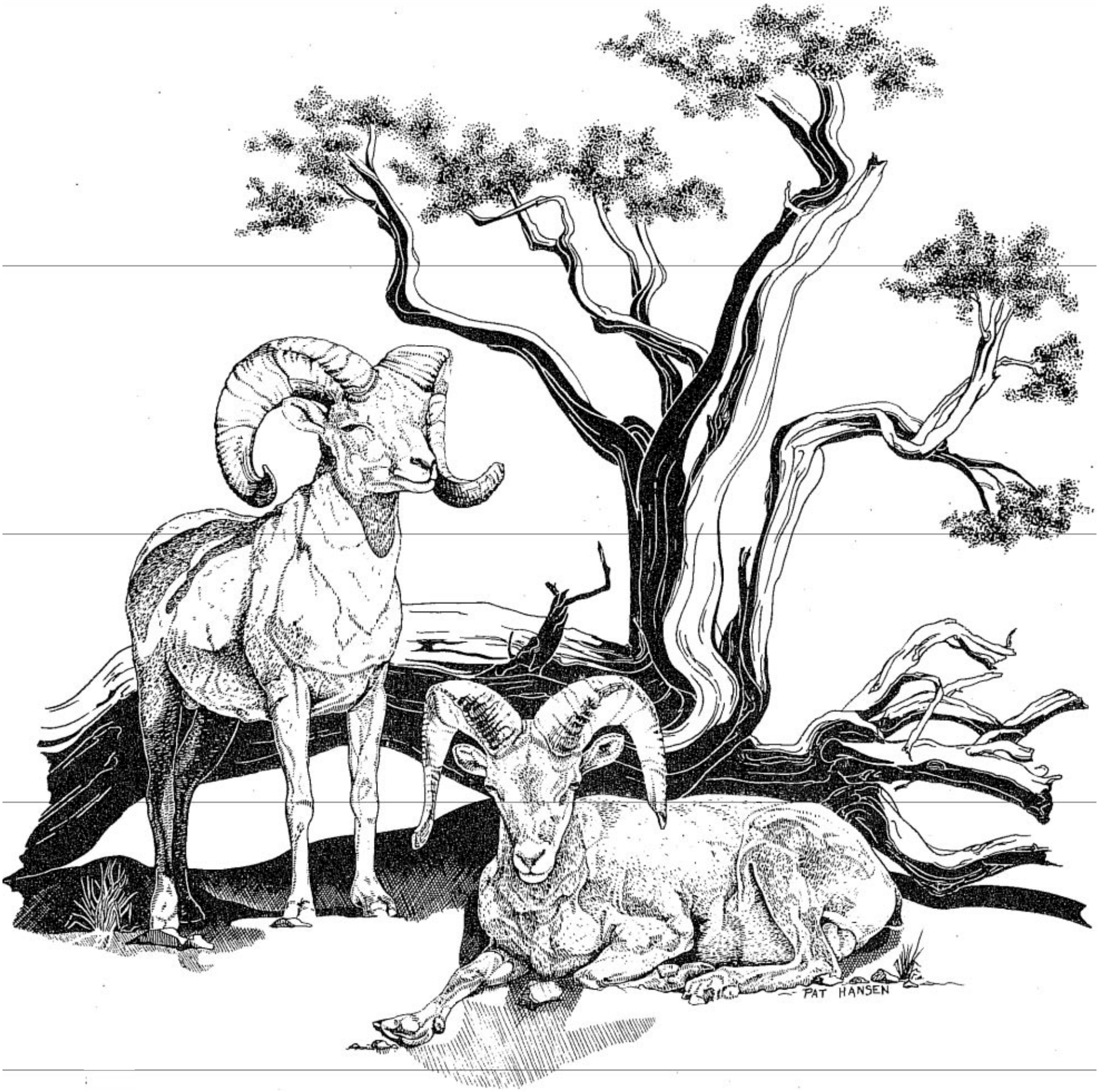
DESERT BIGHORN COUNCIL

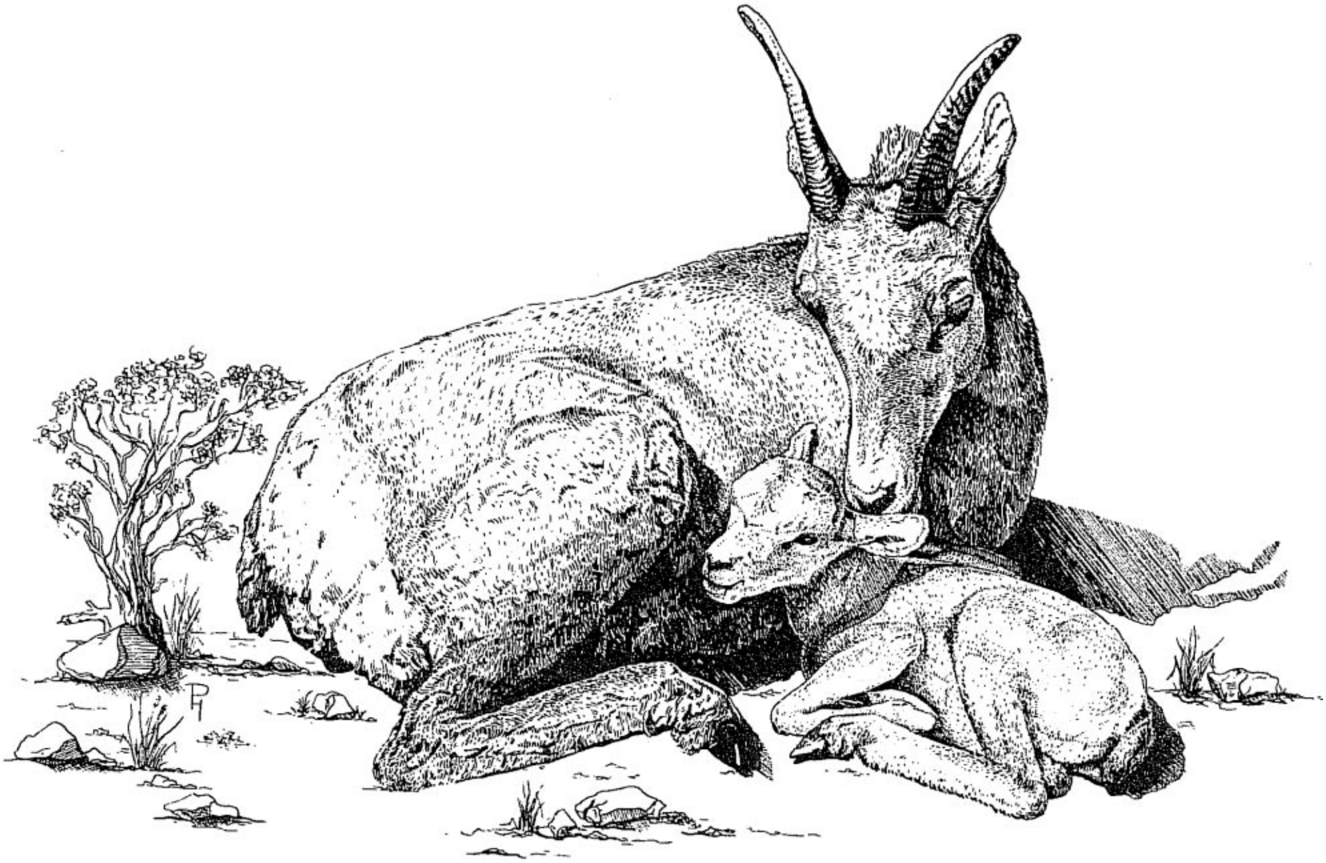


1984 TRANSACTIONS

Desert Bighorn Council
1984 Transactions

A Compilation of Papers Presented At the 28th Annual Meeting,

April 5-7, 1984, Bullhead City, Arizona



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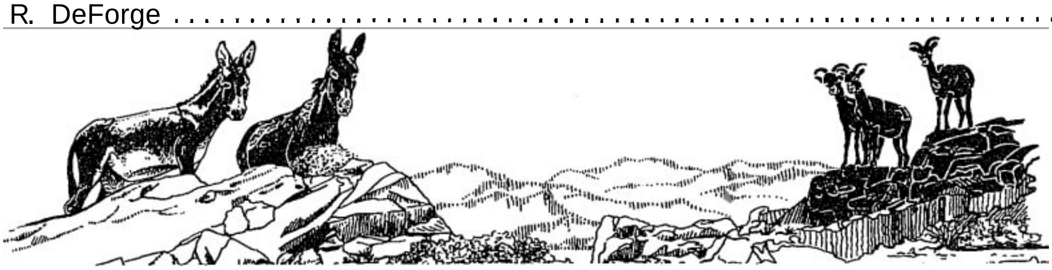

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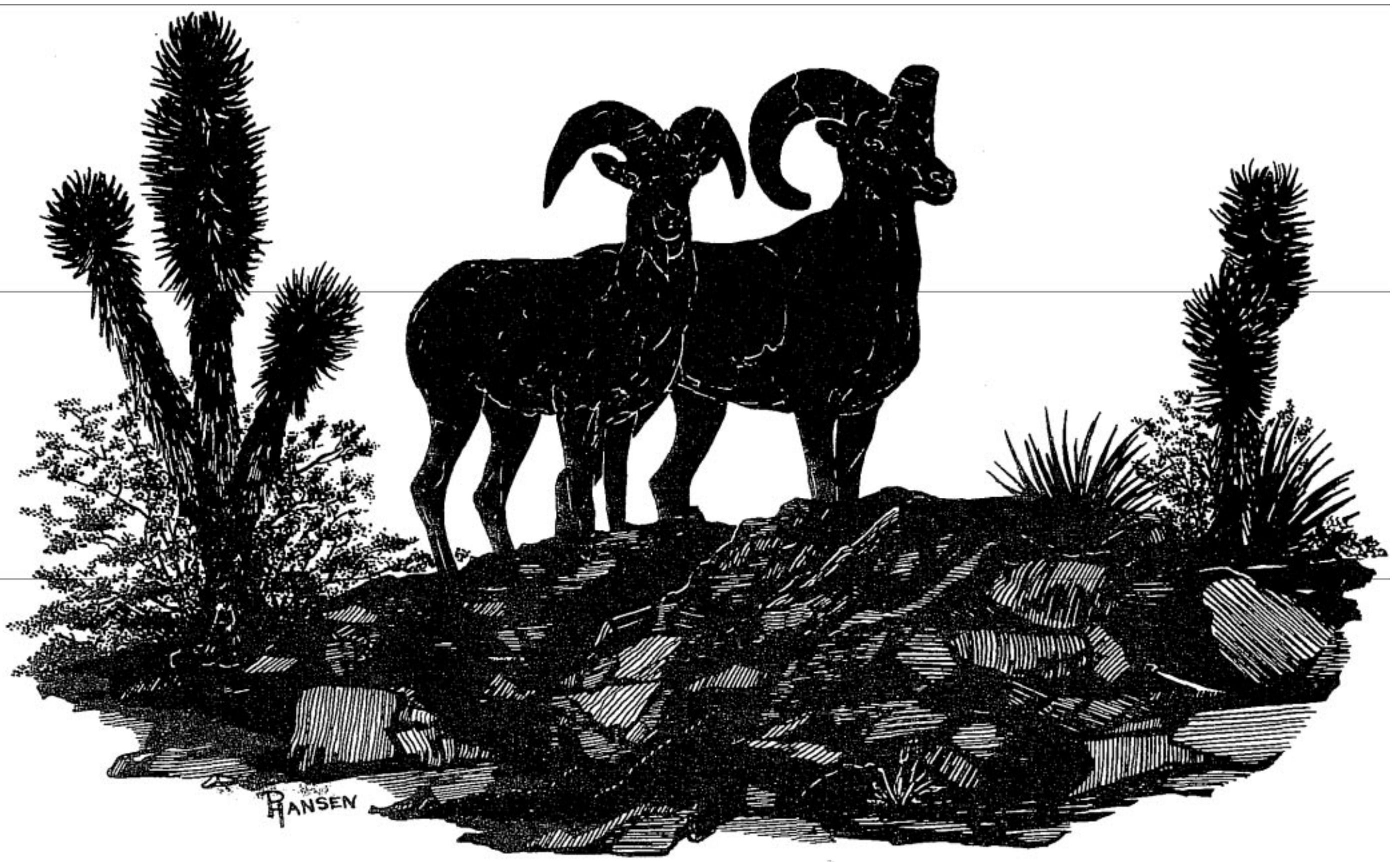

DESERT BIGHORN COUNCIL 1984 - 85

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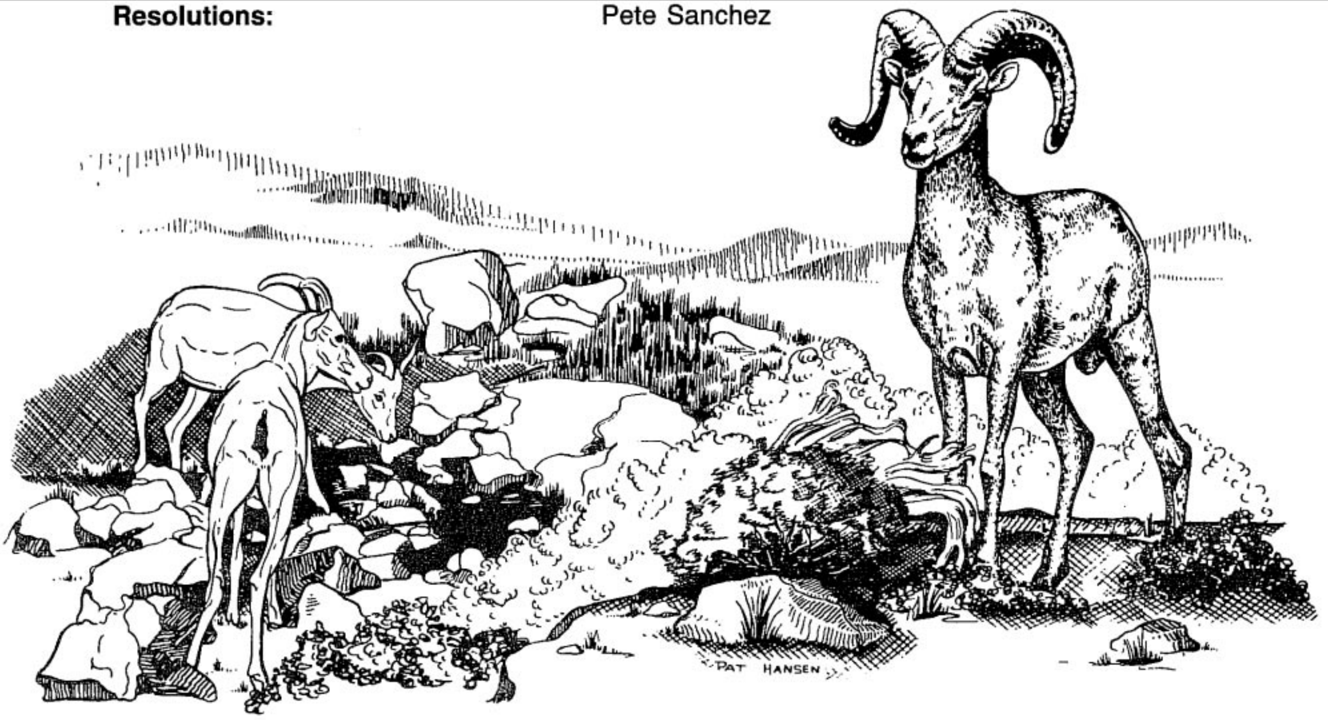

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DESERT BIGHORN COUNCIL MEETINGS AND OFFICERS
1957 — 1984 ANNUAL MEETINGS

Year	Location	Chairman	Secretary-Treasurer
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1958	Yuma, Arizona	Gale Monson and Warren Kelly	
1959	Death Valley, California	M. Clair Aldous	Fred Jones
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1981	Kerrville, Texas	Jack Kilpatric	Peter Sanchez
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1983	Silver City, New Mexico	Andrew Sandoval	Rick Brigham
1984	Bullhead City, Arizona	Jim de Vos. Jr.	Rick Brigham

