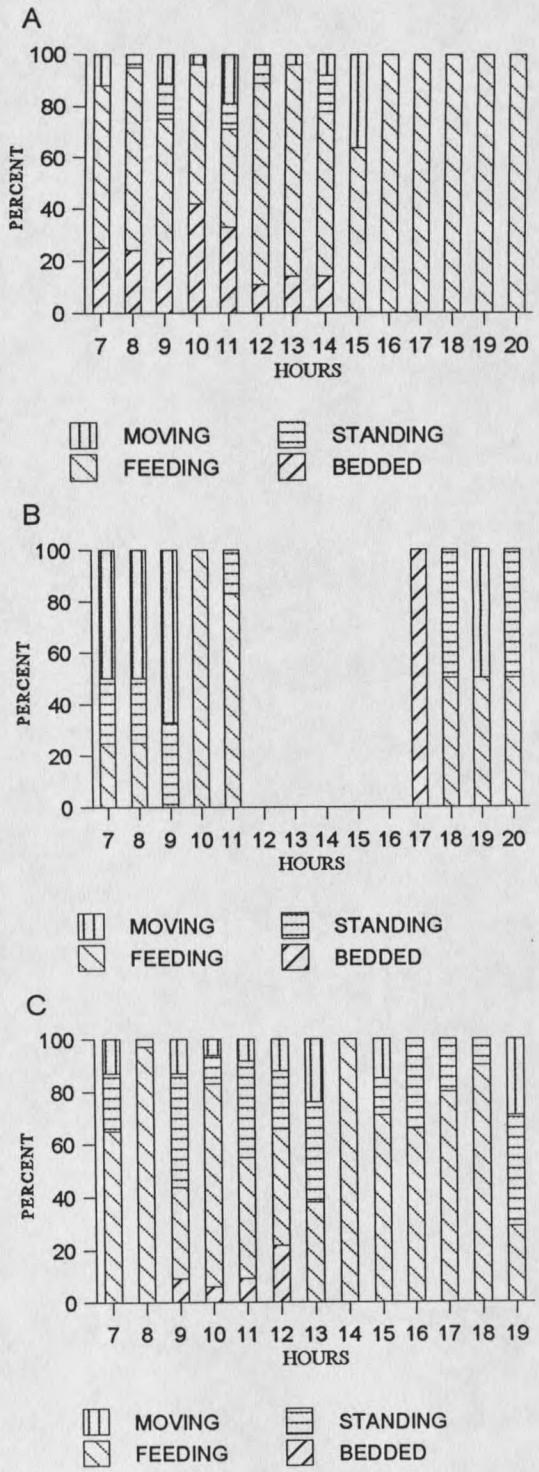


Figure 32. Percent of observations by hour of day in which animals were moving, standing, feeding, or bedded during spring on the Pryor Mountain Study Area. A = bighorn sheep, B = mule deer, C = feral horses.

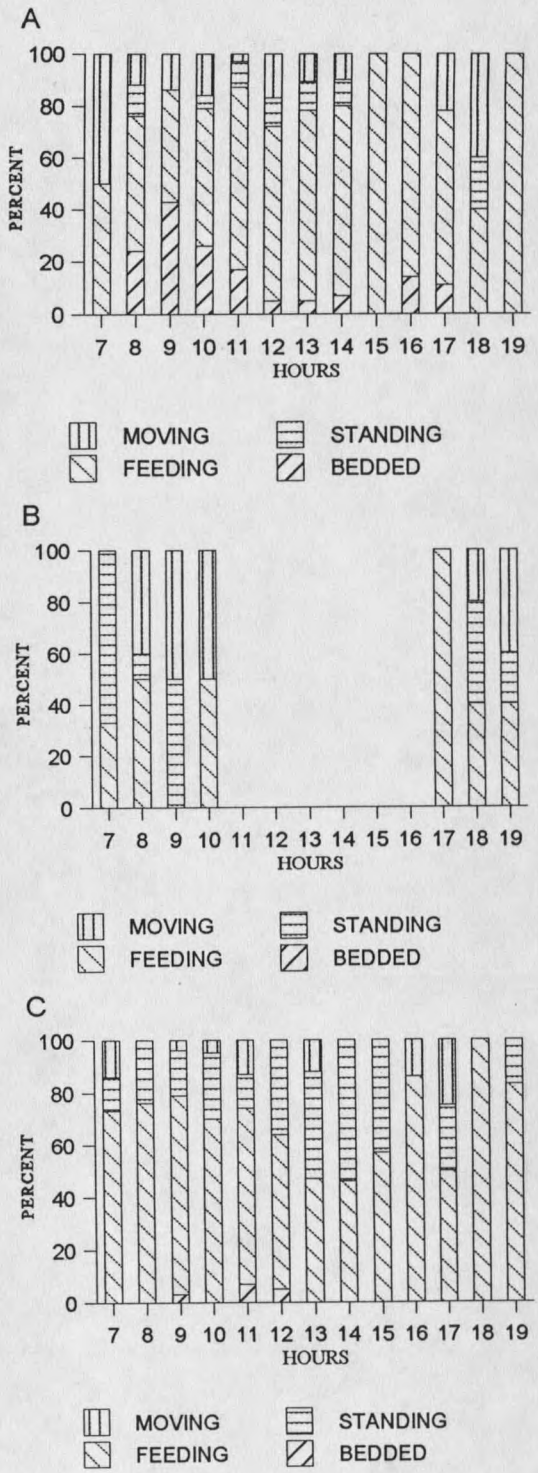


Figure 33. Percent of observations by hour of day in which animals were moving, standing, feeding, or bedded during summer on the Pryor Mountain Study Area. A = bighorn sheep, B = mule deer, C = feral horses.

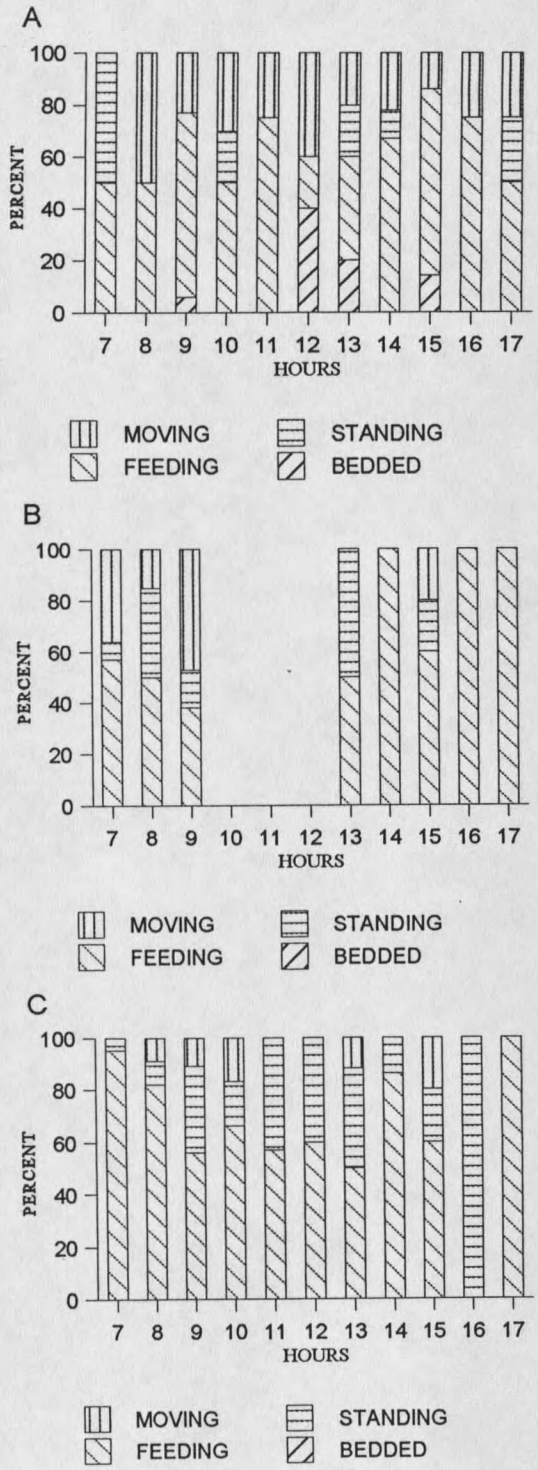


Figure 34. Percent of observations by hour of day in which animals were moving, standing, feeding, or bedded during fall on the Pryor Mountain Study Area. A = bighorn sheep, B = mule deer, C = feral horses.

Population Structure

Bighorn Sheep

The average number of lambs:100 ewes observed on the study area varied by year (Table 12) and month (Figure 35) indicating differences in the observability and survival of young. The fewest lambs:100 ewes were observed during late spring ground surveys and population surveys in 1995. The highest lamb:ewe ratios were observed in late summer and fall.

The average number of rams:100 ewes (Table 12) determined in population surveys varied by year. Averaged across the years and population surveys the population comprised 52 rams:100 ewes. Seasonal variation in rams:100 ewes was related to sexual segregation that influenced relative observability of the sexes. Ratios determined from ground observations were similar.

Table 12. Mean lamb:100 ewe and ram: 100 ewe ratios by season observed on the Pryor Mountain Study Area during 1993-1996 as determined by population surveys and ground observations.

	Year	Winter	Spring	Summer	Fall	Survey Flights
Lambs:100 Ewes	1993	36.9	24.8	50.0	55.6	-----
Rams:100 Ewes	1993	44.9	74.1	NA[a]	NA[a]	-----
Lambs:100 Ewes	1994	55.0	50.5	36.1	-----	18.0
Rams:100 Ewes	1994	37.9	NA[a]	NA[a]	-----	45.3
Lambs:100 Ewes	1995	-----	-----	56.4	-----	6.8
Rams:100 Ewes	1995	-----	-----	NA[a]	-----	40.7
Lambs:100 Ewes	1996	-----	-----	-----	-----	21.3
Rams:100 Ewes	1996	-----	-----	-----	-----	68.5

[a] - NA = Not available. See text for detailed explanation.

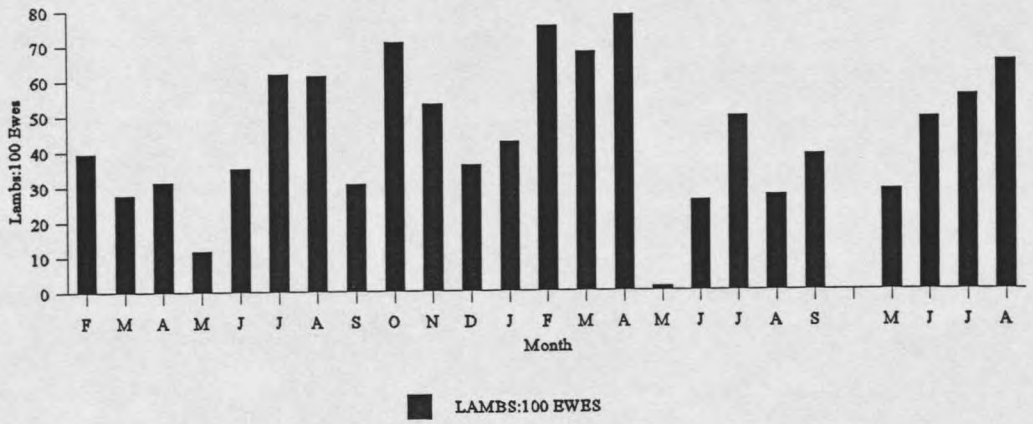


Figure 35. Lamb:ewe ratios by month for the Pryor Mountain Study Area from January 1993 - August 1995, excluding September 1994 -May 1995. Periods from May - April represent individual cohorts.

Mule Deer

Numbers of fawns:100 does and bucks:100 does were relatively consistent from year to year (Table 13), averaging 40.9 fawns:100 does and 15.5 bucks:100 does, respectively. The mean number of fawns:100 does increased slightly from year to year during the study, while the mean number of bucks:100 does fluctuated from year to year.

Table 13. Fawn:100 doe and buck:100 doe ratios determined by winter-spring population surveys on the Pryor Mountain Study Area during 1994-1996.

	1994	1995	1996
Fawns:100 Does	37	40.8	44.8
Bucks:100 Does	18.3	13.4	14.7

Population Size and Growth Rates

Bighorn Sheep

Based on point estimates of population sizes for 1993 - 1996, the Pryor Mountain bighorn sheep herd was at its highest number (≈ 211) during 1993 and/or 1994 (Figure 36), 145 in 1995, and 125 in 1996. Although there was not a significant decline from 1993 to 1996, biological factors such as recruitment and natural mortality indicated a high likelihood of decline. Variance of bighorn sheep estimates decreased with decreasing population size (Figure 36) indicating more marked animals were observed per flight relative to the number of animals available.