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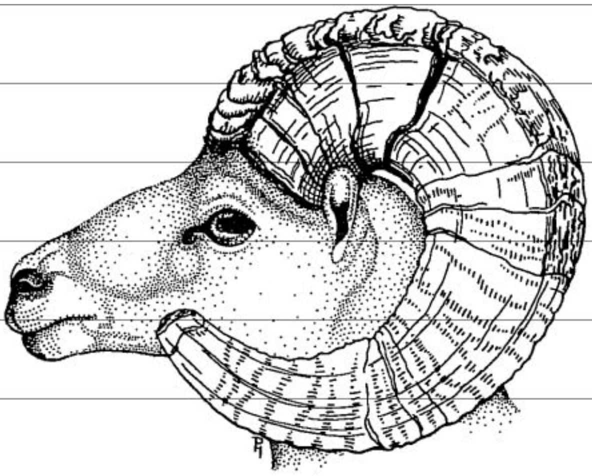

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BIGHORN TROPHY:

1960	Ralph and Florence Welles, U.S. National Park Service, Death Valley California
1962	Oscar V. Deming, U.S. Bureau Sports Fisheries and Wildlife, Lakeview, Oregon
1965	John P. Russo, Arizona Game and Fish Department, Phoenix, Arizona
1966	Charles Hansen, U.S. Bureau Sport Fisheries and Wildlife, Las Vegas, Nevada
1968	Steve James, Jr., Fraternity of the Desert Bighorn, Las Vegas, Nevada
1969	M. Clair Aldoux, U.S. Bureau Sport Fisheries and Wildlife, Fallon, Nevada
1974	The Arizona Desert Bighorn Sheep Society, Inc.
1978	Fauna-Silvestre. Mexico City, Mexico
1979	Robert P. McQuivey, Nevada Dept. of Fish and Game, Las Vegas, Nevada
1983	Charles L. Douglas, U.S. National Park Service, UNLV, Las Vegas, Nevada
	David M. Leslie, Jr., Oregon State University, Corvallis, Oregon
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1968	Nevada Operations Office, Atomic Energy Commission, Las Vegas, Nevada
1969	Pat Hansen, Bighorn Illustrator Specialist, Death Valley, California
1972	Inyo National Forest, Bishop, California
1973	Lydia Berry, Clerk-Stenographer, Desert National Wildlife Range, Las Vegas, Nevada
1979	Jim Blaisdell, U.S. National Park Service, Seattle, Washington
1980	Society for the Conservation of Bighorn Sheep. Upland, California
1981	Dr. Thomas D. Bunch, Dept. Animal, Dairy, and Veterinary Science, Utah State Univ., Logan
	New Mexico Dept. of Game and Fish
	Dr. Grant Kinzer, New Mexico State University
1982	Maurice 'Bud' Getty, California State Parks, Sacramento, CA
	DBC Ewes

AWARD OF EXCELLENCE:

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—In Memoriam—

LEWIS E. CARPENTER

September 12, 1903—November 1, 1983

The 1984 Desert Bighorn Council Transactions are dedicated to Lew Carpenter for his services to bighorn, bighorn habitat, legislative matters, and Council. Lew gave unstintingly of his time for the welfare of desert bighorn, and will long be remembered, and missed, by his friends in the Desert Bighorn Council.

GROUP DYNAMICS AND HABITAT USE OF TRANSPLANTED DESERT BIGHORN SHEEP IN THE PELONCILLO MOUNTAINS, NEW MEXICO

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Las Cruces, NM 88003

Abstract. A 1-year field study was conducted in the Peloncillo Mountains, New Mexico, following a paddock release of 28 desert bighorn sheep *(Ovis canadensis mexicana)*. Radio-telemetry, primarily from the ground, yielded 203 observations and 408 triangulation fixes. Annual mean group size was 3.7. Ewes grouped into 2 cohesive bands, quantified by coefficients of association between 0.42-0.66. Ewes established 2 home ranges 8 km apart, but within 6 km of the release site. A mean annual home range of 9.0 km² ± 0.7 SE was calculated for 7 ewes. Bighorn preferred elevations between 1676-2134 m (61% of all group locations), slopes between 21-50% (63%), westerly and southerly exposures (68%), and grassldesert shrub vegetation types (89%). Ninety-one percent of all groups observed were within 75 m of escape terrain and 96% were located within 1.6 km of available water sources. Annual diet consisted of 68% shrubs, 21% grasses, and 11% forbs.

INTRODUCTION

Due to the precarious status of desert bighorn sheep in many southwestern states, agencies are now aggressively pursuing reintroduction programs. However, few agencies conduct quantitative, follow-up studies (Rowland and Schmidt 1981). This has left large gaps in our understanding of why transplants fail, succeed, or stagnate.

A 1-year radio-telemetry study was initiated to evaluate the transplant of desert bighorn sheep into the Peloncillo Mountains, New Mexico. The objective was to quantify major ecological parameters including group dynamics, home range establishment, habitat utilization, and food habits.

This study was funded by the New Mexico Department of Game and Fish through Federal Aid in Wildlife Restoration, Project W-84-D, and contracted to New Mexico State University. Additional funding was provided by the Bureau of Land Management and the Foundation for North American Wild Sheep. I would like to thank A.V. Sandoval for assistance in all phases of this study; Dr. R. Valdez for selecting me for this study and for logistical support; Drs. R.F. Beck, V.W. Howard, Jr., R.J. Raitt, and S.D. Schemnitz for reviewing the original manuscript; Dr. N.S. Urquhart for the computer analyses; S. Henry, N. Smith, T. Stevenson, and L. Temple for technical assistance; G. Miller, for skillfully piloting the aircraft; and J. Evans for her hospitality while I lived at Sheep Camp.

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STUDY AREA

The study area has been previously described (Sandoval 1982, Elenowitz 1982,1983). In brief, the Peloncillo Mountains are located in the extreme southwest corner of New Mexico. The study area consisted of 202 km² in the central portion of the range. Elevations ranged from 1,280 m at the foothills to 2,109 m at Gray Peak. Peak precipitation occurred between June-October and totaled 46.7 cm. This amount was 33% greater than the average annual rainfall for the Peloncillo Mountains. Vegetation was semi-desert grassland (Brown 1982), and components of the Chihuahuan desert predominated.

METHODS

In June 1981, 28 desert bighorn sheep, comprised of 10 New Mexico rams, 10 Arizona ewes, and 8 lambs born during confinement, were released from a paddock. All 20 adults were radio-collared. The transplant was supplemented with 6 radio-collared rams released directly into the wild during winter 1981-1982. Detailed transplant procedures were described by Elenowitz (1982).

Field work was conducted from May 1981 to May 1982. Each bighorn was located 6-10 times monthly, primarily from the ground. Locations were plotted on 1:24,000 topographic maps and coded to the nearest 8 m with UTM coordinates.

Group integrity was calculated by coefficient of association (Cole 1949) for all combinations of 2 ewes (n = 10). Single level cluster analysis (Lehner 1979) grouped the data for visual interpretation. Home ranges were delineated by the minimum area method (Mohr 1947) and were computed with a compensating polar planimeter. Composite home ranges were derived by overlapping the location overlays of individual bighorn. Core areas (Kaufmann 1962) were then visually determined by outlining areas of concentrated use. Three locational categories were excluded from the home range calculations: exploratory sallies (Burt 1943), travel corridors, and flat country locations.

Bighorn usage of elevation, slope, aspect and habitat type, were compared to availabilities within the study area following Sanodval's (1979) methodology. Chi-square tests were used to test the hypothesis that bighorn used those components in proportion to their availabilities. Sandoval (1982) measured availability of vegetation types. Elevations were obtained from digital terrain tapes from the U.S. Geological Survey. Slope and aspect were derived from elevations using multiple regression (Urquhart 1977). Computer analyses were conducted by Dr. N. Scott Urquhart, Department of Experimental Statistics, New Mexico State University, Las Cruces.

Food habits were determined by microhistological analysis of monthly fecal samples, conducted at the Food Composition and Analysis Laboratory, Colorado State University, Fort Collins. Plant occurrence was expressed as percent relative density (Sparks and Malechek 1968). Usage and availability of forage classes was compared according to Neu et al. (1974).

RESULTS AND DISCUSSION

Group Size. Average monthly group size of 177 observations of predominantly ewe-lamb associations ranged from 2.6 in May to 5.8 in November (Fig. 1). A mean of 3.7 was recorded during the entire study. Following their release in late June 1981, bighorn aggregated, and group size was high. As sheep acclimated in July and August, group size decreased; this was followed by an increase in group size during the fall. The increase was concomitant with greater quantity and quality of forage resulting from summer precipitation. The fall average (4.7) was greater than other seasonal means ($P < 0.05$). Group size declined in winter because the ewes separated into 2 home range groups. The further decline in group size during spring ($\bar{x} = 3.0$) was the result of parturient ewes seeking solitude for lambing, as well as relatively limited forage availability.

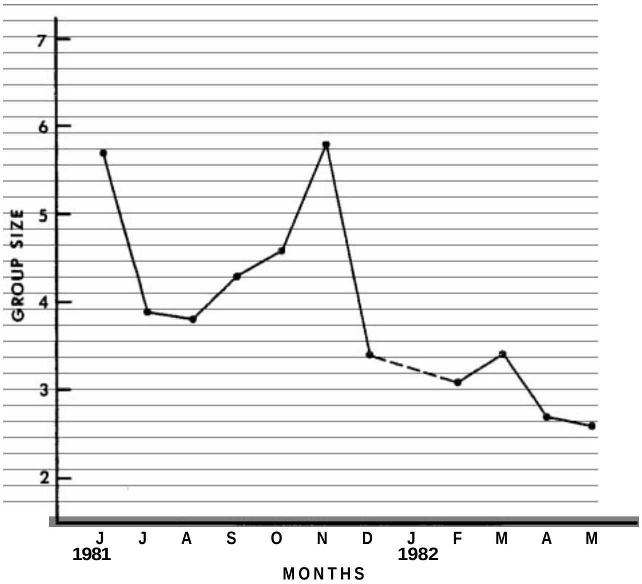


Figure **1.** Average monthly group size of desert bighorn in the Peloncillo Mountains, New Mexico, based on 177 group observations, June 1981-May 1982. Dashed line represents insufficient data in January.

Seasonally, group sizes in the Peloncillo bighorn followed the reported pattern in Nevada and Arizona of larger groups during periods of greater forage and water availability versus smaller groups during dry periods (Simmons 1969, Leslie and Douglas 1979, Chilelli and Krausman 1981).

Ewe Group Cohesion. One of the major concerns with transplants is that the animals may fragment into small groups, rendering them more vulnerable to predation. Based on 474 associations, the 10 ewes grouped into 2 cohesive bands. The Gray Peak and Burro Peak bands had coefficients of association ranging between 0.45-0.66 and 0.42-0.59, respectively (Fig. 2). Most importantly, the majority of band members had coefficients exceeding 0.50, which implies attraction rather than random association (Knight 1970).

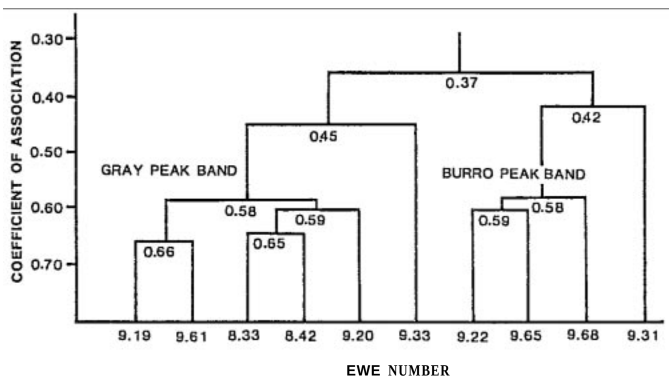


Figure **2.** Cluster analysis of associations between 10 ewes in the Peloncillo Mountains, New Mexico, 1981-1982. Single level cluster analysis based on highest coefficients among all pairs (Lehner 1979) taken from a complete matrix of associations (Elenowitz 1983). Since individuals are linked through intermediates "chaining" occurs, although the relative strengths of association are apparent.

Ewes separated on the basis of divergent movement patterns; Gray Peak band members were sedentary whereas Burro Peak band members were exploratory (Elenowitz 1983). It was possible that some ewes formed alliances based on ties established on their native range or during confinement.

Most researchers have qualitatively characterized the social structure of ewe groups as highly flexible with a low degree of group cohesion (Wells and Wells 1961, Hansen 1965, Chilelli and Krausman 1981). Leslie and Douglas (1979) derived substantially lower coefficients of association than found in this study. Population size is possibly a key determinant. High sheep density in the River Mountains facilitated interchange (Leslie and Douglas 1979), whereas low sheep density in the Peloncillos enhanced group consistency. High group integrity (coefficients between 0.45 - 0.91) occurred in the low density Big Hatchet herd (Watts 1979).

Ewe-Lamb Groups. Coefficients of association were calculated for the 3 ewe-lamb pairs that survived through the study period (Table 1). The ram lamb disassociated from his dam at 16 months of age by following adult rams. Except for temporary disassociation during the 1982 lambing season, the 1981 ewe-lamb pairs were closely associated throughout the study period. These lambs continued to associate with their dams as 2.5-year-old adults, which is evidence of persistent family groups. These observations contrast Leslie and Douglas (1979).

Table 1. Seasonal coefficients of associaticn between 3 desert bighorn ewes and their 1981 lambs in the Peloncillo Mountains. New Mexico, June 1981-May 1982.

	Lamb	Coefficients of Association[a] (No. Associations)			
Ewe No.	Sex	Summer	Fall	Winter	Spring
8.42	F	0.94 (17)	0.88 (15)	0.82 (7)	0.82 (9)
9.61	F	0.85 (14)	0.97 (17)	1.00 (9)	0.57 (6)
9.33	M	0.78 (9)	0.80 (4)	0.77 (5)	0.22 (1)

[a]The higher the value (range 0-I), the greater the association (Cole 1949).

The idea that bighorn ewes are largely unattached or unconcerned for the welfare of their offspring after the first few weeks is found in the literature (Wells and Wells 1961:131, Geist 1971a:249). However, DeForge and Scott (1982) documented group protection of sick lambs by unrelated ewes. Similar observations also were made during this study. In August 1981, when most of the 6-month-old Peloncillo lambs had pneumonia (Elenowitz 1983), ewes were solicitious, often licking mucus from the muzzles of their lambs. When moving, ewes often waited for their lambs when the distance between them exceeded about 50 m. Attachment was most vividly illustrated when a lamb died. Three of the 5 ewes that lost their 1981 lambs remained alone in the area of loss for 4 days to a week, while the rest of their band left the area. These lambs were past weaning when they died, which disputes Geist's (1971a:250) contention that such behavior largely reflects the females' search for relief of painful milk pressure.

Home Range. Sufficient data were collected to analyze home ranges of 7 ewes. The annual ewe home ranges varied from 5.8 km^2 to 10.3 km^2 and averaged 9.0 km^2 $\pm$ 0.7 SE in Size (Table 2). Ewes established 2 composite home ranges, Gray Peak (10.9 km^2) and Burro Peak (3.4 km^2), that were 8 km apart but within 6 km of the release site (Figure 3). The composite core areas comprised 80-90% of all locations and encompassed roughly one-third of the area in composite home ranges. Bighorn frequently used the precipitous west escarpment as a travel corridor between the 2 home ranges (Figure 3).

Table **2.** Annual home range areas of 7 desert bighorn ewes in the Peloncillo Mountains, New Mexico, June **1981 -** May **1982.**

Ewe No.	Area km²	No. **Locations**[a]
8.33	9.5	108-45
8.42	10.3	125-54
9.33	9.8	93-25
9.61	10.5	98-51
9.22	10.3	81-31
9.65	7.0	78-38
9.68	5.8	57-30
Mean ± SE: 9.0 km² ± 0.7		

[a] Total number of locations is given first, followed by the number of observations; the difference is the number of triangulation fixes.