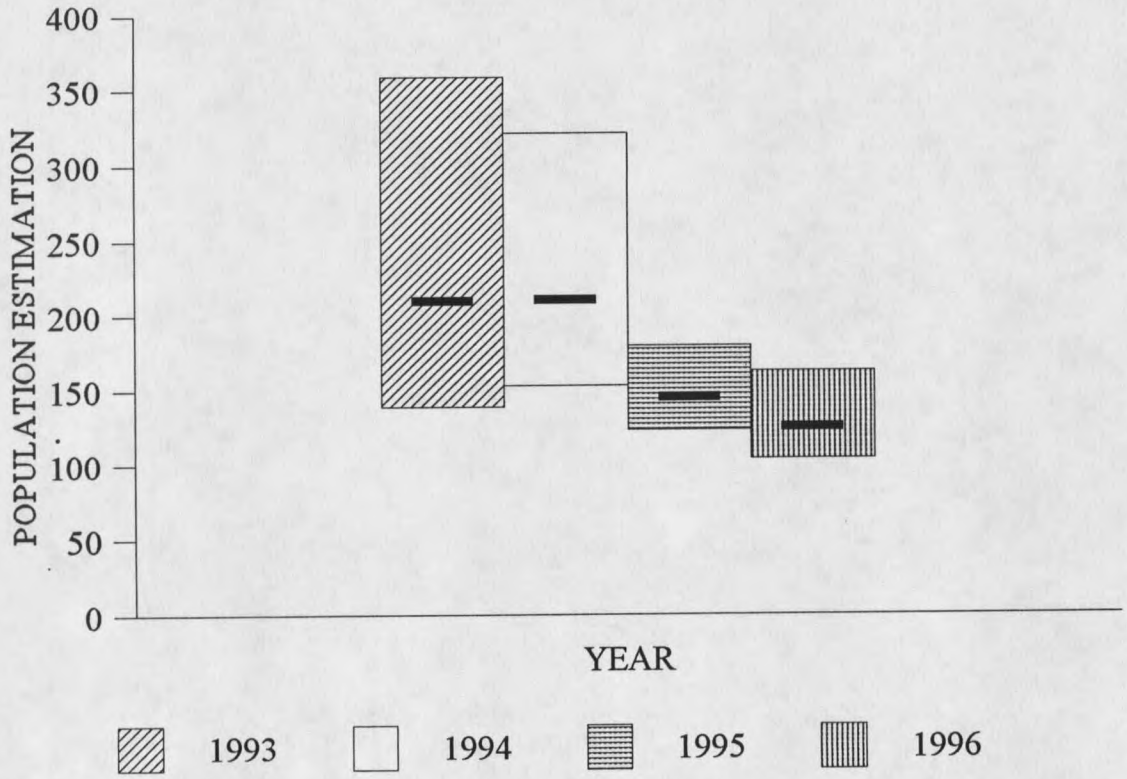


Figure 36. Population estimation (horizontal bar) and the associated 95% confidence intervals (hatched bars) of bighorn sheep on the Pryor Mountain Study Area during winter, 1993-1996 calculated using the joint hypergeometric maximum likelihood estimator.

Mule Deer

Based on winter point population estimates during 1993 - 1996 (Figure 37), the Pryor Mountain mule deer population contained 573 individuals in 1993, increased to a high of about 780 in 1994 and/or 1995, then decreased sharply to about 143 in 1996. The 82% decrease resulted in a change in deer density on the study area from 3.7 animals/km^2 to 0.7 animals/km^2. Variance of mule deer estimates decreased with decreasing population size indicating more marked animals were observed per flight relative to the number of animals available.

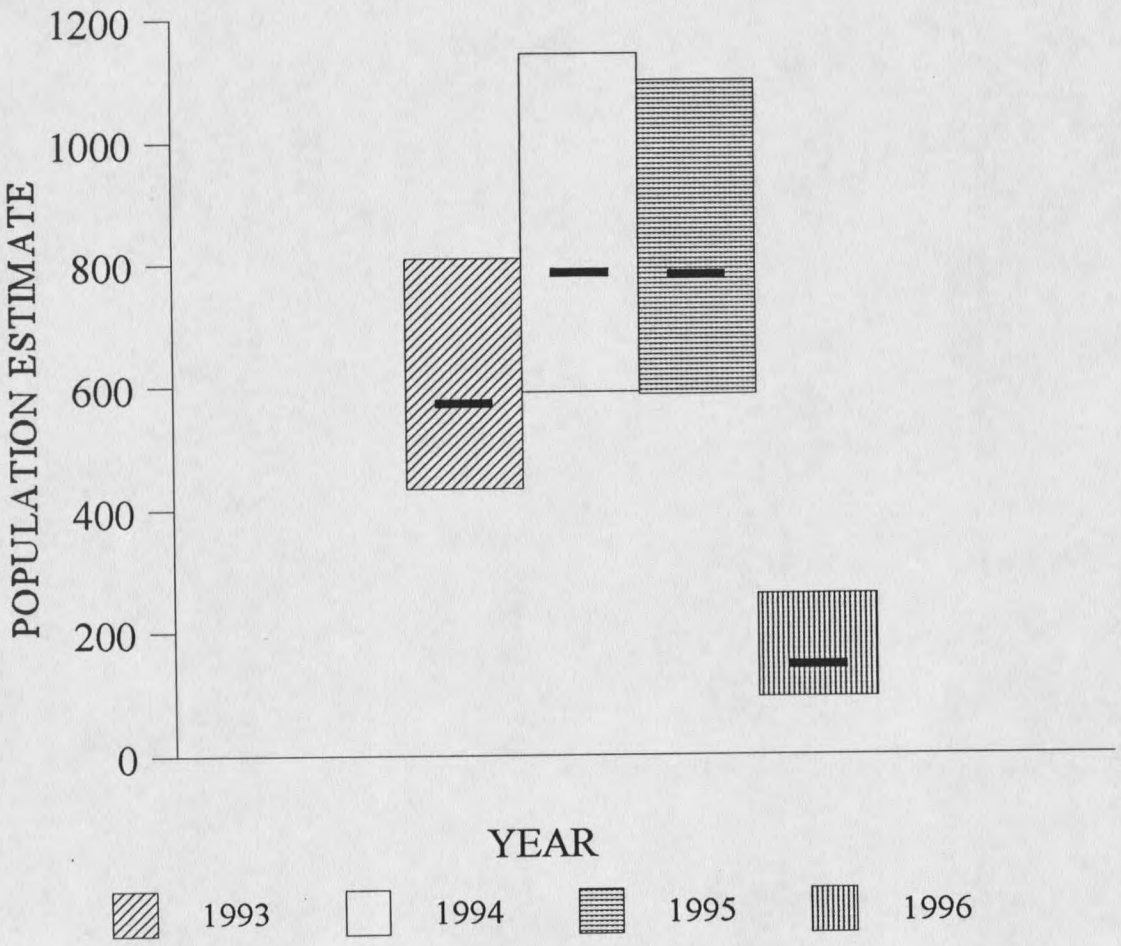


Figure 37. Population estimation (horizontal bar) and the associated 95% confidence intervals (hatched bars) of mule deer on the Pryor Mountain Study Area during winter, 1993-1996 calculated using the joint hypergeometric maximum likelihood estimator.

Feral Horses

Population estimates ranged from a minimum of 144 in 1993 to 177 in 1994, before the culling effort occurred. These estimates were consistent with population size estimates (≥ 140 animals) since 1980. Forty-six animals were removed from the population in 1992, and 51 were removed in 1994. There were 2 known deaths during 1993 - 1995, excluding mortality associated with the 1994 culling operation. One death was of a foal, < 2 days old, and the other was an adult mare.

Percent population increases were 16.5% during 1993, 23.8% during 1994, and 21.2% during 1995. Overall survival of adults and foals was estimated to be very high (98.9%) during the study. Foal survival was estimated at 100%, 97.1%, and 100% during 1993, 1994, and 1995, respectively. Mortality rates were estimated based only on animals which were known to be dead (i.e., carcasses were located). Mortality may have been higher than observed, and the survival rates given should be considered maximum survival rates.

DISCUSSION

Intraspecific Relationships

Bighorn Sheep

Some components of habitat use by bighorn sheep on the PMSA differed from previous work on the herd (Coates and Schemnitz 1989, 1994), likely because of the non-migratory nature of the herd, low productivity of the rangeland, and increased density. The most obvious change in terrain use was an increase in sheep observed > 50 m from escape terrain between 1988 and 1993. Bighorn sheep commonly use steep slopes (Geist 1971), and distance to escape terrain is the habitat parameter most often cited as important to bighorn sheep ecology (Geist 1971, Risenhoover and Bailey 1985, Wakelyn 1987). More than 50% of the observations in this study were > 100 m from escape terrain and more than 50 were in areas with gentle slopes. Other low-elevation sheep populations have been reported to prefer slopes > 30° and/or to range within 100 m of escape terrain (Fairbanks et al. 1987, Tilton and Willard 1982, Cook 1990). Factors such as forage availability and quality may have been more important than distance to escape terrain in determining spatial distribution on the study area (Shannon et al. 1975).

Mountainmahogany and/or juniper complexes were important in the BCNRA in the late 1980's (Coates and Schemnitz 1989) and in this study provided forage, both browse and grass, yearlong. The forage class dominating diets in most Montana bighorn sheep

herds or herds occurring in other Rocky Mountain states or provinces is grass (Oldemeyer et al. 1971, Constan 1972, Pallister 1974, Dailey et al. 1984, Keating et al. 1985, Semmens 1996). These investigators reported the percentage of grass in diets ranging from 54% - 98%. Grasses represented most during the growing season in these studies, Agropyron spp., Poa spp., and Stipa spp., were cool season grasses that began growing in April (Stubbendieck et al. 1992). Early growth, high protein levels, and high digestibility (Welch and McArthur 1985) of these grasses were factors likely influencing consumption.

Browse, however, is a major component of seasonal diets in herds restricted to low-elevation sites (Rominger et al. 1988) and desert populations (Krausman et al. 1989). Low-elevation herds of bighorn sheep often rely on low-growing browse species (Rominger et al. 1988, Cook 1990), such as mountainmahogany or juniper found on the PMSA, that provide a nutritional complement to the sparse, scattered, and often low quality grasses and forbs available on these ranges.

Seasonal browse use appeared to be influenced by weather, especially in winter. Winter 1993 was wetter than normal, with greater snow depth than other years. Increased snow depth may have been responsible for the higher percentage of browse in the 1993 winter diet (Goodson et al. 1991). The other 2 winters had lower snowfall and lower browse consumption. Forb and grass use in winter increased from 1993 - 1995 with a decrease in snowfall.

High visibility provided by low growth forms of browse species in low elevations, such as mountainmahogany and juniper on the PMSA, is key to predator detection in and use of shrubby habitats by bighorn sheep (Risenhoover and Bailey 1980, 1985). Areas used at

distances > 100 m from escape terrain were usually in a vegetation type of mountainmahogany and/or juniper. Bighorns avoid predators by detecting them at long distances and escape predation by climbing up or down steep slopes. The open shrub communities on the study area allowed sheep to exploit forage greater distances from escape terrain than reported in other studies.

Distribution of bighorn sheep among aspects was probably influenced by the occurrence of southern and eastern aspects associated with steeper slopes that provided escape terrain. These aspects provided maximum light and radiation (warmth) during winter months and were the first to provide new grass growth in spring.

Most locations of sheep were at considerable distances from roads, suggesting a negative influence of vehicles or humans. Often, however, sheep were seen on or near the Bad Pass and Sykes Ridge road. Coates and Schemnitz (1989) found high use near the Bad Pass road and reported elevated heart rates in telemetered sheep in response to human approach. They suggested this type of disturbance to be of a chronic nature causing an increase in elevation of cortisol levels, and thought it might become more important as a stressor at high population levels. Use of the landscape at distances > 300 m from the road likely reduced potential disturbance.

Mule Deer

Mule deer use of habitat was related to survival and maintenance on the winter range and reproduction, rearing of young, and survival on the summer range. Deer use of lower elevations associated with eastern aspects on the winter range provided warmer climatic

conditions and reduced exposure to northwest or west winds. While normal climatic conditions seldom affect mule deer, strong winds or storms can increase use of energy reserves (Mackie et al. 1982), and use of these topographic structures likely reduced heat loss in winter.

Gentle slopes on winter ranges in mountainmahogany or juniper vegetation types provided a source of forage and visibility of predators. Mountainmahogany and juniper were characteristic of the lower elevations associated with the eastern and southern aspects of the study area. Mountainmahogany communities are an important vegetative type to mule deer where they occur in Montana (Duncan 1975) and elsewhere (Kufeld et al. 1988). Rugged topography in association with high visibility, provided by juniper and mountainmahogany on the PMSA, is used by mule deer to detect and escape predators in many areas (Geist 1981, Mackie et al. 1982). The unique stotting gait of mule deer allows for efficient maneuvering and use of terrain and low vegetation to avoid predators.

Distribution of deer in relation to roads was relatively similar in all seasons except fall when the frequency of locations closer to roads increased. The increased number of locations near roads in fall was probably related to the location of roads in the winter range. Most main roads on the study area traversed wintering areas for mule deer. Also, the open vegetation and broken topography facilitated observation. Although Rost and Bailey (1979) reported mule deer to avoid areas within 200 m of roads, more than half of the observations in fall were made within 300 m of roads.

Most deer migrated to summer home ranges on the eastern or northern sides of the Pryor Mountain at low to intermediate elevations. The top of the mountain was avoided.

They exhibited little elevation change from winter to summer. Slopes and aspects used by deer in summer were unlike those described by Hamlin and Mackie (1989) and Mackie (1965) in the Missouri River Breaks of Montana and Carson and Peek (1987) in eastern Washington. Mackie reported an increase in use of steep slopes in summer thought to be caused by association with mesic conifer stands, while Carson and Peek noted the use of areas characteristic of high relief but at a small scale.

Rearing of young, maintenance of body condition, and growth of deer was likely facilitated by conifer and sagebrush vegetation types in association with southern and eastern slopes used during late spring and summer. Conifer stands likely provided protection from predators and aided in thermoregulation. Sagebrush provided cover for fawns and cover and forage for dams, as suggested by high use of Artemisia frigida, other Artemisia spp., and Shepherdia spp. in summer.

Diets of mule deer occupying summer range were different from those previously reported for the Pryor Mountains by Firebaugh (1969) who studied summer food habits in fescue-wheatgrass, douglas fir, and spruce fir zones at elevations above about 1800 m. Firebaugh found forbs to be the dominant forage class, while the main browse species (Spiraea betulifolia, Ribes spp., and Symphoricarpos albus) reported by Firebaugh did not appear in this study. Firebaugh suggested high forb use was likely because of the low availability of browse species. Changes in food habits of deer on summer ranges could reflect a different flora, different environmental conditions, different areas, or the difference in techniques used to determine use.

Feral Horses

Changes in elevations used by horses reflected seasonal changes in their use of vegetation on the PMWHR. Lower elevations were used in winter by all horses and by some yearround; others used higher elevations in summer. Use of high elevations may have been underestimated because sampling was biased toward lower elevation habitats. Berger (1986) reported seasonal migration of horses in Nevada in response to vegetation availability. Vertical migration of horses of the PMWHR was also thought to be a response to availability of forage. However, a large segment of the population (i.e., the Dry Head subpopulation) did not migrate. This segment, possibly a subpopulation, had access to permanent water throughout summer but also lacked easy access to upper elevations.

Most forage areas and travel lanes used by horses were associated with 0 - 15° slopes. Berger (1986) found use of slopes increased as wind chill decreased. Aspect selection may have been a major factor in avoidance of exposure to weather factors, such as wind and snow in the PMSA. Animals were often observed using small clumps of juniper or ravines thought to provide protection from weather events. Additionally, southern aspects melted first and likely provided a source of new grass growth in early spring.

Grass is the main forage consumed by horses (Hansen and Clark 1977, Hansen et al. 1977, Olsen and Hansen 1977, Salter and Hudson 1979, Hanley and Hanley 1982, Krysl et al. 1984, Berger 1986). Juniper and grass vegetative types on the PMSA provided a larger relative abundance of grasses compared to other types. Berger (1986) reported horses in Nevada heavily used shrubland and grassland types; juniper type also ranked high

at lower elevations, while use of meadows (i.e., grasslands) accounted for > 99% of use at high elevations. A similar pattern was observed on the PMSA. Hansen and Clark (1977), Hansen et al. (1977), Olsen and Hansen (1977), Salter and Hudson (1979), Hanley and Hanley (1982), Krysl et al. (1984), and Berger (1986) have pointed out the reliance by horses on species such as wheatgrasses, needle-and-threads, Indian ricegrass, Idaho fescue, and sedges, that were important to feral horses on the PMSA. Forbs are often reported in seasonal horse diets in a range from < 1% to 15% (Hansen et al. 1977, Olsen and Hansen 1977, Hanley and Hanley 1982). Forb use by feral horses on the PMWHR was also in this range. Hood phlox was the most commonly used forb. The only other study reporting use of specific species indicated that Russian thistle (Salsola spp.) was the dominant forb (Hansen 1976). Both species were available year round and widespread on the respective study areas.

Browse commonly constitutes only a small fraction (< 10%) of any seasonal diet of feral horses (Hansen and Clark 1977, Olsen and Hansen 1977, Salter and Hudson 1979, Hanley and Hanley 1982). In this study, browse use exceeded 20% of the diet each fall. Earlier, Coates and Schemnitz (1989) found browse to account for 17% and 16% of feral horse diets in summer and fall, respectively. They reported heaviest use of Atriplex confertifolia and Cercocarpus ledifolius, neither of which exceeded 2 % of the diets in this study. I also found the major browse species to change from one year to the next. Artemisia frigida was the major browse species used in the fall of 1993; Ceratoides lanata was the major browse species used in fall 1994. High levels of browse use may have been due to low abundance, availability, or lower nutritional quality of warm season grasses in

fall and winter. The reason for changes in major browse species selection between years is unknown.

Horses are capable of traveling long distances. This likely facilitated feral horse use of areas distant from permanent water sources. Temporary water sources were not considered in the study, but general observations indicated that horses remained in close proximity to temporary water sources until they were no longer available.

Roads close to or part of travel corridors were used by horses to get from lower elevation to upper elevation ranges. Thus, distribution patterns observed were likely the result of sampling technique used and distribution of roads in relation to observable topography, and actual use by horses. Surveys for horses were mainly by road, and most roads traversed the landscape in a manner providing sightability in excess of 1500 m in areas commonly used by horses.

Interspecific Relationships

Space and Habitat Use

Different habitat use patterns were believed responsible for the minimal spatial overlap between bighorn sheep and feral horses. Overlap between the 2 species was restricted to the eastern portion of the PMWHR where both sheep and horses are sedentary. The amount of spatial overlap that may have occurred prior to this study was not known. Coates and Schemnitz (1994) did not report on overlap directly, but reported that rams fed with horses in areas not normally used by sheep. Ewes were not reported to share this behavior.

In winter, horses generally occurred in the juniper vegetation type, while sheep utilized the mountainmahogany and/or juniper vegetation types. In summer, horses make more use of the grassland vegetation type and grazed less steep slopes than used by bighorns. Even though spatial overlap was considered slight, removal of horses from potential sheep range in other areas has been followed by increases in sheep populations, suggesting competition between horses and sheep might occur (Crump 1971, Stelfox 1976).

Seasonal habitat use patterns and spatial distributions were different between bighorn sheep and mule deer. McCullough (1980) reported low spatial overlap of mule deer and bighorn sheep on the National Bison Range in Montana and suggested this low overlap was the most important factor in coexistence. Constan (1972) hypothesized slight competition between bighorn sheep and mule deer based on overlap in use of space and food habits. However, he reported that sheep usually fed in steeper areas than deer. In this study, bighorns also used steeper slopes than mule deer during winter when overlap was more likely. Most deer migrated from the primary sheep range in spring and summer.

Differences in spatial distribution associated with different habitat preferences limited spatial overlap between mule deer and feral horses. Salter and Hudson (1980) described spatial overlap of deer on horses to average 33% during all seasons, horses overlapped deer 87% of the time on an annual basis. I observed little overlap during summers. This greatly reduced the average annual overlap. Seasonal migration to summer ranges by both deer and horses was responsible for reduced overlap during spring and summer.

Forage

The greatest potential for forage competition existed between bighorn sheep and horses during spring and summer. Coates and Schemnitz (1989) described summer, fall, and winter dietary overlap as being 70%, 75%, and 58%, respectively. Although they used a different index, they inferred horses were competing with bighorn sheep. While I did not find a significant amount of overlap in fall and winter diets between bighorn sheep and feral horses, my results do support the significant overlap in summer diet. Competition between bighorn sheep and feral burros has often been implied (Potter and Hansen 1979, Jones 1981, Turner and Weaver 1981), but relationships between bighorn sheep and feral horses have rarely been examined (Crump 1971, Stelfox 1976, Coates and Schemnitz 1989). Crump (1971) found bighorn sheep distribution was enhanced by protecting bighorns from livestock. Stelfox (1976) reported horses in Canadian national parks had reduced the range to poor conditions from 1850 - 1950. The poor range conditions were believed at least partially responsible for poor nutritional condition associated with disease outbreaks in bighorn sheep in the parks.

The forage species most frequently used by both bighorn sheep and feral horses during both spring and summer were Agropyron spp. and Stipa spp. In all years diets overlapped more in spring than summer. During summer, grasses are green and have high nutritional content (Welch and McArthur 1985) and are preferred by both species. Coates and Schemnitz (1989) also reported overlap in summer between ewe and horse diets, but this overlap was due to common forb use, specifically scarlet globemallow (Sphaeralcea cocinea); overlap they reported between rams and horses was with grasses.

Potential for forage competition between bighorn sheep and mule deer was evident during each fall and winter. However, as Mackie (1981) pointed out, there are no direct data to support competition as a limiting factor for either species. Competition for forage has indirectly been implicated as a factor in population regulation in many sympatric populations (Schallenberger 1966, McCullough 1980, Jones 1981). Overlap in forage use, suggestive of competition, most frequently occurs during winter (Schallenberger 1966, Jones 1981). If significant competition occurs between mule deer and bighorn sheep on the PMSA, it most likely would center on use of curlleaf mountainmahogany, the species used in greatest amounts by both. However, I had no data to indicate it was in limited supply or over-utilized during fall and winter or was declining in availability as a result of use by either or both species. Dietary overlap between sheep and deer was greatest during fall and winter 1993, the year of highest precipitation, but was also significant in years of normal precipitation. This indicates that the potential for competition between bighorn sheep and mule deer may be weather mediated.

Forage classes characteristic of deer and horse food habits in the PMSA were sufficiently dissimilar to prevent forage competition given differences in distribution. Hansen and Clark (1977), Hanley and Hanley (1982), and Hansen et al. (1977) examined the foods of horses and mule deer and found no significant overlap. Deer fed mainly on browse species, whereas horses fed on grasses.

Behavior

Dominance of horses over smaller Artiodactyla species has been documented in other

studies (Berger 1986, Westfall et al. 1989, Coates and Schemnitz 1994). The low levels of interspecific interactions I observed were likely due to the broad difference in distribution and habitat between the species (Berger 1986). Coates and Schemnitz (1994) reported 22 instances on 20 separate days over an 18-month period where bighorn sheep rams occurred in groups of horses; in all instances bighorns appeared subordinate to horses. They suggested that horses facilitated feeding by rams on the PMWHR. They hypothesized this facilitation involved increased security from predation that allowed rams to occur in areas not normally exploited by sheep. They also hypothesized that stallions increased their fitness by attracting more mares to what mares perceived as a larger harem. I did not observe ram groups foraging with horses during 1993 - 1995. Berger (1986) described 30 interspecific interactions among ungulates over a 7-year period in eastern Oregon and northern Nevada. In all but 11 interactions, the native species was subordinant to the exotic species. Physical contact was never observed by Berger (1986), but chases and displays were noted. This was also the case when horses assumed aggressive postures at the approach of sheep, and sheep moved away from approaching horses.

Given the heterogeneity of the landscape and the low productivity of the vegetation, physical aggression, either inter- or intraspecific, would likely be energetically more costly to the aggressor. Energy would be more efficiently expended on gathering resources to enhance growth, reproduction, or maintenance (Geist 1974) than on trying to actively exclude other individuals from access to resources.

Population Status, Trend, and Regulation

Bighorn Sheep

The pattern of population growth (Figure 38) in the PMSA based on population estimates from 1975 to 1996 was similar to a pattern often exhibited by colonizing ungulate populations (Caughley 1970, McCullough 1979). During this study, the Pryor Mountain bighorn sheep herd apparently passed through the end of the first, and passed through all of the second, and may habe begun the third of 4 stages of population growth and decline described by Caughley (1970). The first stage covered the "initial increase" from the time of establishment to the peak of population growth. Coates and Schemnitz (1989) documented a portion of the exponential growth of the herd and suggested the herd was growing at the approximate theoretical maximum rate. Using the exponential growth equation,

$$NE_t = N_o e^{rt},$$

where NE_t was the expected population size based on exponential growth, N_o was the initial population size in 1975, r was the growth rate, and t was number of years, a population of 210 animals was expected from a founding population of 6 animals (Coates and Schemnitz 1989) if the population maintained ≥ 19.75% annual growth until 1993, when this study began. Although the growth rate was below the theoretical maximum for bighorns (r = 0.258) suggested by Buechner (1960), the estimate for 1993 of 210 indicated population growth from 1975 - 1993 averaged at least 19.75% annually.

Lamb:ewe ratios in late winter indicated low recruitment to the population from 1994

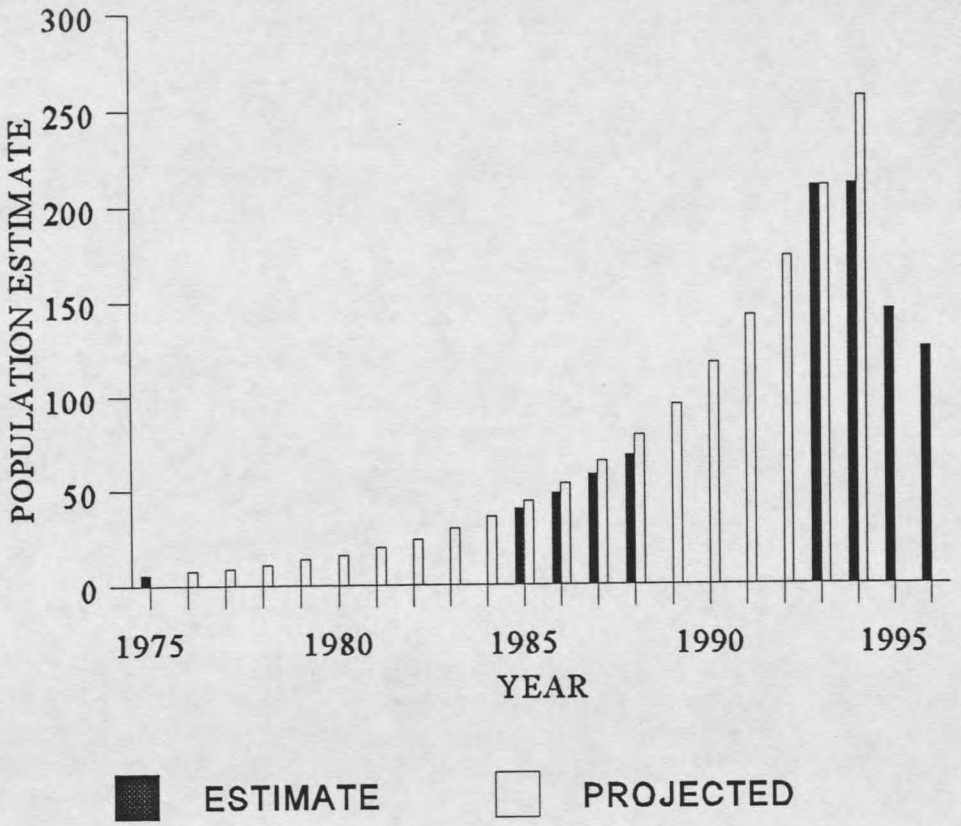


Figure 38. Projected (open bars) and estimated (solid bars) population sizes of bighorn sheep on the Pryor Mountain Study Area. Estimates given for 1975 and 1985-1988 were provided by Coates and Schemnitz (1989), and estimates given for 1993-1996 were calculated during this study using the joint hypergeometric maximum likelihood estimator. Projected estimates were calculated based on an exponential growth rate of 19.75%.

to 1996. Between 1985 and 1988 this herd exhibited lamb:ewe ratios of no less than 47 lambs:100 ewes (Coates and Schemnitz 1989). However, the lamb:ewe ratio progressively declined from 1985 to 1988. The lamb:100 ewe ratios from 1994 and 1996 population surveys indicated marginal recruitment capable of maintaining the herd if mortality were minimal (Wehausen et al. 1987, Hass 1989). This may indicate the habitat used and the extent of use may have been different during this study compared to before 1993. Adult mortality appeared to be minimal during 1994 - 1996 based on radiocollared animals which experienced only 5%, 9%, and 9% mortality in 1993, 1994, and 1995, respectively. These annual mortalities did not include the unknown fate of animals and should be considered minimum estimates. The failure of the population to stabilize in 1996 may have been related to other limiting factors associated with weather conditions or predation.