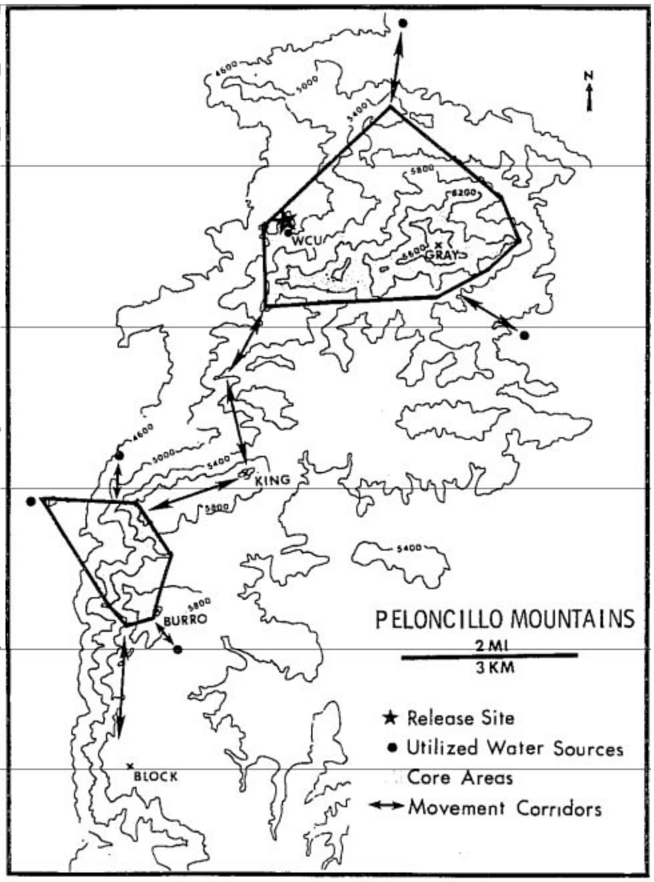
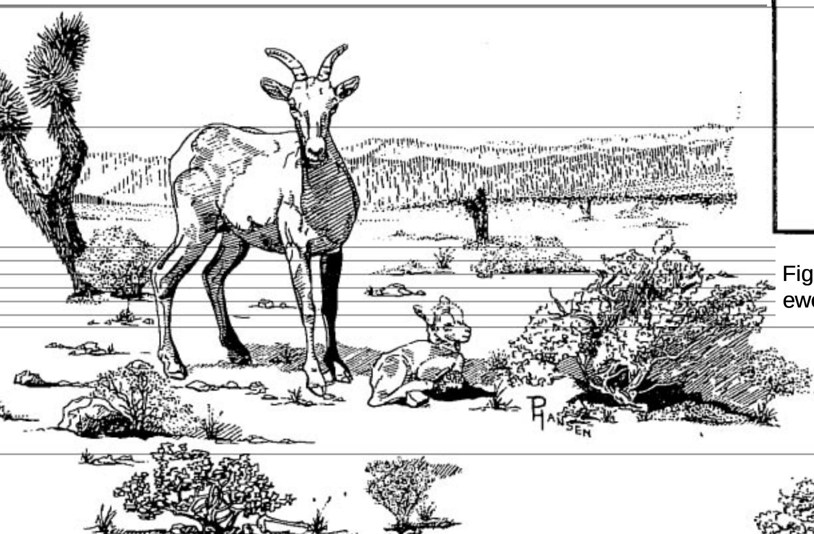


Figure 3. Composite annual home ranges of 7 desert bighorn ewes in the Peloncillo Mountains, New Mexico, **1981-1982.**

Home range size and site varied seasonally (Table 3). The seasonal home ranges of ewe 9.61 (Figure 4) were typical of the Gray Peak band; i.e., constricted home ranges in the summer and winter and expanded home ranges in the fall and spring. This pattern paralleled observations of Leslie and Douglas (1979).



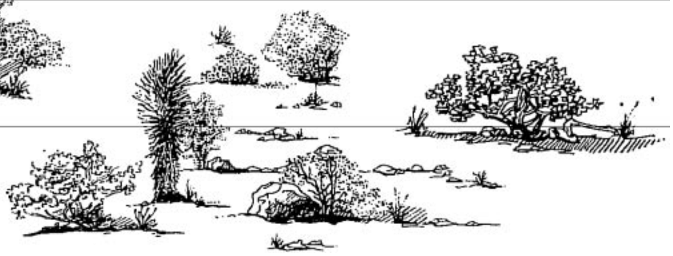


Table 3. Seasonal home range areas of 7 desert bighorn ewes in the Peloncillo Mountains, New Mexico, June **1981 -** May **1982.**

	Annual	Summer		Fall		Winter		Spring	
Ewe No.	km²	km²	% Annual	km²	% Annual	km²	% Annual	km²	% Annual
Gray Peak Band									
8.33	9.5	2.6	27	4.2	44	1.8	19	8.4	88
8.42	10.3	3.6	35	7.1	69	2.0	19	8.0	78
9.33	9.8	2.1	21	5.0	51	1.3	13	6.6	67
9.61	10.5	1.3	12	6.8	65	1.4	13	6.6	63
Mean ± SE		2.4 ± 0.5	24	5.8 ± 0.7	57	1.6 ± 0.2	16	7.4 ± 0.5	74
Burro Peak Band									
9.22	10.3	1.9	18	4.5	44	1.9	18	2.7	26
9.65	7.0	1.9	27	3.7	53	0.6	8	1.5	21
9.68	5.8	2.3	40			2.6	45	1.1	19
Mean ± SE		2.0 ± 0.1	32	4.1 ± 0.4	48	1.7 ± 0.6	24	1.8 ± 0.5	22
Overall Mean ± SE		2.2 ± 0.3	26	5.2 ± 0.6	54	1.7 ± 0.3	19	5.0 ± 1.2	52

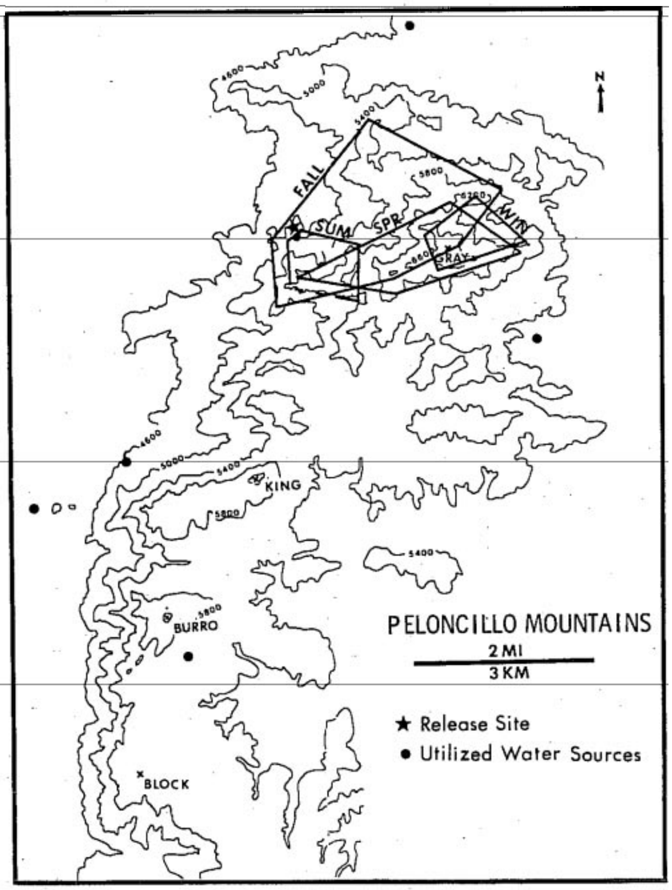


Figure **4.** Seasonal home ranges of ewe **9.61** (Gray Peak band) in the **Peloncillo** Mountains, New Mexico, **1981-1982.**

The restricted summer range ($\bar{x}$ = 2.4 km² ± 0.5 SE) reflected an attachment to the release site instilled by paddock confinement, coupled with high temperatures that possibly deterred travel. Since water availability was high, it probably did not limit dispersal. The expansion of home ranges in the fall ($\bar{x}$ = 5.8 km² ± 0.7 SE) appeared related to cooler temperatures and exploratory behavior. The contracted winter range ($\bar{x}$ = 1.6 km² ± 0.2 SE) might be attributed to the bighorns' independence of free water sources and their reliance on abundant evergreen shrubs contained within the easy Gray Peak area. The expansion in the spring ranges ($\bar{x}$ = 5.0 km² ± 0.5 SE) appeared due to exploration by gravid ewes as they sought areas for lambing and poor vegetative conditions that forced bighorns to forage over greater distances.

The Burro Peak band had a different strategy of home range establishment, as exemplified by the movements of ewe 9.65 (Figure 5): summer-fall home range in the Gray Peak area, exploratory treks in the fall, return to Gray Peak in December, and establishment of Burro Peak home range late December and occupancy through spring.

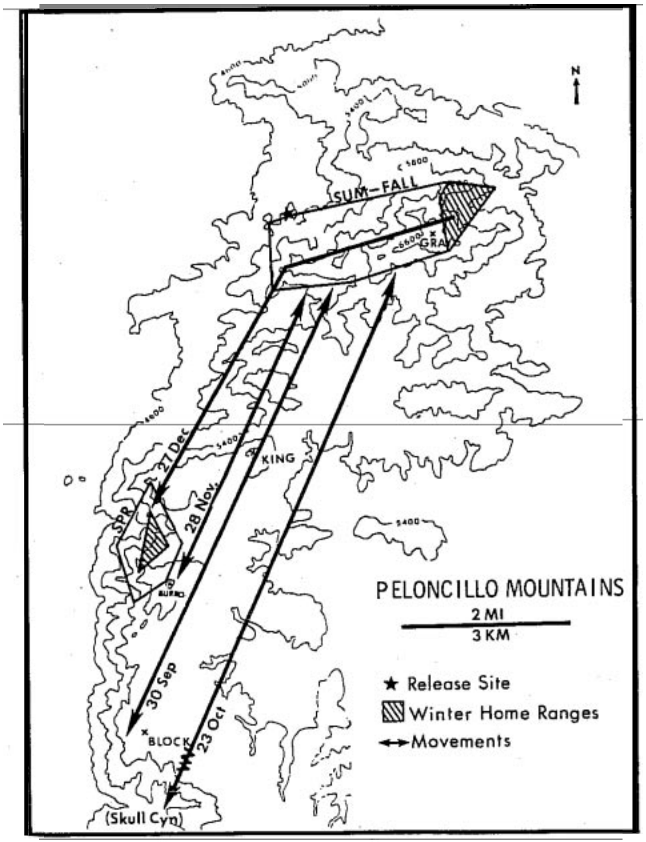


Figure **5.** Seasonal home ranges and fall movements of ewe **9.65** that led to her establishment of Burro Peak home range in January **1982.**

Post-study monitoring indicated that most ewes established their home ranges within the year following the release, with the bulk of their home range occupied 6 months post-release. This indicates that home range establishment and habituation was a relatively rapid process in this transplanted herd.

Habitat Utilization. A total of 177 group observations of 638 individuals was used to analyze bighorn distribution in relation to elevation, slope, exposure, vegetation type, escape terrain, and water sources.

Bighorn use of elevational intervals differed from availability (P 40.005). Elevations between 1676 - 2134 m accounted for 61% of the group locations, whereas these elevations composed only 33% of the available elevations (Figure 6). Seasonal differences were found; higher elevations (41768 m) were preferred in winter and spring.

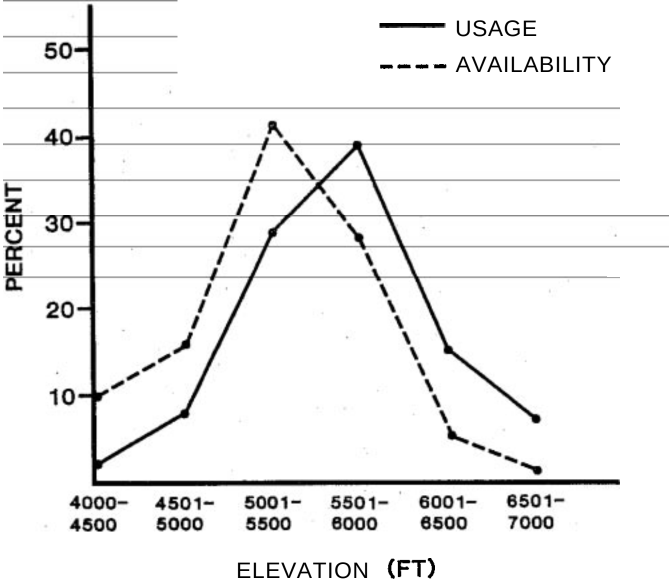


Figure 6. Distribution of desert bighorn groups observed in relation to elevational intervals, Peloncillo Mountains, New Mexico, **1981-1982.**

Bighorn use of slopes differed from availability ($P < 0.005$). Slopes between 21-50% accounted for 63% of the group locations, but these slopes composed only 47% of those available (Figure 7). Steeper slopes were preferred in the summer (27%) and spring (25%). This preference for steeper slopes corresponded with lambing seasons.

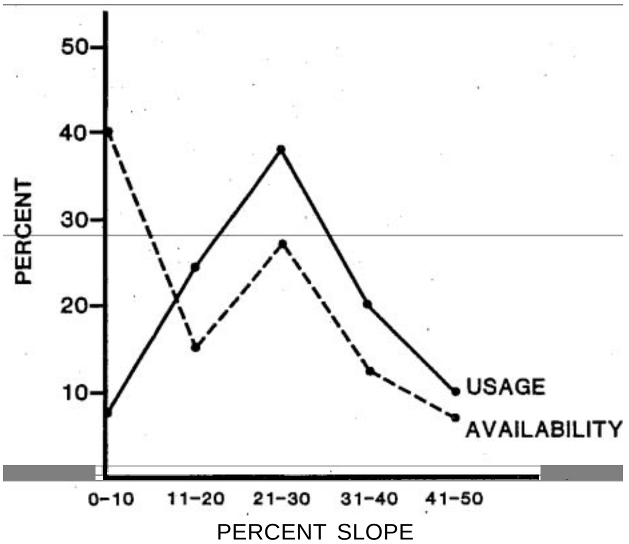


Figure 7. Distribution of desert bighorn groups observed in relation to slope gradients, Peloncillo Mountains, New Mexico, **1981-1982.**

The difference between bighorn use of exposures in relation to availability also was significant (P 40.005). Bighorn selected southerly and westerly aspects in greater proportions (68% of all locations) than were available in the habitat (37%). (Figure 8). However, most of the variability in the chi-square distribution was due to avoidance of flat exposures ($<$ 5% slope), which composed a large proportion (40%) of the study area.

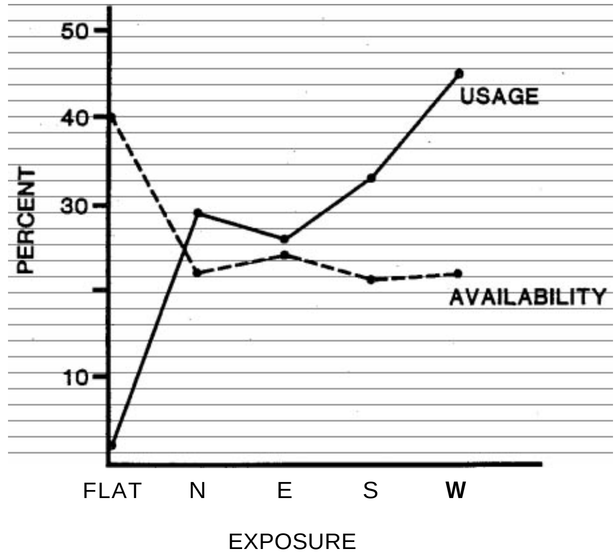


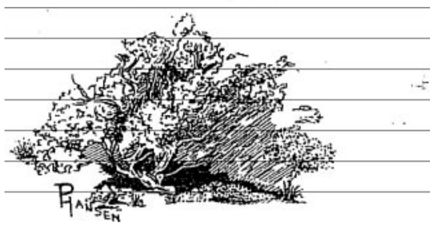
Figure **8.** Distribution of desert bighorn groups observed in relation to **exposure,** Peloncillo Mountains, New Mexico, **1981-1982.**

Distribution of bighorn relative to vegetation type differed from availability ($P < 0.005$). Grassldesert shrub and oak types were preferred (89% use, 39% availability and 10% use, 2% availability, respectively). Bighorn used mixed shrub and desert shrub types to a lesser degree than they were available. Grassland and pinon-juniper types were avoided, which may be explained by their lack of escape cover and reduced visibility, respectively.

Escape terrain was defined as rough, broken topography and included caves, rock outcrops, cliffs, and ravines. Annually, **91%** of all bighorn groups were observed within 75 m of escape terrain. Bighorn moved farthest from escape terrain in fall and winter ($\bar{x}$ = 76 m ± 40 SE). Although fall and winter averages were skewed by the movements of a few groups, they differ from the close affinity for escape terrain observed in summer and spring lambing seasons ($\bar{x}$ = 26 m ± 7 SE and $\bar{x}$ = 16 m ± 3 SE, respectively).

Annually, 96% of all bighorn groups were located within 1.6 km of available water sources ($\bar{x}$ = 1002 m ± 51 SE). During the **warm**-wet season (June-October), bighorn were **observed** closer to water ($\bar{x}$ = 833 m ± 103 SE) than during the cool, dry season (November-May) ($\bar{x}$ = 1166 m ? 170 SE). Observations and time-lapse photography identified 6 utilized water sources, including livestock tanks, potholes, and a water catchment unit (WCU) constructed specifically for bighorn at the release site. Water utilization was recorded during every month except November through January. It appeared that bighorn were independent of free water during these cool months.