The average ram:100 ewe ratio remained relatively constant during the study, with an average of 52 rams:100 ewes in the population. This was similar to 48 rams:100 ewes observed by Coates and Schemnitz (1989) during 1988, the last year of their study. However, the ram:ewe ratio for winter 1996 suggested a possible increase in the number of rams relative to ewes in the population which may indicate higher mortality for ewes.

This study did not identify specific factors responsible for the change in bighorn population point estimates, but the abrupt switch from rapid growth to rapid decline is more consistent with density-independent environmental control than density-dependence. Common causes for declines of bighorn sheep identified in other studies include disease (Scott 1988, Foreyt and Jessup 1982, Dunbar et al. 1985, Foreyt 1994, Foreyt et al. 1994,

Jones and Worley 1994, Semmens 1996), interspecific competition (Ogren 1954, Jones 1981), forage quality (Stelfox 1976, Cook 1990, Dunbar 1992), predation (Murie 1944, Crump 1971, Hass 1989, Jones and Worley 1994, Wehausen 1996), loss of habitat (Woodard et al. 1974, Crump 1971, Wakelyn 1987) and weather (Picton 1984, Douglas and Leslie 1986, Wehausen et al. 1987). Of these possibilities, forage quality (possibly linked to intraspecific competition for desirable forage) is most suspect in the PMSA. Interspecific competition, weather, habitat loss, predation, and disease were apparently not major factors during 1993 - 1995 but could have interacted with low forage quality.

Forage production is low on most of the PMSA (Knight et al. 1987). Weather is dry with a short growing season, primarily from April to June (Smoliak 1956), thereby reducing availability of most highly nutritious vegetation to spring and early summer. Range condition in several areas important to sheep has been declining for more than 20 years (Firebaugh 1969, Gordon and Coop 1973, Hall 1973, BLM 1984, BLM 1992); but forage species used seasonally by sheep still retained edible biomass at the end of the season of use. This combination of characteristics suggests that forage quantity, while low, exceeded seasonal needs. Further, it is possible that overuse over time could have changed species composition by reducing more palatable plant species (especially those selected by livestock, feral horses, and bighorns), and that forage meeting quality requirements for lactation and weaning would likely be a scarce resource. Supplies of these plants may have been adequate until the population reached a level that rapidly exhausted seasonal supplies within 400 m of escape terrain. This scenario is speculative, but of the possible factors contributing to the decline, I ranked forage quality first on the

basis of consistency of its assumptions with conditions in the PMSA.

Bighorn sheep herd size has been suggested as being limited by forage quality in Canada (Stelfox 1976) and Wyoming (Cook 1990). Lamb:100ewe ratios in the PMSA were lower than populations thought to have adequate nutritional resources (Woodgerd 1964, Keating 1982, Weigand 1994, Semmens 1996). Cook (1990) showed forage quality on low elevation (2230 - 2800 m) ranges in south-central Wyoming was adequate for bighorns only in spring and inadequate during the other 3 seasons.

Ewes in the Pryor Mountain herd did not migrate to higher elevations where a higher quality forage supply would be expected in summer. Rams exhibited an elevational migration in summer, and this may have been responsible for the relatively high ram:ewe ratio, even with harvest pressure. Coates and Schemnitz (1989), however, reported the nutritional quality of browse all year on the PMSA, based on crude protein, to be marginal, yet adequate. Given the apparent dietary change and population decline, this nutritional relationship may have also changed within the last decade.

Other studies of Pryor Mountain bighorn sheep indicate the herd has been exposed to Pasturella haemolytica serotype 3, 4, or 3, 4, 10, Chlamydia, parainfluenza 3 virus, bovine respiratory syncytial virus, lungworms, Nematodirus spp., and Marshallagia spp. (Williams et al. 1995). However, I never observed symptoms that would indicate disease as a limiting factor (during 1993 - 1996). The lungworm (Protostrongylus spp.)-pneumonia complex is the most cited disease related explanation for bighorn sheep population declines (Foreyt and Jessup 1982, Semmens 1996). Lungworm larvae counts, an indicator of infection of the parasite, were not elevated (Appendix, Table 25) when

sampled during this study. The bacteria that is implicated in the lungworm-pnuemonia complex (Pasturella haemolytica) may be transmitted by livestock, primarily domestic sheep (Foreyt and Jessup 1982, Foreyt 1994, Foreyt et al. 1994), but no domestic sheep operations were in the area.

Overall, predation was not believed to have been a limiting factor of the Pryor Mountain bighorn sheep herd during the study. In 1993 - 1996, a few ewes were killed by mountain lions. In 1995 and 1996, approximately 70% of lambs disappeared in fall. If predators were responsible, and I have no evidence that they were, this would have been enough to depress recruitment below that needed to maintain population growth but not enough to cause the > 30% population decline between 1995 and 1996. Predation is usually reported as being responsible for ≤ 10% of all mortality of bighorn sheep (Stelfox 1976, Skjonsberg 1988), but a few bighorn sheep populations are thought to be limited by predation (Crump 1971, Hass 1989, Wehausen 1996). Predation by coyotes, after a predator reduction program was terminated, limited bighorn sheep on the National Bison Range (Hass 1989). Also, predation by mountain lions resulted in a declining populations of bighorn sheep in the Sierra Nevada and Granite Mountains of California (Wehausen 1996).

The spring and summer of 1993 were cooler and wetter than normal, and the Pryor Mountain population was at its greatest number during this time. Other seasons and years during the study experienced about average temperatures and precipitation, but lamb:ewe ratios were low and numbers declined during these "better than normal" conditions. Although weather was not considered a direct cause of low lamb:ewe ratios or the

declining herd size in the Pyrors, it has been related to lamb survival in other areas (Picton 1984, Douglas and Leslie 1986, Wehausen et al. 1987). Picton (1984) calculated significant relationships between climate indices and recruitment rates for bighorn sheep thought to be at carrying capacity (K); however, a reduction in sympatric elk resulted in non-significant relationships of climate indices and bighorn recruitment rates. Douglas and Leslie (1986) indicated increased precipitation was responsible for increased lamb survival, and Wehausen et al. (1987) had similar findings. Weather could also operate indirectly (Picton 1984). Low precipitation and extreme temperatures may impact growth of plants (Schultz et al. 1990). A longer series of data than mine would be necessary to address the impact of weather on the Pryor mountain herd and the association between weather and forage plant quality and quantity.

Interspecific competition was not rigorously assessed during this study. I measured overlap between species, while manipulations of populations are necessary to unambiguously address competition. Interspecific competition has been suggested to operate between bighorn sheep, mule deer, elk, and equids (St. John 1965, Oldemeyer et al. 1971, Constan 1972, Stelfox 1976, Coates and Schemnitz 1989) and should not be discounted as an ecological process occurring in the Pryor Mountains. The differential distribution of ungulate species I observed, especially deer in winter and bighorn sheep year round, may have been due to behavioral segregation to avoid interspecific interactions and not choice of optimal habitat as numbers of sheep and other ungulates increased (Hassell et al. 1994). Food habits of the ungulates were similar enough in some seasons to imply competition but not to confirm it. Additionally, the sheep population

growth was suppressed while the feral horse population continued to grow, a classic outcome of interspecific competition.

Loss of habitat has often been associated with bighorn sheep population declines (Crump 1971, Woodard et al. 1974, Wakelyn 1987). No direct loss of habitat occurred on the PMSA, but indirect loss through occupation of sheep habitat by horses, decreased quality due to weather, or over-exploitation of forage was possible. Sheep did increase range use in the Dryhead area when horse numbers were reduced in 1994, but I cannot prove that the sheep response was due to horse removal. Crump (1971) found addition of winter range, through the removal of livestock, provided for a growing bighorn herd. Woodard et al. (1974) described a declining bighorn sheep herd and thought it may have been related to a loss of winter habitat occupied by a cattle operation but was unsure of the ultimate cause.

Wakelyn (1987) examined 36 existing or historic bighorn sheep ranges and found ranges with more bighorn sheep had greater visibility, greater area dominated by grass and rock, and more habitat near escape terrain with greater topographic relief. Vegetative encroachment and fragmentation near escape terrain was greater in ranges that no longer supported bighorns in Colorado. Control of fire has lead to increases in conifer coverage in upper elevations of the Pryor Mountains, but most of the increase occurred before reoccupation of the area by sheep in the 1970's, and the rate of encroachment was unlikely to be rapid enough to precipitate the 1995 decline.

Mule Deer

The mule deer population on the PMSA, thought to be a single, discrete population, declined during the study. The decline may have been related to intraspecific competition, weather, harvest, disease, predation, or interspecific competition. With the exception of harvest, these factors are difficult to separate and in some instances may have a synergistic effect.

Average mule deer fawn recruitment rates from 1993 - 1996 were similar to rates previously reported for the Pryor Mountains (Foss and Whitney 1967, Firebaugh 1969, Foss et al. 1969) and some other eastern Montana mule deer populations (Schwarzkoph 1973, Hamlin 1974, Fritzen 1995). Firebaugh (1969) reported 54 and 32 fawns:100 does in the summers of 1967 and 1968, respectively. Recruitment rates reported in 1967 by Firebaugh likely decreased following the mortality of hunting and the winter season to rates similar to those reported during this study.

Several factors have been postulated as causing the fawn loss that produces low fawn:doe ratios in winter, but predation, as a proximate cause, has been frequently mentioned (Dood 1978, Steigers and Flinders 1980, Riley 1982, Hamlin et al. 1984, White et al. 1987). These investigations found losses varied from 12% to > 70%. I did not monitor fawn mortality or coyote distribution during this study, and only 1 coyote pair was known to have denned near mule deer summer range. An ultimate cause of coyote-mediated fawn mortality has been suggested to be snow depth, which may limit alternate prey populations (Hamlin et al. 1984) of coyotes.

The buck:doe ratios were similar to other populations in Montana (Dusek 1971,

Nyberg 1980, Rosgaard 1981, Fritzen 1995), and were typical of populations at cyclic lows (Pac et al. 1991) but were much lower than previously reported for the Pryor Mountains (Firebaugh 1969). Low buck:doe ratios may be a common situation in some environments and in seasonally hunted populations where bucks are selectively removed. Bucks on the PMSA also may have experienced more hunting pressure throughout the year than other Montana populations, as the CTIR, which contained summer range, had no set harvest season or other regulations on killing deer.

Weather is typically thought of as a density-independent factor which limits mule deer herds either directly through mortality or indirectly through influences on vegetation. Although snow depth, percent snow cover, temperature, and wind have been found to be related to mule deer survival (Picton 1984, Leckenby and Adams 1986, Wood et al. 1989), none of these factors deviated beyond the standard deviations in averages in the Pryors during 1993 - 1995.

Harvest fluctuated through time (Figure 39) and was not significantly correlated ($r = 0.513$, $p = 0.487$) with population size during the study. Harvest in deer management is assumed to be compensatory, in the sense that animals harvested would otherwise be lost from the population through natural mortality, and most deer populations are harvested during a limited season capitalizing upon this concept. However, in variable environments, such as the Pryor Mountains, compensatory processes may not effectively replace other mortality (Mackie et al. 1990). Mackie et al. provided examples of 5 populations of deer that did not respond in a compensatory fashion and indicated the pattern observed was related to the variable environments inhabited by these populations.

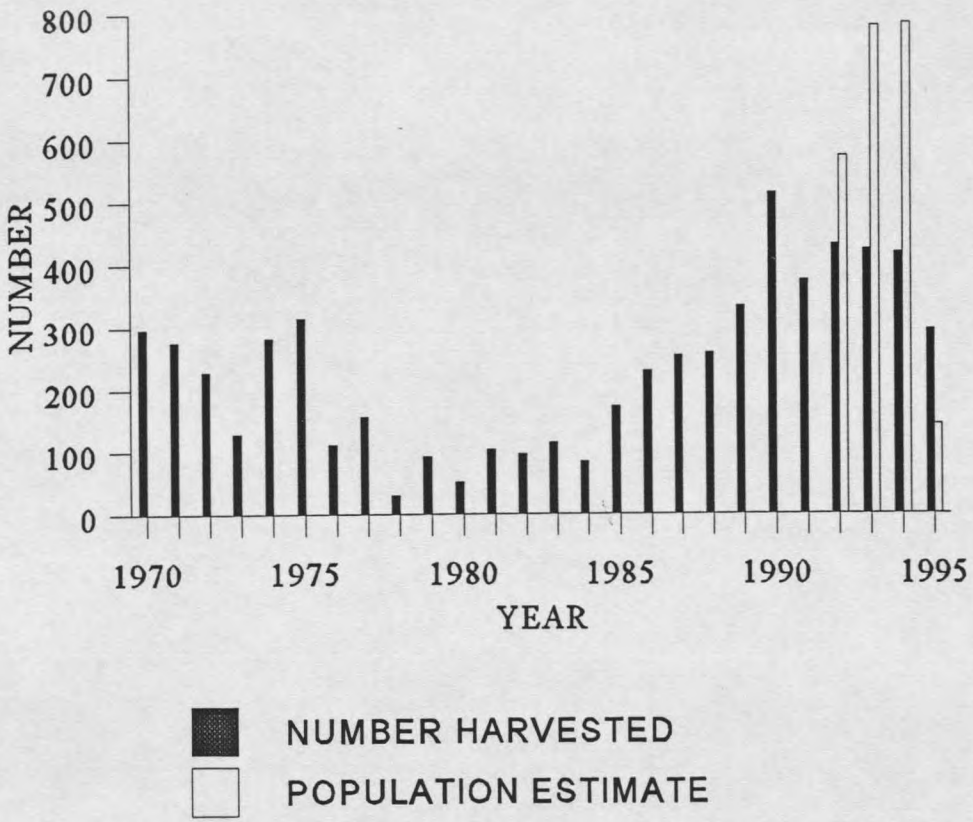


Figure 39. Estimated population size (open bars) of mule deer and mule deer harvest (solid bars) of hunting district 510, which encompasses the Pryor Mountain Study Area. Estimates given for 1993-1996 were calculated during this study using the joint hypergeometric maximum likelihood estimator and harvest figures were provided by Montana Department of Fish, Wildlife and Parks annual harvest reports (unpubl. data).

Additionally, the population of the Pryor Mountains experienced harvest pressure year round, from regular state seasons and unrestricted yearlong hunting on the CTIR. Although I have no data to support additive mortality as a cause of the Pryor Mountain mule deer herd decline, the possibility exists.

The prevalence of disease in mule deer prior to the Pryor Mountain population decline was unknown. Diseases found in the area (Hood 1995, Rhyan et al. 1995) are not common limiting factors in mule deer populations (Hibler 1981, Hoff and Trainer 1981, Wood et al. 1989). Hood (1995), in a disease survey in northeastern Bighorn county, Montana, approximately 90 km from the PMSA, documented antibodies for epizootic hemorrhagic disease (EHD) (31%), bovine viral diarrhea (31%), and parainfluenza virus 3 (37%) in deer. He strongly cautioned that the presence of antibodies does not necessarily mean presence of the disease. EHD is a major cause of epizootics in southeastern Montana but occurs primarily in white-tailed deer, and no carcasses with the symptoms were located in > 200 days in the field during summer. Only mule deer that had been preyed or scavenged upon were examined during this study, and no serological, histological, or cultural examinations were conducted on carcasses; only gross examinations were performed.

Predation can impact all segments of a population, although there is selection for young of the year and males (Hornocker 1970). While a percentage of fawn mortality is often due to predation (Dood 1978, Steigers and Flinders 1980, Riley 1982, Hamlin et al. 1984, White et al. 1987), the role of predators as a factor limiting populations generally has been questioned (Peek 1980, Theberge 1990) despite examples of cervid populations

being controlled by predators (McCullough 1979, Hass 1989, Gasaway et al. 1992, Turner et al. 1992, Adams et al. 1995, McNay and Voller 1995, Wehausen 1996). Predation of adults was not known to be a mortality factor in summer for the Pryor Mountain mule deer population, but older fawns and yearlings were killed during winter. Given the lack of information regarding predation's role as a limiting factor during winter or summer and the unexplained cause of the population decline, further study would be beneficial.

Interspecific competition as a limiting factor of mule deer was not expected, with either bighorn sheep (McCullough 1980, Mackie 1981) or feral horses (Salter 1979, Hanley and Hanley 1982). Competition between mule deer and horses, or between mule deer and other ungulates, related to forage could provide no evidence to confirm competition between the species (Potter and Hansen 1979, Salter 1979, Mackie 1981, Hanley and Hanley 1982).

Feral Horses

The feral horse population has fluctuated (Figure 40) between 86 and 270 animals (Fiest and McCullough 1975, Garrott and Taylor 1990) since establishment of the PMWHR. Although the population during this study never attained the size reported by Fiest and McCullough (1975), numbers were similar to those during 1976 - 1986 (Garrott and Taylor 1990) following a die-off in the winter of 1977-1978, in which 51% of the population was lost. They attributed the deaths to greater than normal snowfall with intermittent warm and cold temperatures creating crusting conditions and low availability of forage. Prior to 1977 - 1978, the foaling rate was one of the lowest reported in the

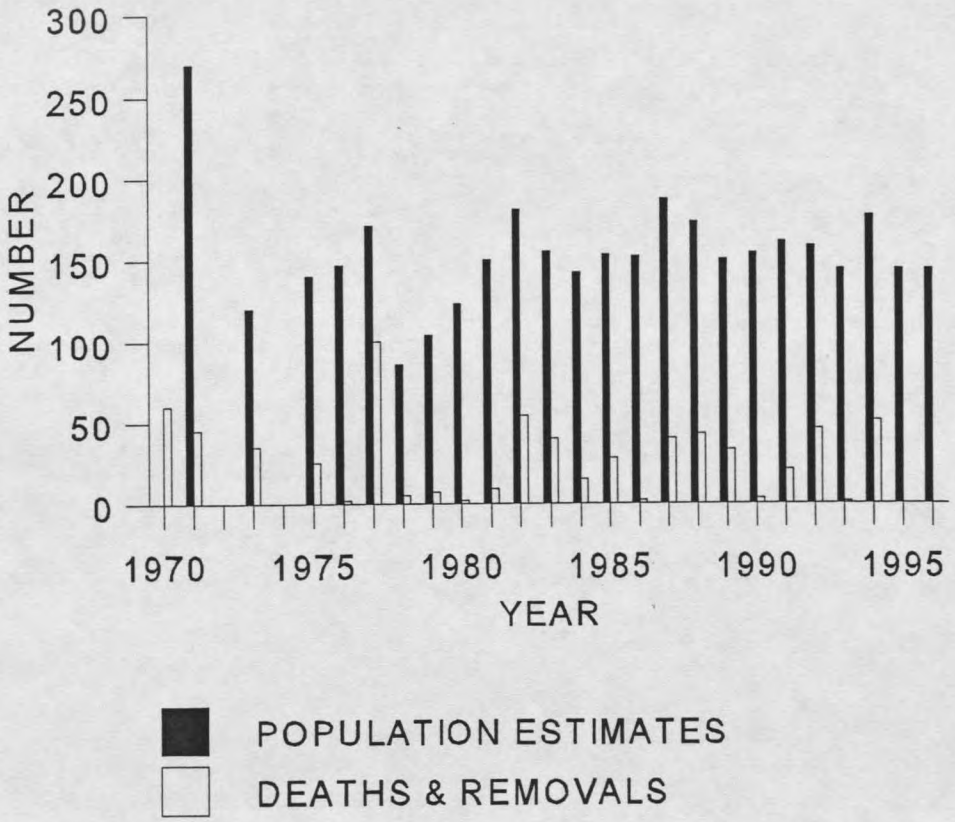


Figure 40. Population estimates (solid bars) and death and removals (open bars) of feral horses on the Pryor Mountain Wild Horse Range from 1971 - 1995. Data presented in 1971 were from Feist and McCullough (1975), from 1976 - 1986 data were from Garrott and Taylor (1990), from 1987 - 1992 data were from BLM (1996), and from 1993 - 1995 data were from this study.

literature (Eberhardt et al. 1982, Berger 1986). Following the die-off, Garrott and Taylor (1990) reported the foaling rate increased from 1979-1982 but decreased again from 1983 to 1986. The change in reproductive rate was suggested to be density-dependent, associated with intraspecific competition for forage. Excluding years of the die-off, the population maintained an average growth rate of 18%. This was similar to the growth rate observed during this study, as well as numerous other studies of feral horses (Wolfe 1980, Eberhardt et al. 1982, Wagner 1983, Berger 1986, Garrott et al. 1991).

Five factors affect the growth rate of feral horses: the percentage of mares foaling annually, the annual survival of foals and adults, the number of years mares are reproductive, the population size, and the age of animals removed during culling operations. Turner et al. (1992) summarized the percent of mares foaling annually in feral populations as ranging from 37% - 71%. The mean foaling rate reported in this study was within that range and was similar to annual foaling rates previously reported for the Pryor Mountain horse herd (Fiest and McCullough 1975, Garrott and Taylor 1990). Fiest and McCullough reported an annual foaling rate of 43% and Garrott and Taylor reported an average annual foaling rate of 27%. Maximum foaling rates have been suggested as high as 90% (Eberhardt et al. 1982), but given the relatively poor range conditions on the PMSA (Cleary and MacIntyre 1973, BLM 1984, BLM 1992), an annual foaling rate of 43% may be expected for the population.

The annual survival rates of foals and adults on the PMWHR were exceptionally high (> 90%) and should be considered estimates of maximum survival rates, as there was no subset of the feral horse population sampled in a manner that made it possible to

accurately determine survival. Garrott and Taylor (1990) reported survival rates of 93% - 99% in most years. Survival rates lower than 90% occur only under severe snow cover conditions as noted by Garrott and Taylor (1990). The severe conditions they described did not occur during this study, and survival was not expected to be less than 90%. With such high survival and reproductive rates, the PMWHR population could double in size every 4 - 7 years (Eberhardt et al. 1982, Garrott et al. 1991).

The number of years mares produce foals, in conjunction with survival of foals, has a direct impact on the population size. Fecundity of mares was expected to peak by age 5 and remain high until age 20 or death (Eberhardt et al. 1982, Garrott et al. 1991). Given the maximum reproductive rate, foal survival, and the span of time a mare is reproductively active, each mare will likely produce no less than 7 offspring in a lifetime.

Garrott and Taylor (1990) hypothesized that population size of the Pryor Mountain feral horse herd affected population growth in a density-dependent manner by reducing foaling rates with increased densities. At higher densities, they suggested plant communities were affected by herbivory, and this ultimately affected reproduction; however, they noted no data were available to substantiate a density-dependent effect.

The age of feral horses culled on other horse ranges (Kirkpatrick and Turner 1991) has been observed to affect population growth rate. Removal of young of the year or foals without removal of the associated mares may result in mares exhibiting compensatory reproduction. In contrast, selective removal of mares > 3 years of age would likely reduce not only population growth rate, but the added demands placed on the resources by reproductively active (i.e., pregnant/lactating) mares.

CONCLUSIONS AND RECOMMENDATIONS

Seven conclusions may be drawn from this study. Each conclusion has associated implications given the unique ungulate community, range conditions, and social and political environments surrounding the Pryor Mountains.

1. Ungulates were spatially segregated most of the year due to either interspecific interactions or inherent habitat preferences. Spatial overlap was least when food habits were most similar and most when food habits were least similar or densities were lowest. Further work is necessary to determine the ultimate consequences of these relationships.
2. Food habits overlapped seasonally, with substantial overlap between bighorns sheep and horses and bighorn sheep and mule deer. The food habits of bighorn sheep, mule deer, and horses appeared to have changed over time (forage classes and major forage species within forage classes), but still exhibited a great amount of seasonal overlap. The status and dynamics of resources (i.e., limited or unlimited, poor or good, stable or declining) should be determined to enable managers to better assess population interactions.
3. Low densities and/or spatial distributions limited direct opportunity for interactions between species. Further, neither interference nor exploitative competition were evident during 1993 - 1995. Determination of the existence and magnitude of competition requires natural or artificial population manipulations.
4. The bighorn sheep population was believed to decline at least during 1994 - 1996

based on point estimates and biological factors. Possible factors responsible, in order of likelihood, were seasonal forage quality, predation, weather, and disease. These competing hypotheses should be investigated more closely.

5. The mule deer population also declined during 1995 - 1996 in apparent association with a general regional decline which may be linked to weather. Given the yearlong harvest pressure to which segments of Pryor Mountain mule deer populations are subjected, the possible impacts of hunting should be investigated more closely.
6. The feral horse population was increasing. Average weather conditions and periodic culling appear to be keeping the population in a structural and physiological state that supports high foal production and survival. An alternative culling protocol involving the selective removal of older mares with foals may reduce the population growth rate.
7. Habitat use by each of the ungulate species was different. These factors should be considered if habitat alterations are to be employed in the proximity of the mutual distributions (i.e., within the PMWHR). Habitat alterations outside of the PMWHR will likely have different behavioral and ecological results.