Food Habits. Annual diet was comprised of shrubs (68% ± 6 SE), grasses (21% ± 5 SE), and forbs (11% ± 2 SE) (Figure 9). Usage and availability of forage classes differed ($P < 0.005$). Although shrubs and grasses each composed equal proportions of the habitat **(46%),** shrub usage was greater than availability ($P < 0.01$), and grass usage was less than availability ($P < 0.01$). In contrast, forbs were used in proportion to their availability ($P < 0.01$).



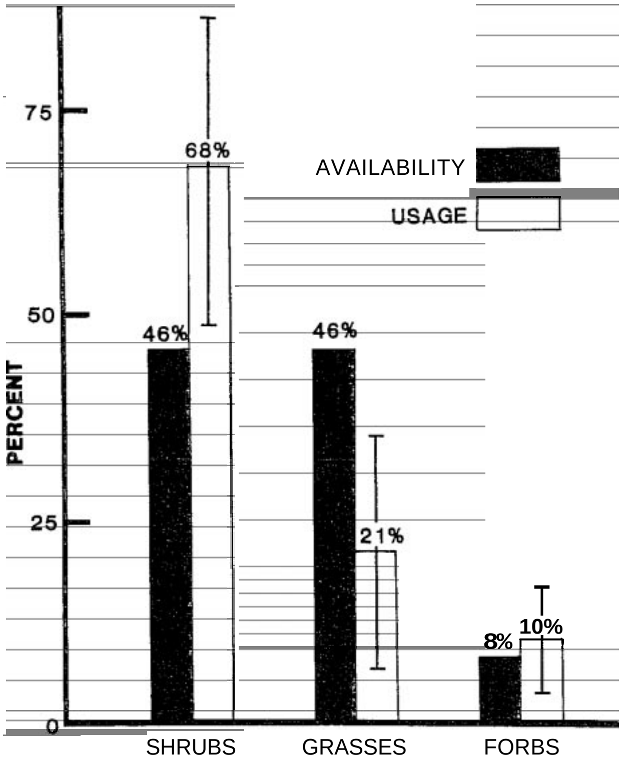


Figure **9.** Desert bighorn usage of forage classes versus availability in the Peloncillo Mountains, New Mexico, **1981-1982. 99%** confidence intervals are shown.

Forage selection varied monthly but was obscured by high preference for shrubs most of the year (Figure 10). Shrub consumption was greatest in winter and early spring as use of grasses declined. The decline in grass use was related to low availability or palatability of most species. Winter rains stimulated production of perennial forbs that reached their highest proportion in the diet between February and April. Precipitation also led to notable use of early grasses in April and a drop in shrub intake. Browse consumption increased when non-woody vegetation cured in May. Grasses were important during the rainy season (June-October) when growth was greatest in most species. Despite their dormant status, grasses composed a significant portion of the diet through December.

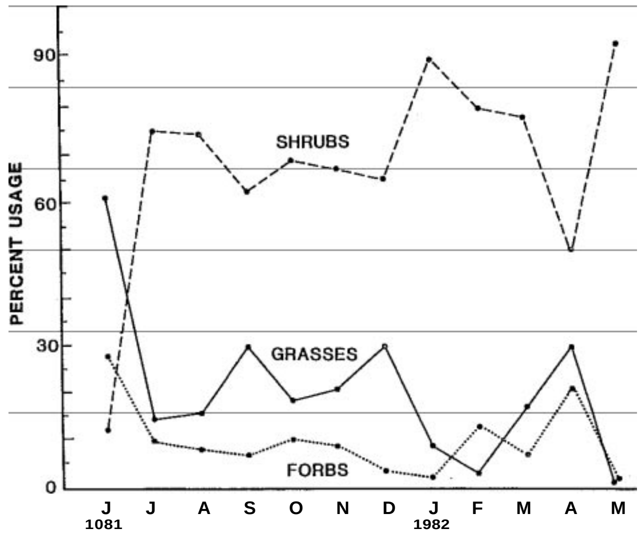


Figure **10.** Monthly utilization of shrubs, grasses, and forbs by desert bighorn sheep in the Peloncillo Mountains, New Mexico, **1981-1982.**

Twelve major taxa accounted for 86% of the annual diet (Table 4). Mountain mahogany (Cercocarpus *montanus)* was the most important food item annually; it also composed the largest proportion of the annual diet in the San Andres (Sandoval 1979) and Big Hatchet mountains (Bavin 1982) in New Mexico. Six other shrubs were included among the top 12 plants; oak (Quercus spp.), fourwing-saltbush (Atriplex canescens), and winterfat (Ceratoides lanata) constituted cool season forage (fall-spring), whereas sotol/yucca *(Dasylirion/Yucca* spp.) and acacia (Acacia spp.) constituted warm season forage (summer). Prickly pear (Opuntia spp.) did not show marked seasonality.

Muhly *(Muhlenbergia* spp.) was the major grass consumed, ranking third in the annual diet. Two other important year-round grasses were brome *(Bromus* spp.) and dropseed (Sporobolus spp.). Brome was valuable as spring forage, representing 11% of the diet. Croton (Croton spp.) was the only forb included among the 12 major plants.

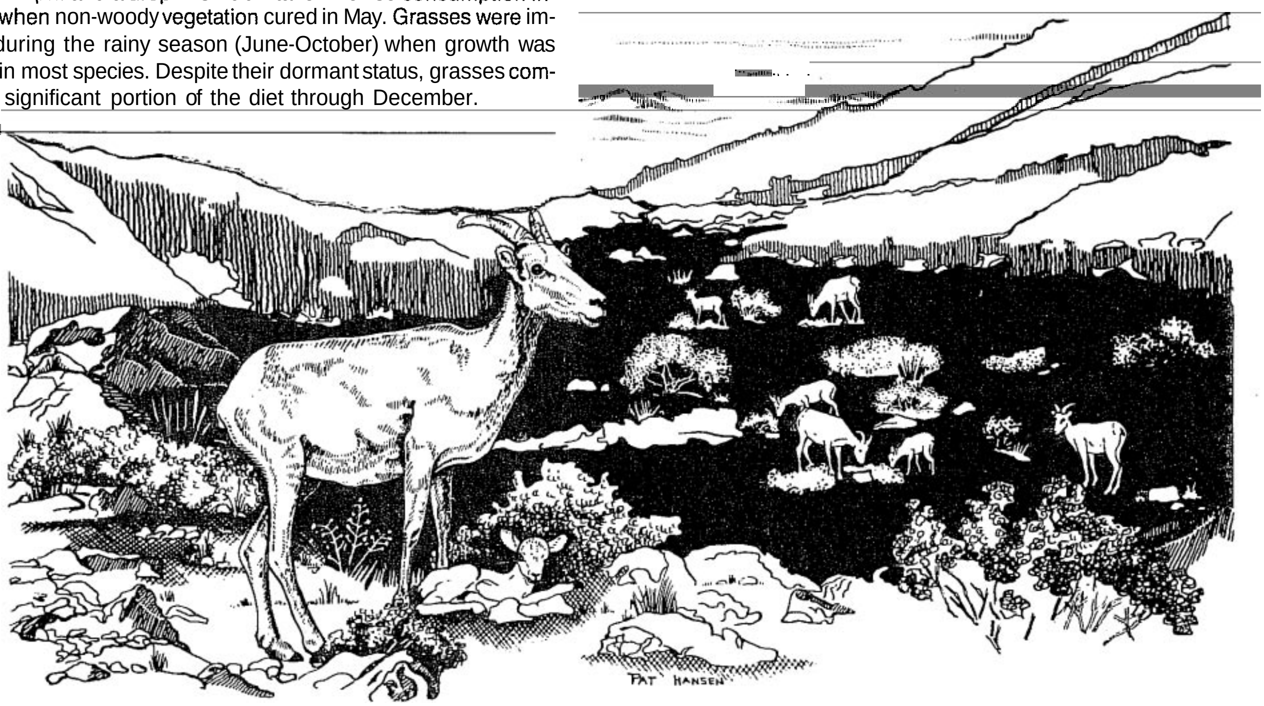


Table **4.** Seasonal occurrence of the 12 major **plants**[a] in the diet of desert bighorn in relation to availability, Peloncillo Mountains, New Mexico, June 1981-May 1982.

	Average Percent Relative **Density**[b]					Availability **(%)**[c]	
	Annual	Summer	Fall	Winter	**Spring**	Composition	Cover
Major Plants:							
Cercocarpus montanus	25.6	14.3	28.4	28.2	31.4	0.4	0.2
Quercus spp.	11.2	5.2	10.1	20.5	8.8	3.7	1.6
Muhlenbergia spp.	9.5	15.8	12.7	6.5	3.0	2.6	1.1
Dasylirion/Yucca spp.	7.8	17.7	7.7	4.0	1.7	7.3	3.1
Acacia spp.	5.0	8.7	6.2	1.0	4.1	4.3	1.9
Opuntia spp.	4.8	4.4	6.6	4.4	3.7	2.7	1.1
Atriplex canescens	4.7	1.2	4.0	5.8	7.3	0.1	tr[d]
Croton spp.	4.1	12.5	3.6	0.1	0.3	2.3	1.0
Bromus spp.	3.9	1.4	1.8	1.7	11.0		
Sporobolus spp.	3.6	3.5	5.0	5.7	0.3	3.4	1.5
Ceratoides lanata	3.0		1.2	2.2	8.2		
Notholaena *sinuata*	2.6	0.5	3.2	2.6	3.9	0.5	0.2
Total	85.8	85.2	90.5	82.7	83.7	27.3	11.7
Forage class:							
Shrubs	68.2	53.8	65.8	79.0	74.0	45.6	19.6
Grasses	21.1	30.7	24.0	14.0	16.0	46.1	19.7
Forbs	10.7	15.5	10.2	7.0	10.0	8.3	3.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	42.8

[a]Major plants constituted ▶% of the annual diet.

[b]Percent relative density = the frequency of occurrence of each plant taxon divided by the frequency of all plant taxa (Sparks and Malechek 1968) as determined by microhistological analysis of fecal samples.

[c]Source: Sandoval (1982). Plants that lack values were not encountered in vegetation transects.

[d]tr = ◄0.1%.

TRANSPLANT ASSESSMENT AND CONCLUSIONS

When an animal enters a new environment, it brings traditions learned from its past. Optimum habitat use and production are dependent upon successful application of old traditions to alterations in topography, vegetation types, food items, water availability, social structure, and predator pressure (Geist 1971b, Cowan 1974).

The principal components that influenced bighorn distribution in the Peloncillo Mountains were high elevations, steep slopes, particular habitat types, escape terrain, and proximity to water. Use appeared to be contingent upon the interspersion of these components. This study suggested that the Peloncillo bighorn habituated to and made optimal use of their new environment. For example, they (1) sought the most precipitous terrain in the study area; (2) selected open vegetation types and elevated terrain, which afford high visibility; (3) selected high-quality foods (e.g., mountain mahogany) unknown to them in their native home; (4) found water sources soon after their release and showed flexibility in their utilization of man-made sources; (5) ceased exploration 6 months post-release and all except 1 ram homed to release sites following exploration (see Elenowitz 1982); (6) established 2 home ranges that were 8 km apart but within 6 krn of the release site; (7) developed a high degree of group cohesion and compatibility, thereby minimizing vulnerability to predation and social stress (Berger 1978); and (8) avoided mountain lion *(Felis concolor)* predation, except in 1 case.

Considering the Peloncillo bighorns' habituation to their new physical and social environment, it is perplexing why optimal production also did not occur. High lamb mortality due to pneumonia was the major factor limiting population increase during the study period (Elenowitz 1983). Further research by the New Mexico Department of Game and Fish is needed to determine causal agents and effective treatment procedures.

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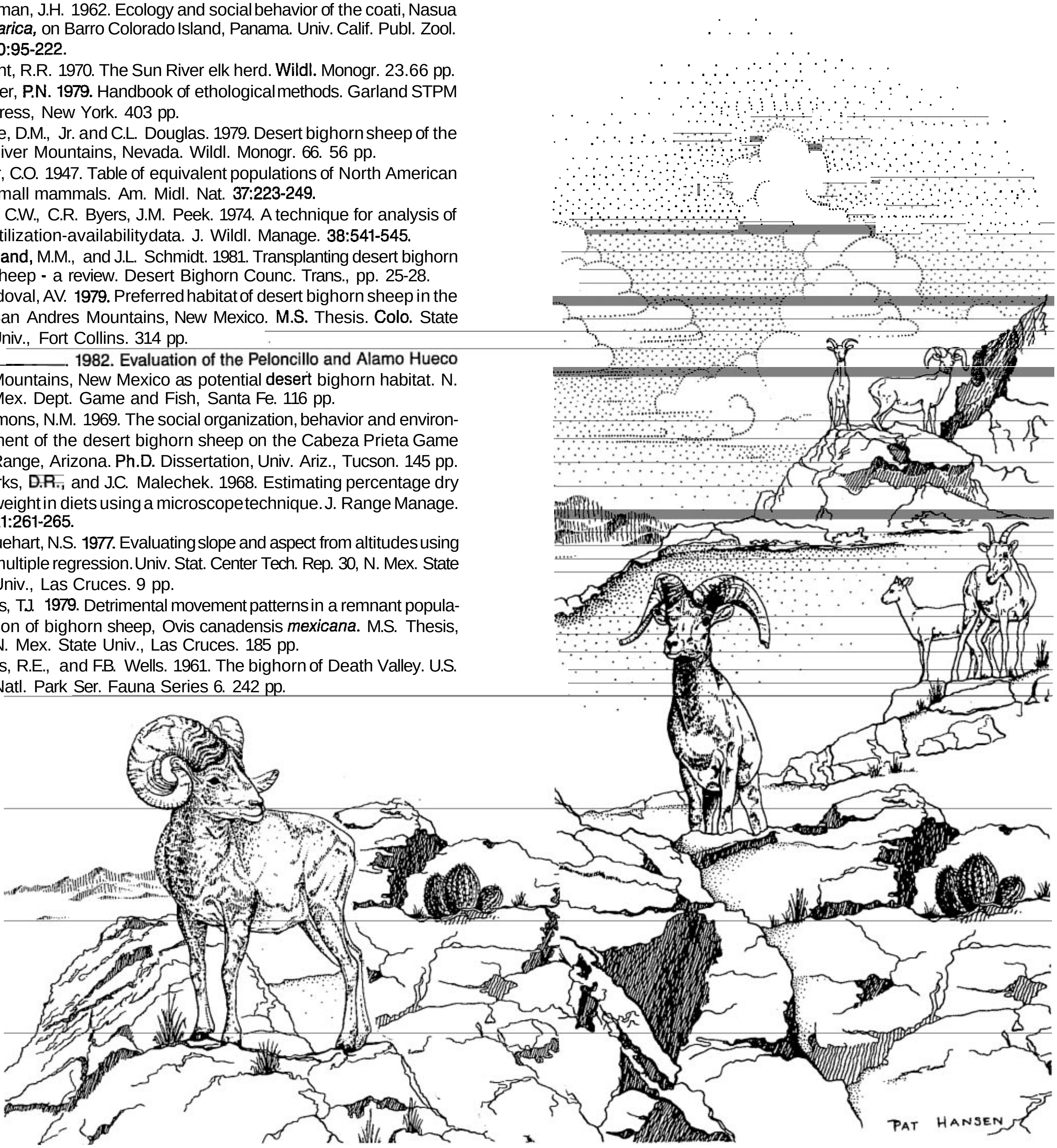

SUMMER ACTIVITY PATTERNS OF FREE-RANGING DESERT BIGHORNS, ZION NATIONAL PARK, UTAH

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Abstract. Diurnal activity patterns, movements and activity budgets obtained during summer 1979 are described for free ranging, reintroduced, desert bighorn ewes *(Ovis* canadensis *nelsoni)* at Zion National Park, Utah. There were 3 periods dominated by feeding and other activity. These were: daylight - 0800, 1145 - 1845, and 1945 - darkness. The two interim periods were dominated by bedding. Diurnal movements ranged from 1.2 km to 2.5 km. Feeding was the most common activity (56% of the daily time budget); bedding was second (36%); and lesser activities included moving, standing, social interactions and drinking. Nocturnal activity patterns could not be obtained; however, evidence suggested that bighorns bedded most of the night.

INTRODUCTION

The daily activity patterns of desert bighorn sheep have been described in general terms by Welles and Welles (1961) and Wilson (1968). Several studies have described desert bighorn activity patterns quantitatively (Welch 1969, Olech 1979, Chilelli and Krausman 1981). This paper presents an analysis and discussion of the daily activity patterns, movements and activity budgets of individual ewes within a herd of free-ranging, reintroduced, desert bighorn sheep. Data were collected in summer 1979 at Zion National Park in southwestern Utah. This research is part of a long-term study on the behavior and ecology of captive and free-ranging, reintroduced, bighorns in the park. These bighorns were part of a group of 20 released from a holding-propagating enclosure in the park in 1978 (McCutchen 1979).

Cooperators of the Zion reintroduction project include the National Park Service, U.S. Department of Interior, the Utah Division of Wildlife Resources, the Nevada State Department of Fish and Game and the Zion Natural History Association. Dave Katzmer of the Student Conservation Association provided field assistance.

STUDY AREA

The study area was described in detail previously (McCutchen 1975). It was located in Zion National Park in the canyon complex between the confluence of the East Fork and North Fork of the Virgin River. Physiographic relief was extreme, elevations varied from 1100 m to about 2100 m. At the uppermost elevations, the Navajo Sandstone formation dominated and formed a sheer cliff over 300 m high. Below that a long, steep, talus slope descended for about 300 m in elevation to the river floodplains below.

The vegetation of the talus slope consisted of a mosaic of dense to open stands of woodland, low shrublands and grasslands. The woodland was primarily pinon *(Pinus* monophylla) and juniper *(Juniperus* osteosperma). Upper elevation shrub areas were dominated by sandsage *(Artemisia filifolia)* and lower elevation shrub areas by blackbrush (Coleogyne *ramosissima).* Grass stands contain galleta *(Hilaria jamesii)* and black gramma *(Bouteloua* eriopoda). Water was widely distributed; rivers, numerous seeps, and springs were present in the study area.

Mean annual precipitation was about 37 cm (14 in.) at the lower elevations. During summer 1979 temperatures ranged from 16 - 38ºC (60 - 100ºF).

METHODS

Most of the bighorn were marked with color coded collars or were instrumented with radiocollars (McCutchen 1979). An attempt was made to obtain 2 daily activity patterns in each summer month. Sampling periods occurred when bighorn moved into areas where they could be easily observed without disturbing them. Observations were made with 7 x 150 binoculars and a 15 x 60 variable powered telescope from 200 m - 600 m.

The first identifiable mature ewe observed at daylight was selected as the focal animal for the rest of the day (Altman 1974). That animal's behavior was continuously monitored and the time was noted when any change in activity occurred. During the sampling periods the focal ewes were associated with a maternal band varying from 10 to 14 animals. Ewes and lambs dominated the herd structure of these groups. However, two yearling rams and two 2-year old rams would occasionally be observed with the herd. An effort was made to locate and observe the animals at sunset the preceding day or at sunrise following the sample day to determine movements and 24-hour activity patterns. Data were recorded using mountain daylight saving time. Individual movement was plotted in the field on a 7-½ minute USGS topographic map and movement distances were later measured to the nearest 0.1 km.

RESULTS AND DISCUSSION

Diurnal Activity Patterns: During summer 1979, five diurnal activity patterns were obtained from three individual desert bighorn ewes. Attempts to obtain 24-hour activity patterns were not successful because of the tendency of bighorns to begin feeding before daylight and feed after darkness when they could no longer be observed. A mean activity pattern was obtained by sampling activity within each of the five diurnal patterns on the hour and at 15 minute intervals. Observations of the activity for each 15-minute interval were then averaged (Figure 1).

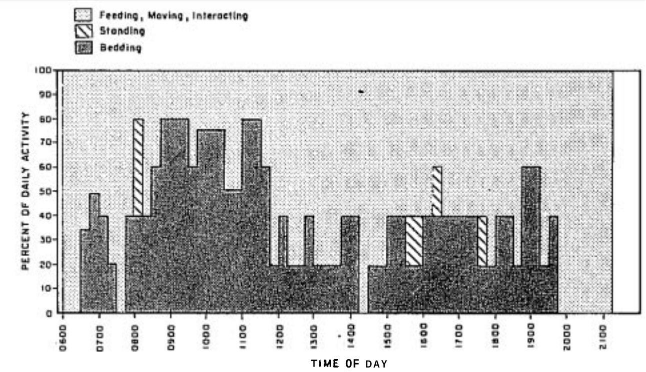

Figure 1. Composite daily activity pattern for desert bighorn sheep, summer 1979, Zion National Park, Utah.

There were 3 periods during the day in which feeding, standing, and moving occupied more than 50 percent of the activity. These were from daylight (about 0600) - 0800, from 1145-1845, and from 1945 until darkness (about 2100). Conversely, bedding dominated from 0800 - 1145 and a 30-minute period from 1830 - 1900. This activity pattern for the Zion bighorns is similar to that obtained by Chilelli and Krausman (1981) for desert bighorns *(O. c.* mexicana) in west central Arizona in early summer. The morning bedding periods, from about 0800 - 1200, were nearly the same. The afternoon bedding period for the Arizona bighorn (Chilelli and Krausmann 1981) was from 1400 - 1600. This differed from the 1830 - 1900 period of the Zion bighorn (Figure 1). Wilson (1968) also noted two bedding periods (mid-morning and mid-afternoon) in Utah desert bighorn *(O. c. nelsoni).*

Diurnal activities of Zion bighorn ewes were not comparable to peninsular bighorn *(O. c.* cremnobates) in southern California where peak activity of maternal bands occurred at 0915 - 1545 (Olech 1974). However, she found that resting dominated during all periods of the day. In New Mexico, desert bighorn *(O. c. mexicana)* showed one peak of activity at 0900 - 1100 (Welch 1969). This activity also is not similar to the Zion bighorn activity. Apparently, the daily activity is highly variable in desert bighorn, depending upon weather, habitat and the physiological needs of the animal (Welles and Welles 1961, Wilson 1968). The time of sunrise and sunset also influences bighorn activity as observed in Dall's sheep *(O. dalli dalli)* (Hoefs 1974).

Nocturnal activity data could not be obtained but there was evidence that bighorn bedded shortly after darkness and usually left their beds to feed shortly before daylight. On one sample day they were observed in their beds at daylight. In addition, bighorn observed until darkness prior to the sample day were observed in the same location the following morning. Simmons (1969) observed that when desert bighorn *(O. c.* nelsoni) bedded and did not move at night, they would be found in the same area at sunrise as at sunset the previous day. If, however, they did feed at night they would be found in the morning some distance away from where they had been observed the previous evening. Observations at Zion were also made on nights other than the sample periods in situations where a spotlight could be used, and bedding generally occurred from shortly after darkness to shortly before or at daylight.

Diurnal Movement: The bighorn at Zion did not move far during a diurnal period (Table 1). Daily movement distances ranged from 1.2 - 2.5 km. Bighorn tended to double back along their route during a day. The linear distances between farthest location points ranged from 0.7 - 1.4 km.

Table 1. Distance traveled by bighorn ewes during daylight activity aeriods in summer 1979. Zion National Park. Utah.

Date	Actual Distance Traveled (km)	Linear Distance Between Farthest Points (km)	Daily Temperature Max. °C	(°F)	Min. °C	(°F)
6/13/79	2.0	0.7	38	(100)	20	(68)
6/21/79	1.7	0.8	34	(93	16	(60)
7/03/79	1.3	1.0	34	(94)	16	(61)
8/15/79	2.5	1.4	29	(84)	17	(64)
8/27/79	1.2	0.7	36	(91)	19	(67)
Mean	1.7	0.9	—	—	—	—
SD	0.5	0.3	—	—	—	—

Activity Budgets: Diurnal activities were fairly consistent among ewes (Table 2). Feeding and bedding dominated the activity. Feeding was the most common diurnal activity and varied from 452 - 510 min. during the daylight period. Bedding varied from 253 - 346 min. per day.

Bedding periods of the ewes were frequently disturbed by lamb suckling, displacement by a dominant animal, or by sexual harassment by a young ram. When this occurred, the affected animals tended to stand or feed for a short period of time before bedding again.

Moving activity was recorded when a bighorn deliberately moved from one area toward another, without feeding, for more than one minute and averaged 31 min. Bighorn generally walked as they fed, and this activity was recorded as feeding. When moving was recorded, bighorn were usually walking. Running was seldom observed.

Two long periods of movement were recorded during the sample days. On June 13, the bighorn became frightened when one rolled a large rock down the slope. The animals formed a compact group and rapidly walked away from the area. Over the next hour they alternately stood or walked, moving about 600 m before they bedded. On August 15 a rainstorm passed overhead and the bighorn became restless and left the floodplain where they had been feeding. For about an hour they alternately walked, fed and watched until they were several hundred meters in elevation up the talus slope.

Standing averaged about 19 min. a day. Animals tended to stand for a short period before they lay down and again after they had arisen from a bed and stretched. They would also stand and stare when they observed something unusual. Social interactions of the ewes were difficult to time because of their brevity, but a variety were observed. Interactions included a ewe nursing or grooming a lamb, displacement (at bed or forage), horning objects, or being sexually harassed by a young ram.

Table **2.** Five daylight activity budgets of desert bighorn ewes during summer 1979, Zion National Park.

Date	Ewe	Minutes of Daily Activity: Bedding	Feeding	Moving	Standing	Interacting	Drinking	Total	Daylight Observation Period
6/13/79	19	253	459	54	33	15	0	814	0630-2110
6/21/79	33	346	468	17	23	0[1]	35	890	0600-2050
7/03/79	21	291	452	11	12	15	0	8602	0700-2100
8/15/79	33	277	489	73	20	0'	6	865	0630-2100
8/27/79	33	346	510	1	9	14	0	880	0630-2110
	X̄	302.6	476.2	31.2	19.4	8.8	8.2	—	
	S.D.	41.9	24.8	30.7	9.5	—	—	—	
	X̄%	36.0	56.0	4.0	2.0	1.0	1.0	—	

1. Interactions observed — too brief to measure.
2. Animal out of sight 79 minutes.

Drinking was observed twice among the 5 sample days. This suggests that bighorn did not need to drink every day. On 21 June the longest drinking session was observed when a ewe spent nearly 35 rnin. at a seep area licking water from the rocks. Welles and Welles (1961) found that ewes in Death Valley watered every 3 - 5 days, averaging 6 - 8 per rnin.

Bedding could dominate the 24-hours activity period in summer, if we assumed that the Zion bighorns bedded within an hour after darkness and arose to feed within an hour before daylight. Beading could occupy up to about 56% (810 min.) of the bighorn 24-hour activity period, and feeding and other activity could occupy about 44% (630 rnin. or 510 rnin. plus 120 rnin.) of the period.

Eccles (1978) observed captive California bighorn ewes during July and August and recorded a mean feeding time of 8.5 hrs. (530 rnin.) and a bedding time of 5.4 hrs. (324 min.). These time budgets are very similar to those of Zion ewes.

There is a need to obtain comparative diurnal or 24-hour activity budgets and movement data for other desert bighorn populations. These data should provide useful indices for energy budgets as well as habitat quality.

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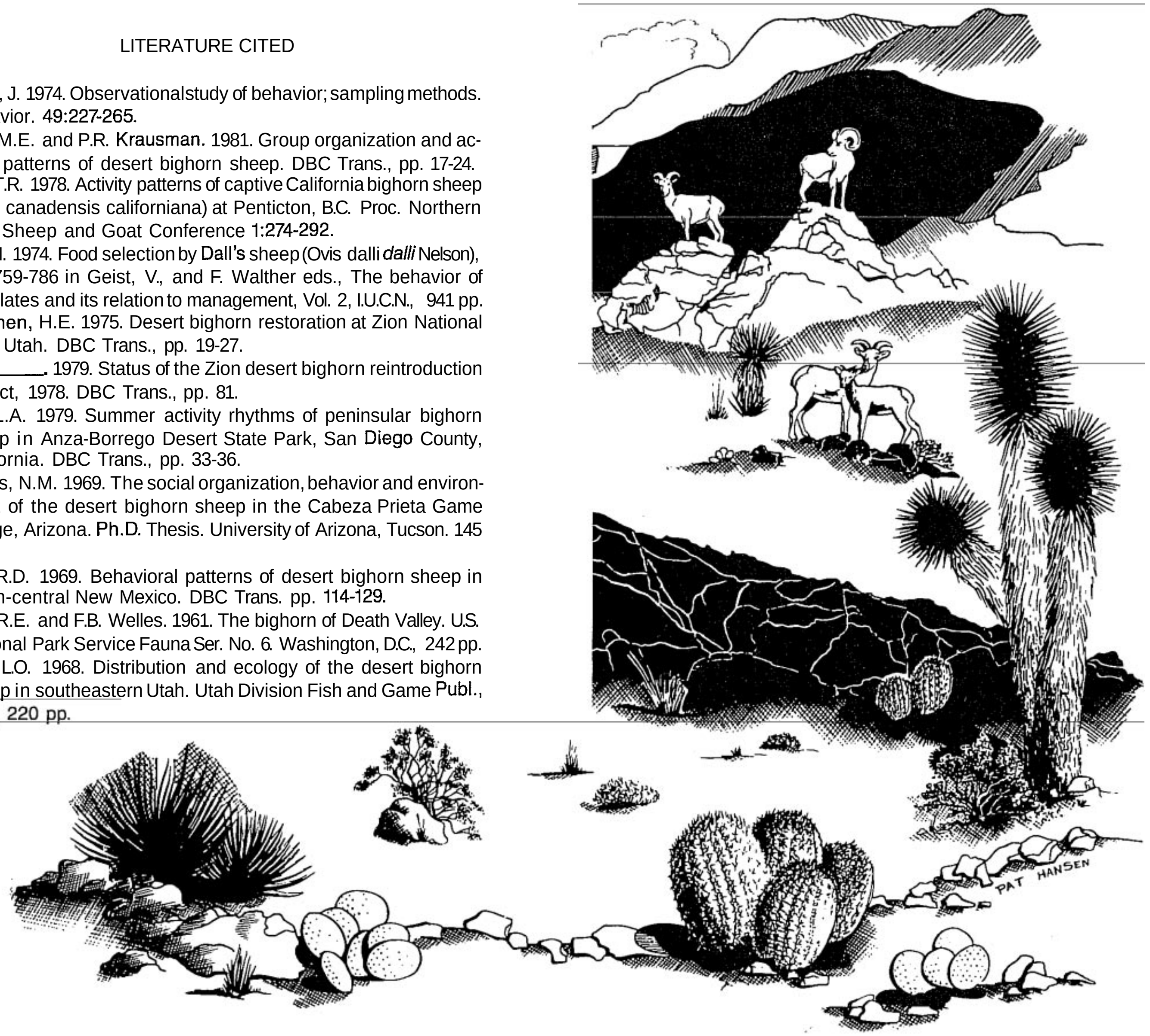

BIGHORN SHEEP WATER DEVELOPMENT IN SOUTHWESTERN ARIZONA

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Abstract: Since water is a basic requirement of desert bighorn sheep *(Ovis* canadensis rnexicana, *O. c. nelsoni),* the Arizona Game and Fish Department has an ongoing program of water development in southwestern Arizona. Water developments include pothole improvement, apron catchment construction, and improvement of mine cisterns and springs.

INTRODUCTION

Water has been identified as a basic requirement of desert bighorn sheep, especially during the hot, late summer, breeding season (Koplin 1960, Wilson 1968, Wilson et al., 1980). Bighorn ranges in southwestern Arizona experience daytime highs in excess of 43°C during June, July, and August on a regular basis. Natural water distribution in these bighorn ranges is highly dependent on geologic formations being conducive to pothole formation. Unfortunately much of the bedrock in southwestern Arizona is fractured so that when a pothole does form, water is not retained from one sporadic storm to the next. Also pothole formation depends on torrential rains moving large volumes of water and sediment, a very slow process in an area with less than 15cm inches of precipitation annually.

In an attempt to ensure water availability for desert bighorn, the Arizona Game and Fish Department has an ongoing program of water improvement, development and maintenance. The Department's efforts can be broken into three basic categories: 1) pothole improvement, 2) apron catchment development, and 3) the development of abandoned mine cisterns and springs.

Pothole Development: Pothole development begins with locating a pothole for potential development during the course of helicopter bighorn surveys or foot surveys. The pothole is later investigated on the ground, and its condition, location, permanence, and feasibility of development are analyzed. If the analysis shows that a pothole could be a permanent water source with a reasonable amount of development effort, and it is located within known sheep range that could benefit from an additional water source, it is scheduled for development.