Harvest

Mule deer and bighorn sheep populations declined 1 year apart from one another while the horse population continued to increase and has been observed to only be limited by weather events or culling. Growth of both bighorn sheep and mule deer populations

ceased, and populations declined sharply during 1994 and 1995, respectively, while the feral horse population continued to increased. Given the sudden, steep declines of the deer and sheep populations, harvest manipulation may be advisable.

Decreasing harvest of bighorn rams may aid in prevention of a genetic bottleneck (Ryman et al 1981) if the decline continues. Harvest of rams represented approximately 10% of the male population before the decline; with a decrease in the ram population, the percentage of the male population harvested may increase two-fold or more. Once the population is stable, harvest of ewes has been found to increase size of rams by reducing the density of ewes, lambs and yearlings on the lambing and summer grounds (Jorgenson et al. 1993) thus providing for favorable growth and survival of male lambs.

To help increase the mule deer population size, agencies regulating hunting may want to consider special regulations addressing harvest. Prohibiting harvest of antlerless deer in the short-term might help the population increase more quickly than possible with regulations under which harvest was controlled during 1993 - 1996. However, it should be noted, the mule deer populations of eastern Montana have experienced cyclic-like fluctuations (Hamlin and Mackie 1989, Wood et al. 1989) during the last 3 decades, and this population will likely recover as others have done in the past.

The horse population has continued to exhibit high population growth rates in association with periodic culling. Culling of more mares ≥ 3 yrs. old with young of the year or foals might reduce the population growth rate in horses to the benefit of bighorn sheep and mule deer.

Water Developments and Fire

Repair of existing or placement of new water sources may enhance bighorn sheep and feral horse distribution if other factors are concurrently modified (e.g., grazing system or other habitat modifications). The most beneficial locations for water source improvement (Figure 41) would be in areas adjacent to the edge of current distribution or areas where use may be enhanced seasonally. It should be noted, however, in desert bighorn and mule deer populations water developments were not important factors (Krausman and Etchberger 1995), and changing water distribution could result in species distribution shifts that could increase spatial, habitat, and forage overlap among sheep, deer, and horses.

The water catchment on Sykes Ridge is in need of repair and would likely enhance use of the area. Bighorn rams and feral horses make use of the area in summer and fall, when free water is least abundant. Two other recommended sites of water catchment development are on the southern end of Sykes ridge and northwest of the BLM-NFS boundary on Burnt Timber Ridge. A water development on the southern end of Sykes Ridge is expected to benefit ewes during the lambing season by reducing sheep grazing and browsing pressure in and adjacent to the Bighorn Canyon. A water catchment located northwest of the BLM-NFS boundary on Burnt Timber Ridge would benefit ewes, rams, and feral horses, with relative benefits for each group dependent upon its exact placement. Rams use this area only periodically and for short duration, likely because of the distance to a reliable water source. Ewes that occasionally use the open slopes between the Burnt Timber Ridge and Crooked Creek may use a water source and the surrounding area more

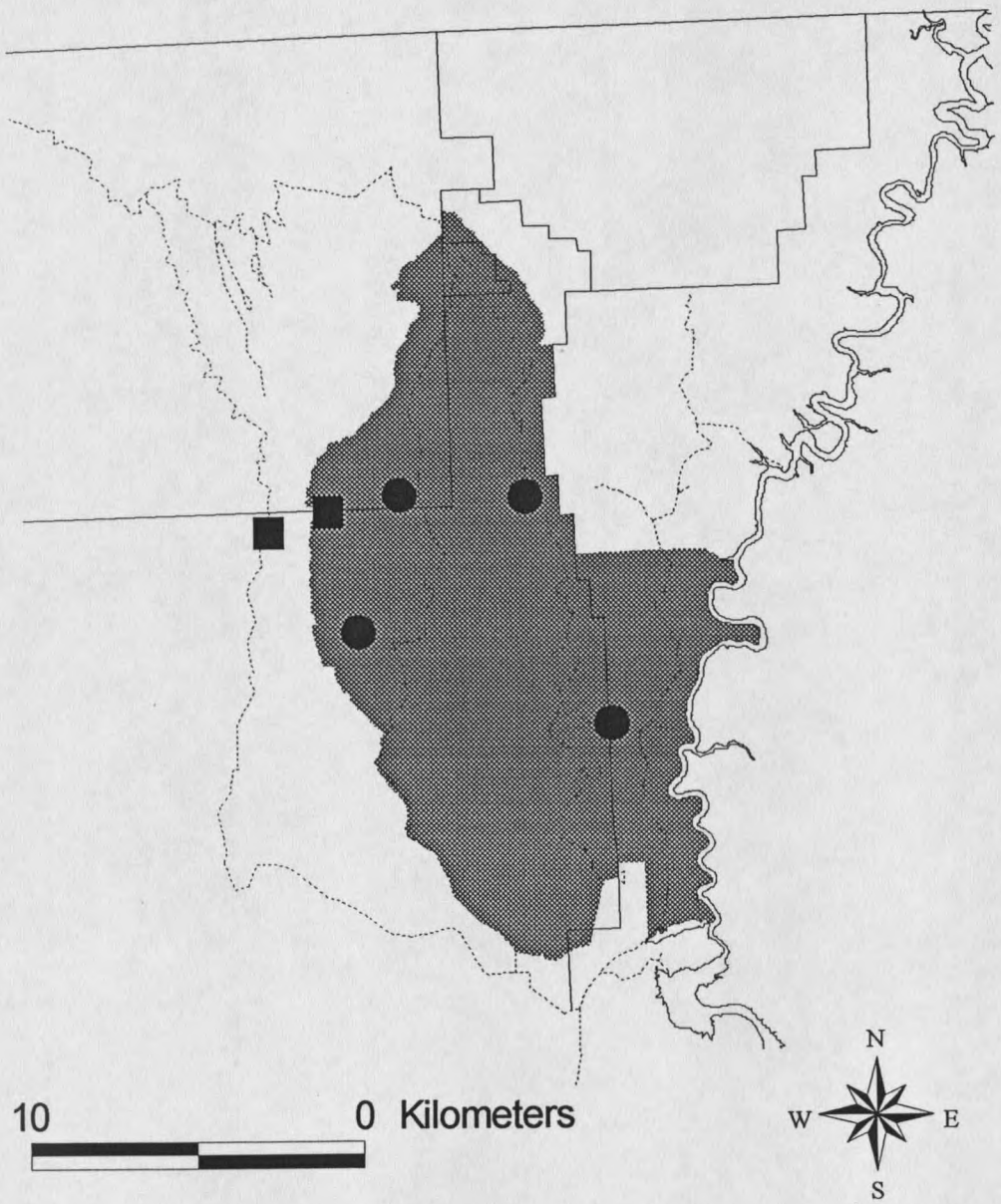


Figure 41. Recommended locations for water development modifications (circles) and potential fire treatment areas (squares) in relation to roads to enhance bighorn sheep, mule deer, and feral horse population distributions. See text for specific recommendations.

in this location if it were near escape terrain. Feral horses used this area, but it was a minor portion of the deer range in 1993 - 1996. This water development would likely increase the distribution of horses and their use of the Burnt Timber Ridge. The water development northwest of the Tillet Ridge was a source of water for feral horses during the study. I recommend this water source be isolated or eliminated such that the distribution of feral horses is greater and shifted elsewhere, especially during the spring and summer months.

Fire has been used routinely to improve range conditions for livestock, but benefits usually endure for only a few years at most (Slovlin et al. 1983, Hobbs and Spowart 1984). Given the dry conditions, slow growth, and unknown fire history of the lower portions of the PMSA, it would be advisable to determine the effect of different fire frequencies on plant communities on a small scale before conducting large scale alterations. Tentatively, two locations (Figure 41) on the PMSA might be considered for burning to enhance sheep habitat and use. Burning at other locations at higher elevations would likely benefit horses, and potentially bighorn sheep in the short-term. However, the fire frequency/history and potential negative responses should be known before such actions are taken.

One location that could result in further expansion and more use by bighorn sheep if burned is the area from the BLM-NFS boundary on Crooked Creek road south approximately 0.8 km and from the edge of Crooked Creek canyon west to the base of the Big Pryor Mountain. The establishment of a water development near the base of the Big Pryor Mountain would facilitate use. The second location that may benefit bighorn sheep

and feral horses if burned would be the flat south of the NFS boundary and east of Crooked Creek above the canyon. Bighorn sheep have been observed using this area for lambing during the last 3 years, but with decreasing visibility use may be deterred in the future.

Grazing System for Horses

The year long, continuous grazing system employed by the BLM for horses since the inception of the PMWHR has resulted in apparent continued decline in range conditions and a greater potential for soil loss (Firebaugh 1969, Gordon and Coop 1973, Hall 1973, BLM 1984, BLM 1992). Crump (1971) and Stelfox (1976) both indicated that bighorn sheep population size improved with the removal of livestock. Yeo et al. (1993) noted that grazing systems such as rest rotation or deferred rotation provide benefits to both mule deer and elk. Grazing systems used to improve range conditions, both for livestock and wildlife, are very popular, although they must be planned and implemented with specific objectives for specific species. A deferred-rotation or rest-rotation system may benefit range conditions on the PMWHR, but the impacts on overlap in use of resources by sheep, deer, and horses could be positive or negative. The use of a grazing system might reduce both spatial and forage competition between feral horses and bighorn sheep in spring and summer by restricting horse distributions, and, as range conditions improved, it could increase overall forage quantity thereby reducing the potential for competition between mule deer and bighorn sheep. A grazing system could also increase uniformity of use of forage in pastures occupied by horses, depriving sheep and deer of underutilized

pockets of habitat. It could also force horses to seasonally use areas within pastures that they do not at present by denying them choice in movement.

The impact of removing forage during spring and summer on winter forage availability was not examined during this study but should also be of concern. Schallenberger (1966) suggested horses grazed on bluebunch wheatgrass during summer in the Sun River canyon of west-central Montana used forage needed by bighorn sheep in winter. Given the continuous, yearlong grazing system used as the management approach for horses in the PMWHR and a non-migratory bighorn sheep population, the impact of summer grazing on forage availability in winter should be given further attention. Given the change in food habits between Coates and Schemnitz's (1989) study and this study, it is possible vegetative changes due to grazing may have occurred.

Instituting a managed grazing system could decrease overlap of space and forage and potentially allow for greater numbers of horses, sheep, and deer in the future. However, a grazing system would require water developments and fencing for success.

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APPENDICES

APPENDIX A

Marked Animals

Table 14 Information for bighorn sheep radiocollared on the Pryor Mountain Study Area.

ANIMAL NUMBER	DATE COLLARED	SEX[a]	AGE[b]	COLLAR FREQUENCY	COLLAR DESCRIPTION[c]	FATE AS OF AUGUST 1995
1	9-21-92	F	JUV	151.315	B/O ARROWS	ALIVE
2	9-21-92	F	JUV	151.861	B/O 10	DEAD
3	9-21-92	F	AD	151.190	B/O PLUSES	ALIVE
4	9-21-92	F	AD	151.440	B/O DOT HORZ. DASH	UNK
5	9-21-92	F	AD	151.750	B/O SOLID HORZ. LINE	UNK
6	9-21-92	F	AD	151.209	B/O HEARTS	DEAD
7	9-21-92	F	AD	150.859	B/O DASH EQUALS	UNK
8	9-21-92	F	AD	150.990	B/O SOLID BOXES	ALIVE
9	9-21-92	F	AD	151.491	B/O ST'S	ALIVE
10	1-14-93	M	AD	150.250	B/Y SQUIGGLE	ALIVE
11	1-14-93	M	AD	151.769	B/O LAZY 3'S	ALIVE
12	1-14-93	F	JUV	151.016	B/Y OPEN CIRCLES	ALIVE
13	1-14-93	F	AD	150.977	B/Y LAZY 2'S	DEAD
14	1-14-93	F	AD	150.915	B/O F'S	DEAD
15	1-14-93	F	JUV	151.393	B/Y HORZ. DASHES	ALIVE
16	1-14-93	F	JUV	151.552	B/O SOLID CIRCLES	DEAD
17	1-14-93	F	AD	151.240	B/Y SOLID TRIANGLES	ALIVE
18	1-14-93	M	AD	150.339	B/O X'S	ALIVE
19	1-15-93	F	JUV	151.562	B/O VERT. DASH DOT	ALIVE
20	1-15-93	M	JUV	151.380	B/O CRESENTS	ALIVE
21	4-7-94	F	AD	151.209	B/O HEARTS	UNK
22	4-8-94	F	AD	150.977	B/Y LAZY 2'S	UNK
23	4-8-94	F	JUV	150.293	B/Y ALTERNATE BARS	ALIVE
24	6-27-95	F	JUV	150.155	B/BL PLUSES	ALIVE
25	7-9-95	F	JUV	150.149	SOLID BLACK	ALIVE
26	7-14-95	F	AD	150.450	B/W STARS	ALIVE

[a]F = Female; M = Male.
[b]AD = Adult; Juv = Juvenile.
[c]B = Black; BL = Blue; O = Orange; W = White; Y = Yellow.

Table 15. Information for mule deer radiocollared on the Pryor Mountain Study Area.