Actual work on potholes generally occurs during January to May and is usually accomplished with the assistance of the Arizona Desert Bighorn Sheep Society. Funding for materials and helicopter time to transport materials and equipment is derived from various sources, including the Arizona Desert Bighorn Sheep Society, the Foundation for North American Wild Sheep, the Bureau of Land Management, and the U.S. Air Force.

Actual development work begins with a thorough cleaning of all silt and debris from the pothole, followed by cleaning with a pumped water stream, if water is available, to ensure that all cracks are clean and ready for sealing. Next, the damsite is thoroughly cleaned and holes are drilled to accommodate steel rebar rods. Holes are drilled with a gasoline powered jackhammer (Pionjar, which is made in Sweden and distributed in the United States by ABEMA, Inc., Norwalk, Connecticut, 06856).[1] Rebar is set in the drilled holes and cemented into place with hydraulic cement (Waterplug) which expands as it sets. Next the base rock is treated with an adhesive agent (Acryl 60) to insure a good joint. (Waterplug and Acryl 60 are products of Standard Drywall Products, Newark, California, 94560). Actual dam construction begins by mixing mortar on site, using materials transported in. Good clean sand is transported in rather than using local sand, which is generally of poor quality. Rocks for the dam are chosen from adjacent hillsides with large, flat, square rocks being preferred. Once the dam is constructed, it and the pothole are sealed. All cracks are sealed with hydraulic cement, and the rest is sealed with a mixture of hydraulic cement, portland cement and lime, with enough Acryl-60 to ensure good adhesion.

A silt diversion dam is built around the pothole if at all possible. A silt diversion structure is preferred over a silt retention dam, since it will not require periodic cleaning as the latter does. The diversion structure is basically a rock gabion consisting of V-mesh wire formed between rows of fence posts set in holes drilled into bedrock. The gabion is filled with loose rock and is capped with more V-mesh wire and wired shut.

If the pothole is exposed to direct sunlight during a large percentage of the day, a shade is constructed over it to reduce evaporation and enhance water quality. Shade construction consists of the placement of 5cm iron pipe uprights into holes drilled into bedrock, the construction of a pipe and 5x10cm wood lattice work attached to the upright posts and the placement of the shade material. The shade itself usually consists of green plastic 85% shade material in two layers sandwiched between two layers of chicken wire, all of which is stapled to the 5x10cm wood portion of the lattice work.

Apron Catchment Development: Apron catchments are developed for desert bighorn as a second option when good pothole sites can not be found in areas needing permanent water. These structures are of the natural or artificial apron type. An artificial apron is used if a suitable site in suitable sheep habitat can be found, since the artificial apron is generally more efficient in collecting water. Artificial aprons are usually constructed of asphalt emulsion placed over fiberglass cloth, although concrete and sheet metal have been used successfully in the past. Water is collected at the bottom of the apron and is piped into a storage tank, constructed of sectioned corrugated steel rings with a vinyl liner. Water is then piped to a trough regulated by a covered float valve. In southwestern Arizona most artificial apron catchments are constructed with approximately 462 m^2 of collecting area and 26,498-37,854 l of storage capacity.

Natural apron catchments usually consist of a small dam across a small drainage with a pipe running to one or two 7,571 l fiberglass storage tanks, and a float regulated trough. Site selection for the apron is important with large expanses of smooth exposed bedrock preferred, since the apron must be efficient enough to collect water during light rains. The fiberglass tanks weigh approximately 227 kg and can be flown in by helicopter.

Development of Springs and Mine Cisterns: The Department has taken advantage of other development opportunities such as springs and mine cisterns. Unfortunately, there are very few springs in southwestern Arizona. Springs feeding into potholes have been developed in much the same manner as described earlier for potholes. Mine cisterns are usually cut into hard rock, usually fed by a natural watershed. These water sources can either be a primary source for direct use by sheep, or covered and used as an auxiliary source to be pumped into a developed pothole. Mine cisterns are usually in need of sealing, which is accomplished in the same manner as pothole sealing.

[1] Mention of equipment or materials does not constitute an endorsement by the State of Arizona.

CONCLUSION

Water development is an important part of habitat improvement programs for desert bighorn in southwestern Arizona, and will likely continue as part of cooperative Habitat Management Plans with the Bureau of Land Management and with the much appreciated assistance of the Arizona Desert Bighorn Sheep Society.

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ACTIVITY PATTERNS OF CALIFORNIA BIGHORN ON SHELDON NATIONAL WILDLIFE REFUGE

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Abstract: Activity patterns of California bighorn sheep (Ovis *canadensis* californiana) on Sheldon National Wildlife Refuge in northwestern Nevada were investigated by direct observation from June 1978 to August 1980. Sheep spent 4.8, 6.8, 6.8, and 7.7 hours per day feeding during spring, summer, fall, and winter, respectively, and exhibited two major peaks in daily activity. Analyses suggested that daily activity patterns were largely determined by the digestive physiology and diurnal nature of the species; but they also reflected seasonal variations in the thermal environment and forage base, plus social requirements of the animal's reproductive cycle.

INTRODUCTION

A variety of daily activity patterns have been reported for bighorn sheep *(O.* canadensis): one peak of activity each in morning and evening (Davis and Taylor 1939, Honess and Frost 1942:7, Simmons 1969:58, Drewek 1970:36, Van Dyke 1978:36); morning and evening activity peaks, plus a peak at midday (Mills 1937, Davis 1938, Smith 1954:49, Blood 1963:91, Berwick 1968:81, Simmons 1969:58, Chilelli and Krausman 1981); one activity peak in the morning and two in the afternoon (Welch 1969:128); and frequent alternate intervals of activity and rest (Welles and Welles 1961:59, Woolf et al. 1970:56, Kornet 1978:20). Furthermore, Geist (1971:261) found that Stone's sheep *(O.* dallistonei) switched from two peaks of activity each morning and afternoon in October to one peak at noon and another in the afternoon in February. Bighorn sheep apparently adapt their daily activity patterns to local and seasonal conditions (Welles and Welles 1961:59), yet few studies have documented seasonal activity patterns through the entire year (Chilelli and Krausman 1981) and related them to specific environmental conditions (Simmons 1969). Such information is prerequisite for selecting optimum times to count, trap, and perform other management operations.

During summer 1968, eight California bighorn from Hart Mountain in Oregon were released in a 700 ha enclosure within historic range (Cowan 1940, Hall 1946, McQuivey 1978) on Sheldon National Wildlife Refuge (SNWR), northwestern Nevada (Richardson 1973, Carter 1975). This paper presents the seasonal activity patterns of California bighorn sheep on SNWR and discusses effects of certain environmental and behavioral factors on these patterns.

Thanks are due to the following: the U.S. Fish and Wildlife Service and the Order of the Antelope, both of Lakeview, Oregon, for financial support during the study; B.E. Coblentz, J.A. Crawford, D.M. Leslie, Jr., S.H. Sharrow, and A. Winward among others at Oregon State University for advice and support throughout the study; J. Yoakum, Bureau of Land Management for advice and support during the study and manuscript preparation; J.D. Wehausen and an anonymous reviewer for manuscript reviews.

STUDY AREA

SNWR contains several extensive tables of volcanic origin, which have been cut by many watercourses. Extensive cliffs border some of the watercourses, and most tables are edged by low rimrock. The study area lies in Humbolt County in the Hell Creek and Virgin Creek drainages. Elevations range from 1500 to 2000 m.

The area is arid. Precipitation varies from 20 to 28 cm annually. Vegetation consists primarily of sagebrush *(Artemisia* spp.) communities with an understory of bunchgrasses and forbs. Several deciduous, woody species including quaking aspen *(Populus* tremuloides) and willow (Salix spp.) are found near permanent water. Curl-leaf mountain mahogany (Cercocarpus ledifolius) occurs in small isolated clusters on rocky areas at higher elevations. Additional ungulates inhabiting the area are mule deer (Odocoileus hemionus), pronghorn antelope (Antilocapra americana), domestic cattle (Bos *taurus),* and feral horses *(Equus* caballus).

MATERIALS AND METHODS

Field work spanned 16 months between June 1978 and August 1980 and included portions of all four seasons. Work was concentrated in the Hell Creek area that was occupied by female and young sheep. Data on ram activity patterns are not discussed.

The area was frequently traversed on foot, and an observation point was established on a distant ridge from which about 90% of the Hell Creek area was visible. A 30x spotting scope and 8x32 mm binoculars were used to observe sheep; these were necessary because sheep closer than 1 km often reacted to human presence. Only observations of undisturbed sheep were used in analyses.

Activity pattern information was collected as an index of sheep-minutes. Once located, sheep were monitored continuously for as long as they remained visible; at ten minute intervals, instantaneous activity of each individual was recorded. Five classes of activity were recognized. There were two feeding classes: (1) feeding in place occurred when sheep fed for ten or more minutes in one location, and (2) active feeding, which occurred when an individual was neither feeding in one location for ten plus minutes nor actively moving without feeding. The two resting classes were defined as: (1) bedding, primarily in day beds although some night bedding activity was recorded, and (2) standing occurred both when sheep were at rest and alert. Active, the fifth class, included locomotion, comfort behaviors, and reproductive activities.

Cloud cover, wind velocity, precipitation, snow depth, and ambient temperature were recorded at hourly intervals during observations. Relative seasonal nutrient availability was estimated subjectively on the basis of plant phenology and average availability of forage on the entire area.

Both seasonal activity pattern differences and hourly differences within seasons were analyzed with the X^2 statistic and contingency tables ($p = 0.005$) (Snedecor and Cochran 1967). Season consisted of three months, beginning with spring (April - June). Day length varied by as much as four hours within a single season, so sunrise and sunset were chosen as points from which time was scaled. Consequently, length of the midday block was variable.

RESULTS

Sheep exhibited a basic daily pattern that included early morning feeding, one major morning peak and one minor midday peak in resting, and an increasing frequency of feeding through the afternoon. This basic pattern held throughout the year, with some shifts of resting behavior to earlier or later in the day and some variation

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in the magnitude of resting peaks (Figures 1A-D). Sheep frequently were observed moving toward a favored bedding site during the last light of the day, then feeding away from the same site at first light the following morning. This pattern suggested that sheep on SNWR often remained in and near their bedding sites at night.

Spring: Sheep activity during spring showed relatively indistinct periods of feeding and resting, yet bedding tended to increase in late morning and early afternoon. Sheep spent less time feeding (30%; 4.8hr) in spring than in other seasons; conversely, more time was spent bedding (38%; 6.1hr), standing (21%; 3.4 hr), or being active (11%; 1.7 hr) (Figure 1A).

Weather in spring was variable, with snow or rain storms alternating with occasional clear, warm days. Temperatures averaged 4ºC at sunrise, 14ºC at midday, and 7ºC at sunset. The best forage conditions of the year occurred in spring, with both quality and quantity relatively high due to new growth of many herbaceous species.

Summer: In summer sheep spent nearly half (45%; 6.8 hr) of the day feeding and half of the day resting 49%; 7.3 hr) (Figure 1B). During this season sheep exhibited two distinct periods of feeding and one of resting. They fed actively in the cool hours from before sunrise until about two hours after sunrise, then as air temperature rose above 24ºC, sheep bedded in the shade of west facing cliffs on substrates that had cooled overnight. Later as the sun approached the zenith and shade left morning bed sites, sheep moved to any shade available, usually below east facing cliffs. Substrates below east facing cliffs were heated by morning insolation; perhaps as a result, sheep often stood rather than bedding again. As soon as the air temperature started to drop in early afternoon, sheep began moving to feeding areas and fed increasingly until after sunset. A marked increase in feeding in place occurred during the hour preceding sunset.

Weather in summer was consistently clear in the mornings, with partly cloudy afternoons, and occasional overcast days. Temperatures averaged 16ºC at sunrise, 28ºC at midday, and 20ºC at sunset. The daily high temperature rarely went above 32ºC. Summer forage conditions were good because quantity remained high and quality only dropped slightly as desiccation progressed; some green plants were available throughout summer.

Fall: Sheep distributed their time more evenly between the five recognized activity categories in fall than in other seasons. They spent the same number of hours feeding (6.8 hr) in fall as in summer (Figure 1C); but the percentage of the day spent feeding was greater in fall (57%) because day length averaged 12 hours in fall, three hours less than in summer. Less bedding occurred during the day in fall than in other seasons (17%; 2.1hr). The daily pattern of activities in fall was similar to that of summer, with the exception that the morning resting period began earlier, as soon as the sun rose. Within the morning resting period, bedding replaced standing as the primary resting activity at midday.

Winter: Sheep spent more time (64%; 7.7hr) foraging in winter than in any other season; conversely, less time was spent in active (5%; 0.6hr) and standing (7%; 0.8 hr) categories (Figure 1D). The daily pattern was quite similar to that in fall, but more distinct as a result of the reduction in active and standing categories.

Winter weather was consistently clear or thinly overcast, with occasional snow storms. Temperatures averaged -6ºC at sunrise, 7ºC at midday, and 1ºC at sunset. Both quantity and quality of forage were lowest in winter.

DISCUSSION

Activity patterns of bighorns on SNWR may be best explained by considering food as the animal's most basic requirement. Bighorn sheep need about 1.5 to 1.8 kg dryweight of forage per day (Hansen 1980:76, Anderson and Denton 1978 and Hebert 1973, cited by Van Dyke et al. 1983:11). Baile (1979:307) suggested that concentration of tissue metabolites, or a feeling of fullness in the gastrointestinal tract, may be the internal stimulus that regulates feeding behavior throughout the day in ruminants. While night feeding in bighorn sheep has been reported in some studies (Simmons 1969:62, Geist 1971:262), it probably was not common on SNWR. Thus, extensive feeding early in the morning was probably a result of fasting and ruminating overnight; late morning resting was a consequence of filling the rumen early in the morning. Afternoon feeding was probably an attempt to fill the rumen before night rumination. The small increase in activity that produced a bilobed resting peak in late morning reflected comfort movements and shifts to different bed sites.

Although the basic daily activity pattern of SNWR bighorn may have been largely determined by the predominately diurnal nature of the species and its digestive physiology, other factors apparently were involved that produced seasonal variations in the basic pattern. The first two factors relate directly to the energy requirements of the animals: (1) seasonal variations in the thermal environment, and (2) seasonal nutrient availability. The last two factors were behavioral constraints: (1) the need of security from predators by ewes with young lambs, and (2) harassment of ewes by rams during the rut.

Sheep were able to take advantage of the most favorable thermal conditions by shifting activities spatially and temporally, thus reducing energy loss through active thermoregulation. Simmons (1969:58), Turner (1973:84), and Leslie and Douglas (1979:38) found that in summer, desert bighorn (*O.* c. mexicana, *O.* c. *cremnobates,* and *O.* c. *nelsoni)* avoided activity during the hottest hours of the afternoon. On SNWR similar behavior was observed on those occasional days when temperatures rose above 32ºC; however, summer high temperatures averaged only 28ºC, and sheep used a thermal strategy similar to that found in Arizona on "cool days" (Simmons 1969:58). They avoided heat gains early in the day in favor of moderate heat gains in the afternoon. Heat gained late in the day may have been beneficial because nights were cool and heat carried into the night bedding period would have reduced the necessity of heat production during the night.

During cold mornings in mid-winter, Rocky Mountain bighorn *(O. c.* canadensis) (Berwick 1968:81) and Stone's sheep (Geist 1971:261) avoided activity and preferred to forage in warmer afternoon hours. A similar pattern was found on SNWR with the possible exception that, when observed before sunrise, sheep were almost always actively foraging. Feeding initiated in the morning before first light was likely a result of overnight fasting and an effort to warm up through movement and increased circulation. As soon as the sun rose, it was more efficient energetically to lie in the sun and absorb its heat while staying out of the wind. During this season, sheep rested almost ex- si id rocl or shrubs that formed windbreaks s was also noted by t (1971:256) l Stelfox (1976:34). Additionally, l usually rested by lying down rather than standing as in other seasons; this probably was an effort to minimize convective heat loss, which Moen (1973:276) found to be of major importance to white-tailed deer *(O. virginianus).*

Like the thermal environment, forage resources available to sheep on SNWR varied seasonally. In apparent response to seasonal reductions in nutrient availability, sheep increased their time spent feeding. Similar results were reported for domestic sheep by Arnold (1960, 1962); yet, I was unable to determine whether forage consumption was simultaneously reduced due to slower digestion rates for winter feeds, as predicted by Geist (1971:270) from results of domestic sheep studies (Blaxter et al. 1961).