ANIMAL NUMBER	DATE COLLARED	SEX[a]	AGE[b]	COLLAR FREQUENCY	COLLAR DESCRIPTION[c]	FATE AS OF AUGUST 1995
1	1-14-93	F	AD	151.717	B/O OPEN BOXES	ALIVE
2	1-14-93	F	AD	150.728	B/O DOT HORZ. DASH	UNK
3	1-15-93	M	AD	150.744	B/O ZIG ZAG	DEAD
4	1-15-93	F	AD	151.069	B/O DIAMONDS	ALIVE
5	1-15-93	F	AD	150.959	B/O DOTS IN STRIPES	ALIVE
6	1-15-93	M	JUV	150.265	B/Y HEARTS	UNK
7	1-15-93	F	AD	150.293	B/Y ALTERNATE DASH	DEAD
8	1-15-93	F	AD	151.990	W/G SOLID DOTS	UNK
9	1-15-93	F	AD	150.886	B/O ALTERNATE DOTS	UNK
10	1-15-93	F	AD	151.289	B/Y VERTICAL LINES	DEAD
11	1-15-93	M	AD	151.805	B/Y LAZY M'S	UNK
12	1-15-93	F	AD	151.512	B/O M'S	UNK
13	1-15-93	F	AD	150.120	B/W PLUSES	UNK
14	1-15-93	F	AD	151.658	Y/G OPEN CIRCLES	UNK
15	1-15-93	F	AD	150.929	W/R BROKEN H'S	UNK
16	1-15-93	F	AD	150.280	B/Y OPEN BOXES	UNK
17	1-15-93	F	AD	151.268	B/O BROKEN H'S	UNK
18	1-15-94	F	YOY	150.625	B/BL DOT DIAMOND	ALIVE
19	1-21-94	M	JUV	150.500	B/BL ARROWS	DEAD
20	2-3-94	M	YOY	150.250	B/BL 2 HORZ STRIPES	UNK
21	2-5-94	F	AD	150.375	B/BL SLASH BOX	UNK
22	2-9-94	M	JUV	150.575	B/BL BAR THRU DOT	DEAD
23	2-15-94	F	YOY	151.550	B/W SLASHES	ALIVE
24	2-16-94	F	YOY	151.450	B/W STARS	UNK
25	2-16-94	F	AD	150.275	B/W SLASH DASH	ALIVE

[a]F = Female; M = Male.
[b]AD = Adult; JUV = Juvenile; YOY = Young of the year.
[c]B = Black; BL = Blue; G = Green; O = Orange; R = Red; W = White; Y = Yellow.

Table 16. Description of marked feral horses on the Pryor Mountain Study Area.

ANIMAL	COLOR	SEX	AGE	FATE AS OF AUGUST 1995
1	Sorel	M	Adult	Alive
2	Grulla	F	Adult	Alive
3	Dun	F	Adult	Alive
4	Buckskin	F	Adult	Alive
5	Buckskin	F	Juvenile	Alive
6	Sabina	F	Adult	Alive
7	Bay	F	Adult	Alive
8	Blue Roan	F	Adult	Alive
9	Black	F	Adult	Alive
10	Black	M	Adult	Alive
11	Bay	F	Adult	Alive
12	Black	M	Adult	Alive
13	Grulla	F	Adult	Alive
14	Buckskin	F	Adult	Alive
15	Dun	F	Adult	Alive
16	Black	M	Adult	Alive
17	Black	F	Adult	Alive
18	Sorel	M	Adult	Alive
19	Red Roan	M	Adult	Alive
20	White	F	Adult	Alive

APPENDIX B

Seasonal Food Habits

Table 17. Mean percent diet composition as determined by microhistological identification of epidermal fragments for bighorn sheep on the Pryor Mountain Study Area, 1993-1995; n = 2 for all samples.

	WIN	WIN	WIN	SPR	SPR	SUM	SUM	FALL	FALL
PLANT	1993	1994	1995	1993	1994	1993	1995	1993	1994
Achillea millefolium	----	0.9	0.15	0.6	----	----	0.2	0.2	0.4
Arenaria hookeri	----	----	----	----	----	----	0.45	----	----
Astragalus oreganus	----	----	----	1.45	----	0.4	0.3	0.3	----
Descurainia pinnata	----	----	----	0.6	----	----	----	----	----
Erigeron spp.	----	0.4	----	2.8	1.0	0.45	0.3	0.25	0.1
Eriogonum spp.	----	----	----	0.5	----	0.55	0.3	----	----
Erysimum/Lithospermum spp.	----	----	----	12.8	1.1	1.95	----	0.05	0.2
Gaura coccinea	----	----	----	0.45	----	----	----	----	----
Halogeton spp.	----	----	0.15	----	0.2	----	----	0.25	----
Helianthus spp.	----	----	----	0.3	----	----	----	----	----
Lesquerella alpina	0.75	----	0.15	0.25	0.2	0.5	----	0.85	0.2
Lupinus spp.	----	0.2	0.15	0.25	0.2	----	----	----	----
Phlox hoodii	1.3	1.1	10.0	1.4	1.3	0.3	1.2	----	1.7
Senecio canus	----	0.3	----	----	----	----	----	----	----
Sphaeralcea spp.	----	----	----	----	----	0.05	----	----	----
Tragopogon dubius	----	----	0.75	0.1	----	----	----	----	----
Trifolium spp.	----	----	0.05	----	----	----	----	----	----
Yucca glauca	0.5	4.1	----	----	----	0.1	0.15	0.55	0.2
Other Forbs	0.1	1.2	1.6	3.9	2.7	1.3	2.95	0.95	2.15
Total Forbs	2.65	7.7	13.0	25.4	6.7	5.6	5.9	3.4	4.95
Amelanchier alnifolia	----	----	0.35	0.1	1.3	0.45	----	0.7	----
Artemesia frigida	----	1.3	0.85	0.05	1.6	1.45	2.3	2.4	0.5
Artemisia spp.	4.8	7.9	1.0	5.75	----	1.4	0.75	4.05	5.2
Atriplex spp.	0.1	0.7	0.1	----	----	----	0.3	1.15	0.5
Ceratoides lanata	2.65	5.6	3.6	0.2	3.8	8.45	14.95	6.95	3.5
Cercocarpus ledifolius	68.55	31.75	25.1	4.1	17.6	32.5	36.9	51.35	39.55
C. ledifolius stem	2.1	1.65	----	----	----	----	0.35	8.05	5.8

Table 17. Continued.

Chrysothamnus spp.	0.1	------	0.1	1.6	0.2	0.8	0.85	------	0.4
Juniperus spp.	9.95	5.15	------	------	------	------	------	1.55	------
Physocarpus spp.	-------	1.1	1.0	0.5	0.2	------	0.05	0.9	0.6
Pinus flexilis	-------	------	------	1.2	------	------	------	------	------
Salix/Populus spp.	5.15	1.0	1.15	------	0.2	0.2	3.05	0.45	0.4
Sambucus spp.	-------	0.4	------	------	------	------	------	------	------
Sarcobatus vermiculatus	0.2	------	0.3	------	------	------	------	------	------
Shepherdia spp.	-------	------	------	------	------	0.1	------	------	------
Other Shrubs	0.15	1.05	0.4	0.25	0.4	0.6	------	1.45	------
Total Shrubs	93.75	57.6	33.95	13.25	25.3	45.95	59.5	79.0	56.45
Agropyron spp.	1.6	15.1	26.65	26.3	36.7	23.5	16.65	7.75	17.5
Agrostis spp.	-------	1.4	0.15	2.2	------	------	------	------	0.9
Andropogoan scoparlus	-------	0.2	------	------	------	0.65	------	------	------
Aristida fendleriana	-------	0.1	0.65	1.15	------	0.7	0.35	------	------
Bouteloua spp.	-------	0.25	0.5	0.2	------	0.6	0.4	------	------
Bromus japonicus	-------	3.75	2.5	1.5	2.7	0.15	0.55	2.2	3.35
Dactylis glomerata	-------	------	------	0.2	------	------	------	------	------
Distichlis spicata	-------	-------	-------	-------	-------	0.25	0.15	------	------
Elymus spp.	-------	-------	-------	0.3	------	0.95	------	------	------
Festuca idahoensis	------	1.85	1.4	4.25	------	3.1	0.65	0.3	0.3
Koeleria macrantha	-------	------	------	------	------	0.55	------	------	------
Oryzopsis hymenoides	0.45	0.8	0.35	0.9	0.9	0.15	------	0.65	0.6
Phleum spp.	------	0.4	------	------	------	------	------	------	------
Poa spp.	0.2	2.05	7.0	9.6	5.6	4.0	4.15	3.45	4.15
Sitanion hystrix	-------	0.25	1.15	0.1	------	0.35	------	0.35	0.2
Stipa spp.	0.95	5.35	7.35	5.0	7.6	11.0	7.8	2.55	8.35
Other Grasses	-------	1.9	1.0	1.35	2.7	1.0	0.4	------	2.55
Total Grasses	3.2	33.4	48.7	54.0	64.9	46.95	31.0	17.25	37.9

Table 17. Continued.

Carex spp.	0.1	1.1	3.4	4.55	------	1.35	3.3	0.3	0.5
Juncus spp.	------	------	------	------	1.1	------	0.3	------	------
Total Sedge/Rush	0.1	1.1	3.4	4.55	1.1	1.35	3.6	0.3	0.5
Lichen	------	------	0.85	------	------	------	------	------	------
Composite	0.3	0.2	0.1	2.55	2.0	0.15	------	0.05	0.2
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 18. Mean percent diet composition as determined by microhistological identification of epidermal fragments for mule deer on the Pryor Mountain Study Area, 1993-1995; n = 2 for all samples.

	WIN	WIN	WIN	SPR	SPR	SUM	SUM	FALL	FALL
PLANT	1993	1994	1995	1993	1994	1993	1995	1993	1994
Achillea millefolium	------	------	------	0.8	------	0.7	------	------	------
Arenaria hookeri	------	------	------	2.1	------	1.55	------	------	------
Aster spp.	------	------	------	------	------	0.4	------	------	------
Astragalus oreganus	------	------	------	1.7	5.0	1.15	0.8	------	------
Balsamorhiza spp.	------	------	------	------	0.2	0.05	0.05	------	------
Brassica spp.	------	------	------	------	------	0.2	------	------	------
Castilleja spp.	------	------	------	------	------	1.4	------	------	------
Centaurea spp.	------	------	------	0.5	0.45	------	------	------	------
Comandra umbellata	------	------	------	0.65	------	------	0.35	------	------
Cryptantha flavoculata	------	------	------	0.1	0.2	0.25	1.45	0.15	------
Erigeron spp.	0.1	0.15	------	------	0.65	2.45	1.3	0.3	------
Eriogonum spp.	------	------	------	------	------	------	0.35	------	------
Erysimum/Lithospermum spp.	------	0.25	------	14.65	41.9	11.5	2.0	0.6	------
Galium spp.	------	------	------	0.85	------	------	------	------	------
Gaura coccinea	------	------	------	1.7	0.4	0.2	0.3	------	------
Helianthus spp.	------	------	------	------	------	0.1	0.35	------	------
Lesquerella alpina	------	------	------	------	------	------	------	0.05	------
Lupinus spp.	------	------	------	6.35	3.65	0.2	0.45	------	------
Mentzelia spp.	------	------	------	1.15	------	------	------	------	------
Monarda spp.	------	------	------	6.85	------	------	------	------	------
Penstemon spp.	------	------	------	0.1	------	------	------	------	------
Phlox hoodii	------	------	------	------	------	0.45	------	------	------
Plantago spp.	------	------	------	1.05	------	------	0.05	------	------
Potentilla spp.	------	------	------	1.0	0.85	0.6	------	------	------
Pyrola spp.	------	------	------	------	0.35	0.35	------	------	------
Senecio canus	------	------	------	1.55	------	------	0.2	------	------
Sphaeralcea coccinea	------	0.05	------	------	------	------	------	------	------
Tragopogon dubius	------	------	------	------	------	0.25	0.15	------	------

Table 18. Continued.

Trifolium spp.	0.05	0.05	-------	12.45	------	------	1.4	0.5	0.1
Yucca glauca	-------	-------	------	0.5	------	------	------	0.05	------
Other Forbs	0.6	0.03	0.55	6.9	16.6	13.5	3.6	1.0	0.4
Total Forbs	0.75	0.53	0.55	60.95	49.25	35.3	12.8	2.7	0.5
Abies spp.	-------	-------	------	------	6.4	------	------	------	------
Acer spp.	-------	-------	------	1.1	2.05	------	------	------	------
Artemisia frigida	-------	-------	------	0.1	0.05	0.8	11.6	------	------
Artemisia spp.	13.8	3.55	7.0	0.9	2.1	3.75	9.3	5.9	2.3
Atriplex spp.	-------	0.95	0.7	------	------	------	0.9	------	------
Berberis spp.	-------	-------	------	------	4.3	0.1	------	------	------
Cercocarpus ledifolius	71.7	84.1	66.7	0.1	0.8	0.6	1.85	75.6	73.7
C. ledifolius stem	5.4	3.0	4.6	------	------	------	------	8.0	5.9
Chrysothamnus spp.	-------	-------	------	------	0.35	------	0.5	------	0.8
Juniperus spp.	6.8	6.4	19.4	------	8.2	4.4	7.85	7.8	15.6
Pinus flexilis	-------	0.45	------	------	3.75	4.9	------	------	------
Rhus trilobata	0.35	-------	0.35	23.05	0.2	------	0.35	------	------
Salix spp.	-------	-------	------	0.7	------	------	------	------	------
Salix/Populus	-------	-------	------	------	------	0.85	6.45	------	------
Sambucus spp.	-------	-------	------	------	1.1	------	------	------	------
Shepherdia spp.	-------	-------	------	5.8	0.55	37.15	------	------	------
Other Shrubs	0.55	0.35	0.55	0.1	0.35	0.9	0.8	------	T
Total Shrubs	98.6	98.9	99.3	31.85	30.2	53.45	39.6	97.3	98.6
Agropyron spp.	0.2	-------	------	0.8	1.5	0.35	7.4	------	0.2
Agrostis spp.	-------	-------	------	------	0.75	1.7	0.9	------	------
Andropogon scoparius	-------	-------	------	------	------	------	0.95	------	------
Aristida fendleriana	-------	-------	------	------	------	0.2	------	------	------
Bromus japonicus	-------	------	------	1.25	------	1.8	6.05	------	0.2

Table 18. Continued.

Dactylis glomerata	------	------	------	0.45	------	------	3.15	------	------
Festuca idahoensis	------	------	------	------	------	------	4.85	------	------
Koeleria macrantha	------	------	------	------	------	------	1.25	------	------
Oryzopsis hymenoides	------	------	------	------	------	------	3.95	------	------
Phleum spp.	------	------	------	------	------	------	3.5	------	------
Poa spp.	------	------	------	0.95	2.35	1.55	5.4	------	------
Sitanion hystrix	------	------	------	------	------	------	0.35	------	------
Stipa spp.	------	------	------	------	0.9	0.5	7.8	------	------
Other Grasses	0.3	------	0.1	0.1	0.8	0.35	1.3	0.05	------
Total Grasses	0.5	0.0	0.1	3.55	5.85	6.45	46.85	0.05	0.4
Carex spp.	------	------	0.15	------	12.8	0.35	0.45	------	------
Total Sedge/Rush	0.0	0.0	0.15	0.0	12.8	0.35	0.45	0.0	0.0
Lichen	------	0.45	------	------	0.3	------	------	------	0.6
Composite	------	------	------	0.9	1.2	4.45	0.3	------	------
Insect	------	------	------	------	0.2	------	------	------	------
Seed	------	------	------	0.1	------	------	------	------	------
Flower	------	------	------	2.65	0.2	------	------	------	------
Other	0.2	------	------	------	------	------	------	0.05	------
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 19. Mean percent diet composition as determined by microhistological identification of epidermal fragments for feral horses on the Pryor Mountain Study Area, 1993-1995; n = 2 for all samples.

	WIN	WIN	WIN	SPR	SPR	SUM	SUM	FALL	FALL
PLANT	1993	1994	1995	1993	1994	1993	1995	1993	1994
Achillea millefolium	------	0.35	------	------	0.1	------	0.3	0.35	------
Arenaria hookeri	------	------	------	------	------	------	------	0.45	------
Astragalus oreganus	0.05	------	------	1.05	------	0.1	------	------	0.15
Comandra umbellata	------	0.65	0.45	------	------	------	0.65	1.15	0.05
Cryptantha flavoculata	------	------	------	------	------	------	0.1	0.15	------
Erigeron spp.	------	------	------	0.05	0.25	------	------	0.15	------
Erysimum/Lithospermum spp.	------	0.25	0.05	0.15	------	0.3	------	0.1	------
Lesquerella alpina	------	0.5	------	------	------	------	0.1	------	------
Lupinus spp.	0.1	------	------	0.4	------	------	0.95	------	0.55
Brassica spp.	------	------	0.9	------	------	------	------	------	0.05
Phlox hoodii	6.05	8.10	0.55	0.35	0.1	------	10.1	4.25	------
Senecio canus	------	------	0.5	------	------	------	------	0.1	------
Tragopogon dubius	0.8	2.9	------	0.25	0.1	------	0.25	0.6	------
Trifolium spp.	------	------	------	------	------	------	------	0.05	------
Yucca glauca	------	------	------	------	------	------	0.25	------	0.45
Other Forbs	0.55	1.75	1.6	1.75	0.4	T	2.15	0.7	0.3
Total Forbs	7.55	14.5	4.05	4.0	0.95	1.2	14.9	8.05	1.55
Artemesia frigida	0.9	0.95	1.4	------	------	T	4.05	10.15	2.45
Artemisia spp.	1.35	3.2	0.05	0.2	0.55	T	5.05	1.9	0.1
Atriplex spp.	------	0.55	------	------	------	------	0.25	1.65	0.35
Ceratoides lanata	0.6	4.0	2.95	0.1	1.05	5.0	7.6	5.5	15.85
Cercocarpus ledifolius	------	1.65	------	------	------	------	0.25	0.25	1.05
Chrysothamnus spp.	0.4	0.2	2.5	------	------	0.15	0.4	2.4	0.5
Physocarpus spp.	------	------	------	0.15	1.1	0.65	------	------	------
Rhus trilobata	------	------	------	------	------	------	0.1	------	0.65
Sarcobatus vermiculatus	------	1.0	------	------	------	------	------	1.45	0.25
Sheperdia spp.	------	------	------	------	------	1.0	------	------	------

Table 19. Continued.

Other Shrubs	------	0.4	------	------	------	------	0.15	0.3	------
Total Shrubs	3.25	11.95	6.9	0.45	2.7	7.6	17.85	23.6	21.2
Agropyron spp.	28.9	27.2	36.75	29.95	43.9	29.85	17.0	26	30.15
Agrostis spp.	-------	1.9	0.85	1.35	0.25	0.45	0.3	------	2.0
Schizachyrium spp.	0.45	2.65	1.25	1.0	3.5	------	0.7	4.6	------
Aristida fendleriana	1.85	4.05	2.95	1.6	2.5	2.35	1.1	1.45	2.35
Bouteloua spp.	1.0	0.25	7.15	1.2	3.3	1.95	0.4	1.1	1.0
Bromus japonicus	6.9	6.0	3.05	2.5	0.95	1.6	1.7	4.7	0.8
Dactylis glomerata	-------	-------	------	0.2	------	0.75	------	------	------
Distichlis spicata	0.25	-------	------	------	0.15	------	------	0.35	------
Elymus spp.	-------	-------	------	0.25	------	1.2	------	------	------
Festuca idahoensis	5.2	2.15	3.35	7.95	5.5	6.05	7.3	0.35	4.6
Koeleria macrantha	2.15	1.3	0.6	1.05	0.15	1.75	0.8	3.15	0.95
Oryzopsis hymenoides	3.45	1.05	3.1	1.2	0.6	3.1	2.05	1.95	2.15
Phleum spp.	-------	0.45	------	0.45	------	0.5	------	------	------
Poa spp.	9.95	5.3	6.3	14.25	7.15	8.75	8.65	3.25	7.45
Sitanion hystrix	2.3	1.85	0.75	0.65	1.4	0.8	------	3.2	1.3
Sporobolus spp.	------	------	------	0.2	1.6	0.8	------	------	------
Stipa spp.	12.95	13.45	13.4	14.25	15.55	22.1	20.0	10.15	17.5
Other Grasses	0.6	2.05	1.1	1.1	3.25	2.3	1.15	2.7	2.1
Total Grasses	75.95	69.65	80.6	78.8	89.75	84.55	61.15	62.95	72.35
Carex spp.	11.85	2.95	3.75	9.7	5.1	3.4	4.75	4.45	4.25
Eleocharis spp.	------	------	-------	------	------	2.4	------	------	------
Juncus spp.	1.4	0.45	0.9	6.6	1.5	1.0	1.05	------	0.6
Total Sedge/Rush	13.25	3.4	4.65	16.3	6.6	6.8	5.8	4.45	4.85
Lichens	------	0.5	0.3	0.25	------	------	------	0.95	0.05
Composite	------	------	0.35	0.2	------	------	0.3	------	------
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 20. Wilcoxon and Kruskal-Wallis results of differences between years for like seasons for each species and forage class.

SPECIES	FORAGE CLASS	SEASON	Z-VALUE	P-VALUE
BIGHORNS	BROWSE	WINTER	0.267	0.875
BIGHORNS	BROWSE	SPRING	0.231	0.817
BIGHORNS	BROWSE	SUMMER	0.000	1.000
BIGHORNS	BROWSE	FALL	0.274	0.784
BIGHORNS	FORBS	WINTER	-0.612	0.540
BIGHORNS	FORBS	SPRING	NC[a]	NC
BIGHORNS	FORBS	SUMMER	NC	NC
BIGHORNS	FORBS	FALL	NC	NC
BIGHORNS	GRASSES	WINTER	2.655	0.265
BIGHORNS	GRASSES	SPRING	0.651	0.515
BIGHORNS	GRASSES	SUMMER	0.357	0.721
BIGHORNS	GRASSES	FALL	-1.098	0.272
DEER	BROWSE	WINTER	0.328	0.849
DEER	BROWSE	SPRING	0.959	0.349
DEER	BROWSE	SUMMER	-0.267	0.790
DEER	BROWSE	FALL	0.959	0.337
DEER	FORBS	WINTER	NC	NC
DEER	FORBS	SPRING	0.656	0.512
DEER	FORBS	SUMMER	-0.598	0.550
DEER	FORBS	FALL	NC	NC
DEER	GRASSES	WINTER	NC	NC
DEER	GRASSES	SPRING	NC	NC
DEER	GRASSES	SUMMER	-1.939	0.053
DEER	GRASSES	FALL	NC	NC
HORSES	BROWSE	WINTER	0.000	1.000
HORSES	BROWSE	SPRING	NC	NC
HORSES	BROWSE	SUMMER	0.000	1.000

Table 20 (continued)

HORSES	BROWSE	FALL	0.968	0.333
HORSES	FORBS	WINTER	0.894	0.371
HORSES	FORBS	SPRING	NC	NC
HORSES	FORBS	SUMMER	NC	NC
HORSES	FORBS	FALL	NC	NC
HORSES	GRASSES	WINTER	0.873	0.646
HORSES	GRASSES	SPRING	1.391	0.164
HORSES	GRASSES	SUMMER	0.996	0.320
HORSES	GRASSES	FALL	0.667	0.505

[a] No Comparison made.

APPENDIX C

Disease Characteristics

Table 21. Results of lungworm larvae analysis from fecal samples collected from bighorn sheep of the Pryor Mountain Study Area during summer, 1995.

DATE	N	% POSITIVE	LARVAE/GRAM
6 JUNE 1995	23	57	8.8
20 JUNE 1995	10	70	0.8
16 JULY 1995	11	55	13.7
31 JULY 1995	10	40	1.9
13 AUGUST 1995	40	20	0.4

Table 22. Results of gastrointestinal parasite analysis from fecal samples collected from bighorn sheep of the Pryor Mountain Study Area during summer, 1995.

DATE	N	MEAN EGGS/GRAM	GENUS IDENTIFIED
20 JUNE 1995	10	6	Marshallagia
31 JULY 1995	8	6	Marshallagia, Nematodirus
13 AUGUST 1995	32	13	Marshallagia

APPENDIX D

Habitat Associations

Table 23. Differences between distributions of habitat components for the Pryor Mountain Study Area between winter 1993 - summer 1995.

HABITAT COMPONENT	SEASON AND YEAR	D.F.	P-VALUE	CHI-SQUARE VALUE
ELEVATION	WINTER 1993	4	0.221	5.72
	SPRING 1993	6	0.000	91.9
	SUMMER 1993	6	0.000	135.3
	FALL 1993	6	0.000	22.9
	WINTER 1994	4	0.000	16.9
	SPRING 1994	6	0.000	108.5
	SUMMER 1994	6	0.000	44.4
	SUMMER 1995	6	0.000	91.7
SLOPE	WINTER 1993	6	0.185	8.81
	SPRING 1993	6	0.000	116.0
	SUMMER 1993	6	0.000	35.4
	FALL 1993	4	0.000	42.7
	WINTER 1994	4	0.005	15.1
	SPRING 1994	4	0.000	28.7
	SUMMER 1994	4	0.000	33.4
	SUMMER 1995	4	0.001	19.1
ASPECT	WINTER 1993	8	0.035	16.53
	SPRING 1993	8	0.000	73.0
	SUMMER 1993	8	0.000	38.71
	FALL 1993	8	0.103	13.27
	WINTER 1994	8	0.049	15.6
	SPRING 1994	6	0.000	28.6
	SUMMER 1994	8	0.022	17.94
	SUMMER 1995	8	0.013	19.3

Table 23. Continued.

VEGETATION	WINTER 1993	10	0.000	74.8
	SPRING 1993	10	0.000	76.4
	SUMMER 1993	10	0.000	183.9
	FALL 1993	10	0.000	90.6
	WINTER 1994	10	0.000	42.6
	SPRING 1994	10	0.002	28.3
	SUMMER 1994	10	0.000	46.4
	SUMMER 1995	10	0.000	101.3
DISTANCE TO WATER	WINTER 1993	4	0.001	19.2
	SPRING 1993	4	0.000	28.6
	SUMMER 1993	4	0.010	13.3
	FALL 1993	4	0.039	10.1
	WINTER 1994	4	0.000	24.0
	SPRING 1994	4	0.004	15.2
	SUMMER 1994	4	0.054	9.13
	SUMMER 1995	4	0.000	24.8
DISTANCE TO ROADS	WINTER 1993	4	0.001	13.3
	SPRING 1993	4	0.000	51.9
	SUMMER 1993	4	0.000	39.3
	FALL 1993	4	0.000	42.8
	WINTER 1994	4	0.000	38.6
	SPRING 1994	4	0.000	27.4
	SUMMER 1994	4	0.000	36.5
	SUMMER 1995	4	0.000	43.4

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