Reproduction has additional influences upon activity patterns of animals. In spring, ewes stayed with their lambs in or near escape terrain (Hansen 1982, 1984). Because forage in these concentration areas was limited and lambs rested often, ewes also rested much of the day, and feeding occurred as repeated short forays away from cliffs.

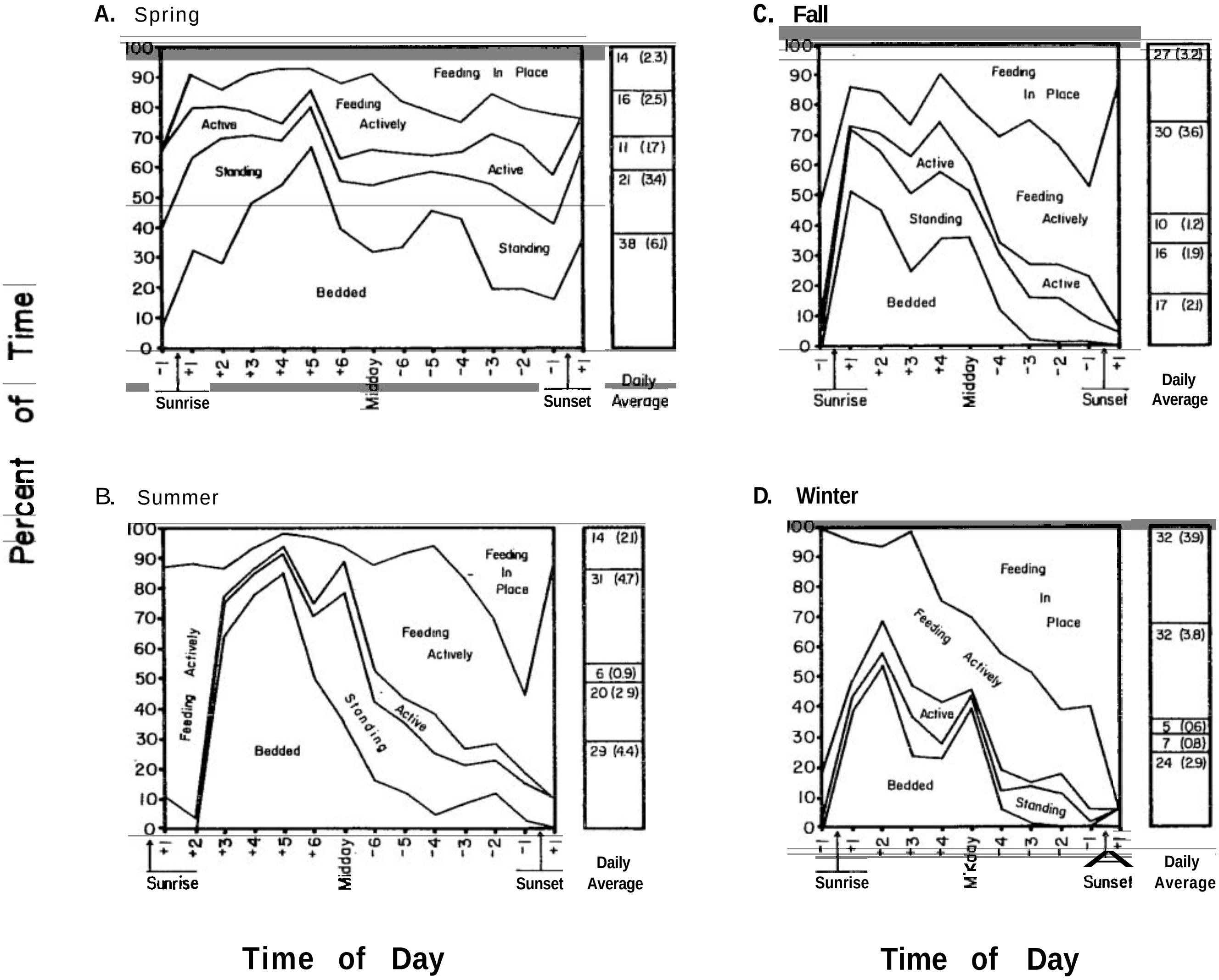

Figure 1. Daily patterns of activity by season, and mean values for each season expressed as percent and hours ( ), of California bighorn sheep on Sheldon National Wildlife Refuge (from Hansen, **1982).**

During fall, the presence of rutting rams in the ewe/lamb area did not change the daily pattern of feeding and resting of females. Instead, the effect was to increase the amount of time spent active and standing. The effect of the rut on ram activity patterns was undoubtedly greater, and studies are needed to establish ram activity patterns and the factors affecting them. Indeed, further studies are needed to quantify environmental factors noted subjectively here and to establish bighorn activity patterns under other environmental conditions.

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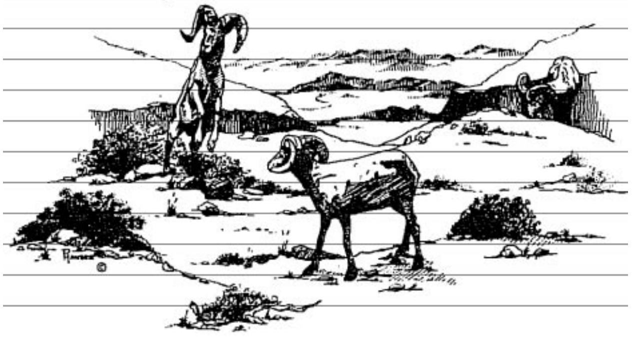

CATTLE GRAZING IN DESERT BIGHORN SHEEP HABITAT

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Abstract: Ecological overlap between desert bighorn sheep (Ovis canadensis nelsoni) and domestic cattle was investigated in the White Canyon area of San Juan County, Utah. Use of topographic types, diet overlap, and social intolerance between bighorn and cattle were monitored from 1982-83. Cattle and bighorn use different topographic types and have significant differences in diet composition.

INTRODUCTION

Cattle are grazed in desert bighorn sheep (Ovis canadensis ssp.) habitat in several western states. Impacts of grazing on desert bighorn have not been fully investigated, so reliable knowledge of how bighorn populations respond is largely unavailable.

In Utah, cattle and desert bighorn *(O.c.* nelsoni) are sympatric on winter ranges, many of which are administered by the Bureau of Land Management (BLM). In order to formulate a livestock grazing statement that adequately addressed desert bighorn needs, the BLM contracted Utah State University to conduct an ecological investigation of desert bighorn sheep in southeastern Utah (King and Workman 1982). A major objective was to determine desert bighorn and domestic cattle relationships with respect to habitat use, diet overlap, and social intolerance.

STUDY AREA

The study was conducted in the White Canyon area of San Juan County, Utah (Figure 1). The area is bordered to the north by Dark Canyon, to the west by Lake Powell, to the south by Wingate Mesa, and to the east by Natural Bridges National Monument.

Precipitous mesas and broken valley floors create a rugged environment for cattle and bighorn. Five distinct topographic types can be identified in the area (Figure 2). Chinle talus slopes average ≥ 60% slope and are characterized by shadscale (Atriplex *confertifolia),* galleta grass *(Hilaria jamesii),* and ephedra (Ephedra sp). Mossback - Shinarump mesa tops average 0-10% slope and are characterized by blackbrush (Coleogyne *ramosissima)* and galleta grass interspersed with dense stands of pinyon pine *(Pinus edulis)* and Utah juniper (Juniperus osteosperma). Moenkopi talus slopes average 30-40% slope and are characterized by blackbrush, galleta grass, and pinyon - juniper associations. Organ Rock talus slopes average 20-40% slope and are characterized by pinyon - juniper stands with a blackbrush and galleta grass understory. Cedar Mesa Valley floors average 0-10% slope and are characterized by blackbrush and galleta grass interspersed with pinyon and juniper.

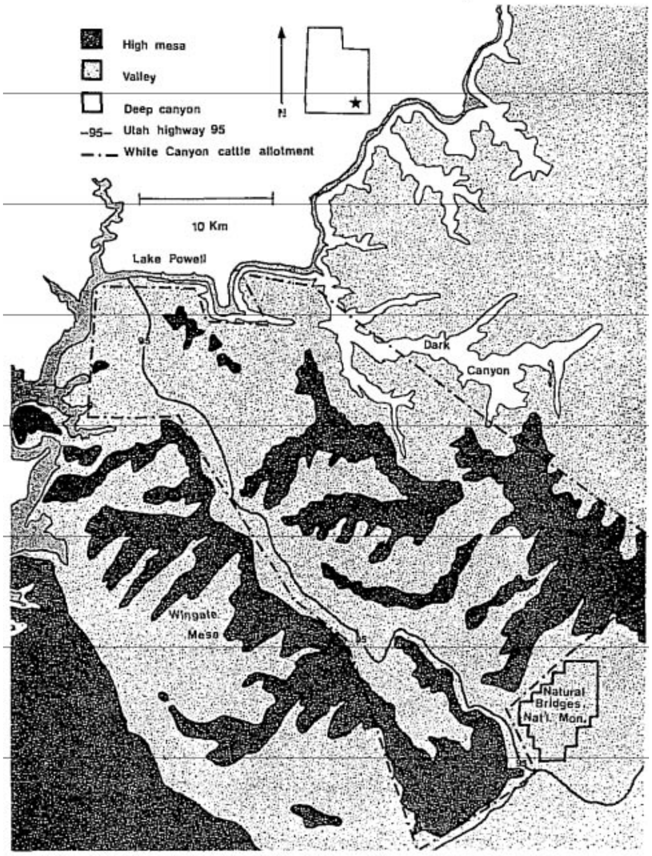

Figure 1. White Canyon area of southeastern Utah.

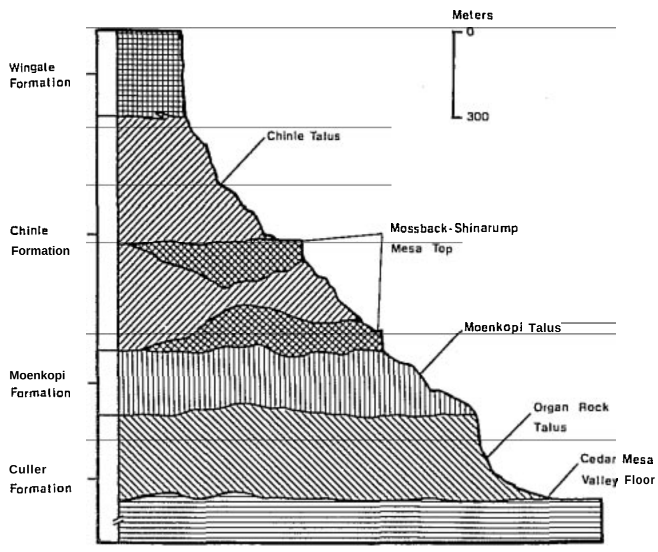

Figure 2. Generalized topographic types in the White Canyon area.

Although cattle were grazed in the White Canyon area as early as 1887 (Wilson in Trefethen 1975:103), accurate records of numbers do not exist. In the 1940's and 1950's, as many as 7000 cattle and 7180 domestic sheep were grazed in the area that now comprises Canyonlands National Park south to the San Juan River (BLM grazing records, San Juan Resource Area Office, Monticello, Utah). In 1959 this area was subdivided into 3 smaller units, including the White Canyon Allotment. The White Canyon Allotment is managed under a rest rotation pasture system and grazing privileges are 450 cattle year round (McClure, pers. comm.). In the White Canyon portion of the allotment, cattle are run from early November to late April or early May. The permittee has a cow-calf operation.

METHODS

Observations on bighorn and cattle were made during two grazing seasons (November-April, 1981-1982 and 1982-1983) to determine habitat and forage use patterns when cattle and bighorn were sympatric. Bighorn were observed when cattle were not present on the range (May-October, 1982 and 1983) to determine if bighorn habitat use patterns changed.

Habitat Use: Observations were obtained while hiking or driving through the study area. When bighorn or cattle were located, the number of animals in each of the five topographic types was recorded. Data were analyzed by constructing a 2 x 5 contingency table comparing use of topographic types by bighorn and cattle (Steel and Torrie 1980).

Forage Use: Bighorn and cattle were investigated by observing feeding animals, generally from ◄ 50 m, with 10 x 50 binoculars and a 15-60 power spotting scope and recording frequencies of plant use. Use of a culm of grass, leaf or stem of forbs, or leader or leaf of browse constituted one feeding instance (Lauer and Peek 1976). Diet for all animals in a feeding group was recorded at 2 minute intervals during a 15 minute scan sampling period (Altmann 1974). Foraging behavior was observed for as long as possible during peak feeding periods (early morning, mid day, late afternoon). Dietary items were recorded by plant species whenever possible. When species couldn't be identified, they were recorded by forage class (grass, forbs, browse). Feeding records were expressed as frequencies and do not represent actual quantities of forage ingested.

Diet similarities were determined by constructing a 2 x 3 contingency table comparing use of each of 3 forage classes by bighorn and cattle (Steel and Torrie 1980). A Percent Similarity Index (PSI) was also calculated to determine equity of bighorn and cattle diets with respect to proportion that shared diet items contributed to total diets for each animal (Whittaker 1975).

RESULTS

Habitat Use: During the 2 grazing seasons, a total of 288 bighorn and 618 cattle sightings were recorded in the White Canyon area (Fable 1). Contingency analysis indicated a highly significant difference in topographic type selection between bighorn and cattle (X^2 = 689.2, df = 4, P ◄ 0.01). Bighorn selected higher, steeper talus slopes and cattle used lower, gentler slopes and valley floors (Figure 3).

Table 1. Contingency table comparing number of locations of cattle and bighorn in topographic types during the grazing season (November-April 1981-82, 1982-83) in the White Canyon area in southeastern Utah. Numbers in parentheses are expected values.

	Topographic type					
	Mossback-Shinarump mesa top	Chinle talus	Moenkopi talus	Organ rock talus	Cedar mesa valley floor	Total
Desert bighorn	33 (10.49)	89 (28.29)	112 (35.60)	29 (46.09)	25 (167.52)	288
Cattle	0 (22.51)	0 (60.71)	0 (76.40)	116 (98.91)	502 (359.48)	618
Total	33	**89**	112	**145**	***527***	**906**

Chi-square = 689.21'
df = 4
P ◄ 0.01

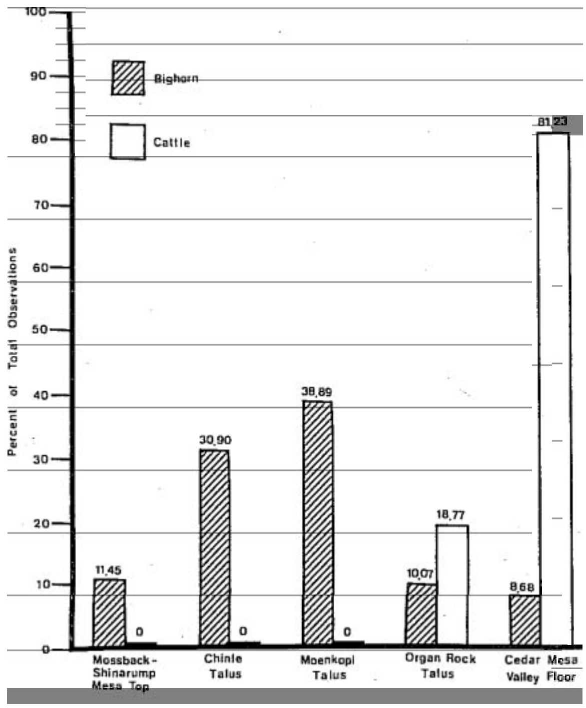

Figure 3. Topographic types selected by bighorn and cattle in White Canyon during grazing season.

Forage Use: Cattle and bighorn diet selection was monitored during 2 grazing seasons. Ninety-one cattle were observed feeding and 2331 feeding instances were recorded. Grass (56.03%) was most often selected by cattle, but browse (43.5%) was also an important component of their diets (Table 2). Important plant species selected by cattle were cheatgrass *(Bromus* tectorum), galleta grass, blackbrush, and shadscale (Table 3).

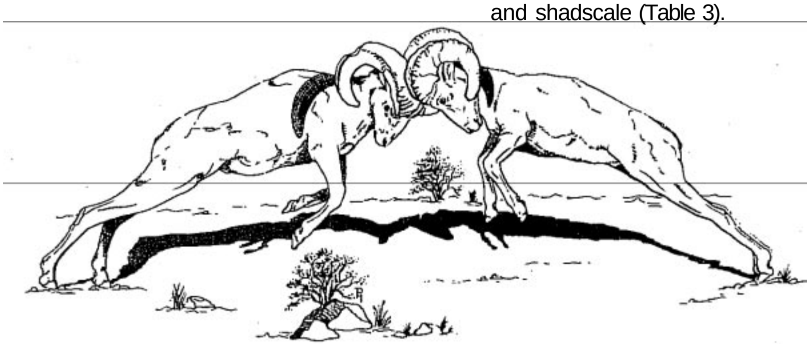

Table **2.** Contingency table comparing cattle and bighorn diets by forage class during the grazing season (November-April **1981-82, 1982-83).**

	Forage class			
	Grass	Browse	Forbs	Total
Cattle				
Feeding instances	1306	1016	9	2331
Expected values	(751.5)	(1566.9)	(12.6)	
Desert bighorn				
Feeding instances	189	2101	16	2306
Expected values	(743.6)	(1550.1)	(12.4)	
Total	1495	3117	25	4637

Chi-square = 1214.2*
df = **2**
$P < 0.01$

One hundred thirty-four bighorn sheep were observed feeding and **2306** feeding instances were recorded. Browse **(91.10%)** was highly selected over grass **(8.20%)** and forbs **(0.69%)** by bighorn (Table 2). Important plant species selected were blackbrush, cliffrose (Cowania mexicana), cheatgrass, and **galleta** grass (Table **3).**

Contingency analysis indicated a highly significant difference in diets between cattle and bighorn with respect to forage class ($X^2 = 1214.2$, df = **2**, $P < 0.01$). Cattle were primarily grazers and secondarily browsers, while bighorn were almost exclusively browsers (Figure **4).**

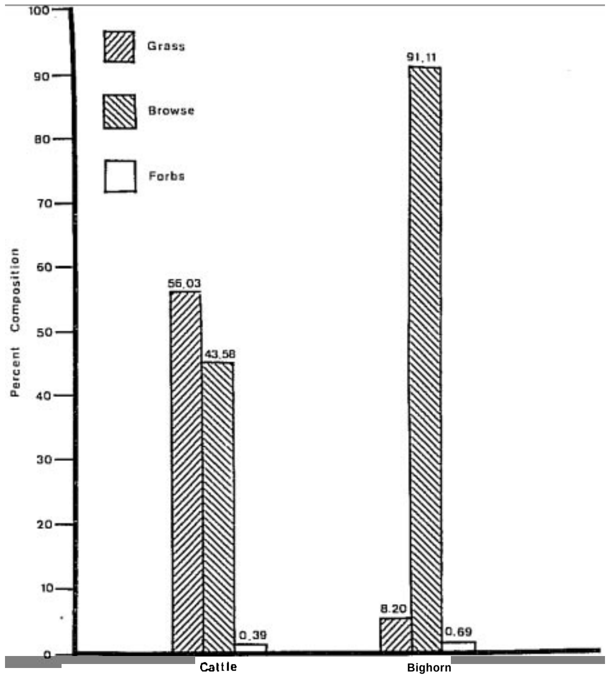

Figure **4.** Percentage of forage class in diets of cattle and bighorn during grazing season **(Nov.-Apr. 1981-82, 1982-83).**

Table **3.** Plant species selected by cattle and desert bighorn during the grazing season (November-April **1981-82, 1982-83).**

	Bighorn (n = **134**)		Cattle (n = **91**)		
	Feeding instances (n)	Percent total	Feeding instances (n)	Percent total	PSI value
Coleogyne *ramosissima*	1690	73.3	346	14.8	14.8
Cowania mexicana	376	16.3	0	0.0	0.0
Bromus tectorum	81	3.5	734	31.5	3.5
Hilaria jamesii	47	2.0	492	21.1	2.0
Oryzopsis hymenoides	40	1.7	66	2.8	1.7
Rhus trilobata	18	0.8	0	0.0	0.0
Elymus salinus	15	0.7	0	0.0	0.0
Ephedra sp.	7	0.3	74	3.2	0.3
Stanleya pinnata	7	0.3	0	0.0	0.0
Gutierrezia sorothrae	4	0.2	120	5.2	0.2
Juniperus osteosperma	3	0.1	2	0.1	0.1
Chrysothamnus sp.	3	0.1	4	0.2	0.1
Atriplex confertifolia	0	0.0	320	13.7	0.0
Atriplex canescens	0	0.0	150	6.4	0.0
Unidentified forbs	9	0.4	9	0.4	—
Unidentified grass	6	0.3	14	0.6	—
Unidentified browse	0	0.0	0	0.0	—
Total	2306	100.0	2331	100.0	23.0

Although forage classes were used differently by bighorn and cattle, there was considerable overlap in plant taxa selected. Cattle and bighorn both had 10 identifiable taxa, 8 of which were common to both animals. A PSI value was calculated to estimate dietary overlap. As the PSI value approaches 100, diets approach equity. The calculated PSI value of 23.0 indicates minimal dietary overlap.

Social Intolerance: Bighorn sheep and cattle generally use available habitat differently (McCann 1956, Barmore 1962, Ferrier and Bradley 1970, Dean and Spillet 1976, Dean 1977). Habitat use dissimilarities based on preference differences, and social intolerance of cattle by bighorn are possible explanations. Evidence conclusively supporting either hypothesis is lacking, however.

A total of 677 bighorn were observed and classified with respect to topographic type during 2 non-grazing seasons (Table 4). Contingency analysis indicated no significant difference in topographic type use by bighorn during the grazing and non-grazing seasons (X^2 = 5.62, df = 4, P > 0.10). This suggests that bighorn did not use habitat differently when cattle were off the range (Figure 5). Whether the observed separation during the grazing season and failure of bighorn to use areas vacated by cattle during the non-grazing season is a result of social intolerance or preference is unknown.

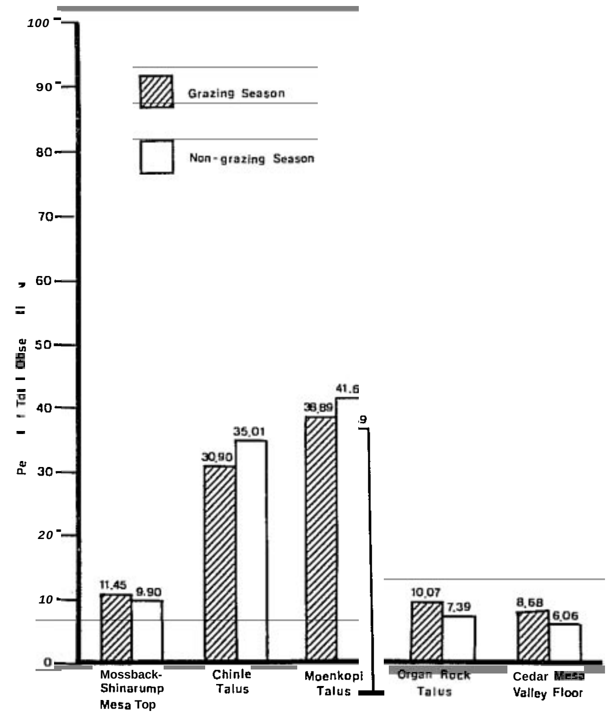

Figure 5. Topographic types selected by bighorn in White Canyon during grazing and non-grazing seasons.

Table 4. **Contingency table comparing number of locations of bighorn in various topographic types during the grazing season (November-April** 1981-82,1982-83) **and non-grazing season (May-October 1982, 1983).**

	Topographic type					
Season	Mossback-Shinarump mesa top	Chinle talus	Moenkopi talus	Organ Rock talus	Cedar Mesa valley floor	Total
Grazing						
Locations (n)	33	89	112	29	25	288
Expected values	(29.84)	(97.29)	(117.58)	(23.58)	(19.70)	
Non-grazing						
Locations (n)	67	237	282	50	41	677
Expected values	(70.16)	(228.71)	(276.42)	(55.42)	(46.30)	
Total	100	326	394	79	66	965

Chi-square = 5.62
df = 4
P > 0.10

DISCUSSION

The ecological separation observed in habitat and diet may lead wildlife and land managers to infer there is little or no conflict between desert bighorn and domestic cattle in the White Canyon area. Several issues have emerged during the study that should encourage caution in formulation of liberal grazing management plans, however.

First, limited overlap in use of the range during both the grazing and non-grazing seasons does not mean that bighorn do not avoid areas used by cattle. The long grazing history and long grazing season may be sufficient to cause bighorn to avoid cattle-use areas even when livestock are not present. In other areas, there is correlative evidence of range expansion and population increase when cattle grazing was terminated (Bates 1982, Gallizioli 1977). Habitat abandonment by bighorn when cattle were introduced into an area has also been seen (Wilson in Trefheten 1975:103, Irvine 1969).

Second, although dietary overlap is currently minimal, it may not always be that way. Some of the disparity in diets may be a function of differences in plant composition in the various topographic types in the White Canyon area (Wilson 1968). Since bighorn were only rarely observed in areas used by cattle, diets could not be adequately sampled to determine degree of overlap. Considering the high percentage of shared diet taxa (80%) it is possible that diets could converge if cattle and bighorn were forced to use the same topographic types. This situation may occur in the White Canyon area if livestock operators are allowed to make use of mesa tops and upper talus slopes by driving cattle or through mechanical manipulation of the habitat.

Third, there may be problems of disease transmission between bighorn and cattle. Positive titers for blue tongue, a viral disease, have been found in both animals (King and Workman 1982, 1983). Blue tongue is one of several diseases suspected to be responsible for high lamb mortality by predisposing them to secondary pneumonia infections (DeForge et al. 1982). Cattle and bighorn may serve as reservoirs from which the blue tongue virus is transmitted between populations.

These cautionary examples presented in the foregoing discussion do not prove or disprove the existence of competition between desert bighorn and cattle in southeastern Utah. They suggest that the matter of cattle impacts on desert bighorn must be monitored closely through appropriate experimental designs so often lacking in wildlife studies (Mackie 1978). An appropriate method would be to remove or add a species in a given area so that the impact on a second species could be monitored (Connell 1977). It would be enlightening to remove cattle from an area where they are now sympatric with desert bighorn and evaluate the population effects on the bighorn for an extended number of years.

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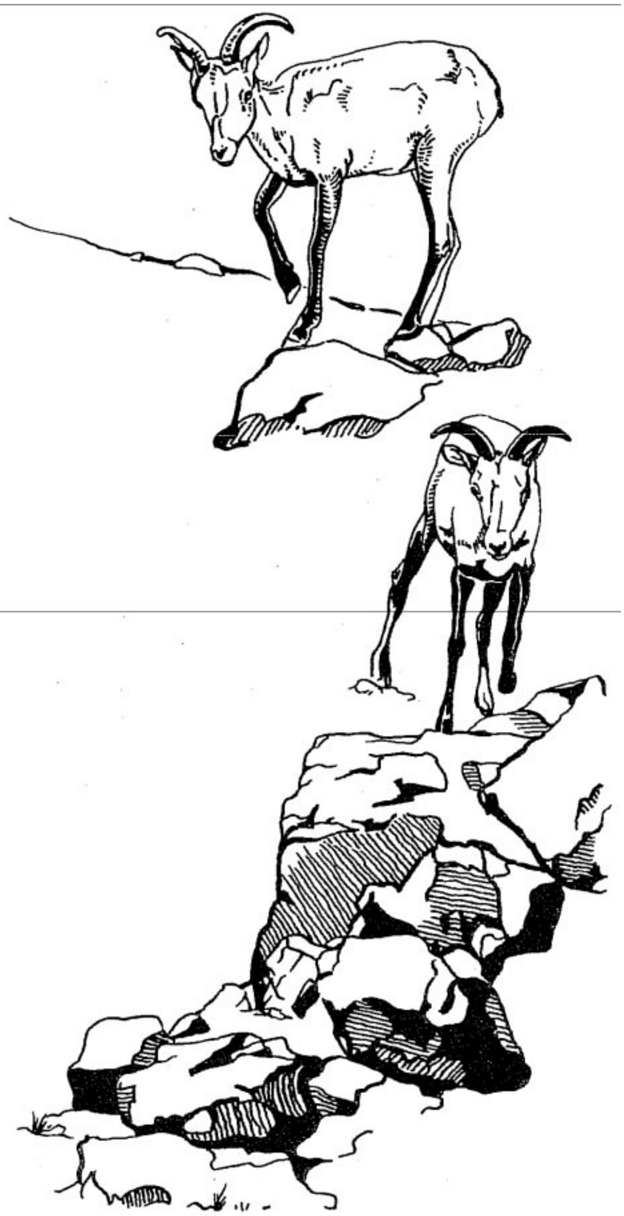

NIGHTTIME ACTIVITY OF DESERT BIGHORN SHEEP

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Abstract. Desert bighorn sheep (Ovis canadensis mexicana) are considered to be diurnal ungulates. Despite observations in some studies indicating that considerable foraging and many other activities occur at night, most studies have concentrated on a dawn-dusk schedule of behavioral observations. This emphasis on daylight studies is not surprising considering the difficulty of following bighorn after dark.

Using an available-light starlight scope, we observed desert bighorn for 9 nights in summer and late fall in the Plomosa and New Water mountains of western Arizona. Bighorn sheep were active at night during both seasons. Their activity pattern of foraging, interacting, and resting was similar to their usualy daytime patterns. In the summer, the sheep were active at night around waterholes only until summer rains began and water became available elsewhere. They continued to be active at night away from waterholes after the summer rains began. The desert bighorn did not visit waterholes at night during the fall observations, but they were active away from water on all nights of observation. The fall nighttime activity indicates that desert bighorn have a general nonseasonal nocturnal habit that is not a direct consequence of heat stress in summer.

INTRODUCTION

Daytime activity has been the focus of most behavioral studies of bighorn sheep (Turner 1973, Leslie and Douglas 1979, Olech 1979, Chilelli and Krausman 1981, Seegmiller and Ohmart 1981). This emphasis results from the difficulty of observing sheep at night and because bighorn have been assumed to be diurnal. Little effort has been made to determine what bighorn do at night. Russo (1956: 42) described the activity of a bighorn ewe with her lamb. "They returned to the shallow cave just before nightfall. In the morning both animals moved out again before it was light enough to see through the scope." Similarly, Welles and Welles (1961: 59) began a description of a typical activity pattern with, "the bighorn are likely to rise at dawn...." Both the preceding statements imply that the bighorn were not active during the night.

In contrast, Geist (1971: 262) stated that mountain sheep were usually widely dispersed at nightfall but were found somewhere in the cliffs the next morning. He went on to write that they probably grazed extensively at night. Simmons (1969) also reported bighorn activity at night in the Kofa and Cabeza Prieta National Wildlife Refuges. He stated that sheep fed at night during the hot desert summers and that the Cabeza Prieta bighorn that he observed were never relocated at first light where they had been left the night before. Furthermore, Simmons saw or heard sheep moving around on both moonlit and moonless nights during summer and winter.

The above observations make it apparent that bighorn sheep are active at night, but they give no indication of what types of activity the sheep engage in, nor do they indicate how much time the sheep spend active as opposed to resting. Such information is necessary to understand the ecology and evolution of desert bighorn sheep.

The study was funded by Southern California Edison and Arizona Public Service utility companies. We thank Dave Stevens for providing the scope for us.

MATERIALS AND METHODS

The study area, described by Witham and Smith (1979) and Cochran and Smith (1983), encompasses the Kofa, Plomosa, and New Water mountains of Yuma and La Paz counties in western Arizona. These mountains support large populations of native desert bighorn sheep (Monson 1980), including 35-40 sheep that have been radio-collared for a long-term study (Witham and Smith 1979).

To observe sheep at night, we obtained a night-viewing starlight scope during June-July and November 1983. The scope takes in available light and amplifies it electronically; it then projects the image onto a smaller phosphor screen in the eyepiece. With its 5x power, the scope was effective for viewing sheep up to 100 m away, depending on the amount of moonlight available.

During June-July 1983 we sat at nearby waterholes through the night to observe sheep. When possible, sheep were classified according to the criteria of Hansen (1965) and Geist (1971) and the sheep activities were recorded as foraging, standing, moving, interacting, or bedded. On 2 nights (7 July and 29 July) when no sheep were observed, the observer left the waterhole area at 0200. On the remaining 7 nights, the observer was in place from dusk to dawn (approx. 1945 to 0550).

In November sheep did not visit waterholes so we located radio-collared sheep late in the afternoon and watched into the night (dusk was approx. 1735). Once the sheep disappeared from view, it was not possible to relocate them at night and the observations were broken off. The latest observations in November were at 0040.

Observations at waterholes are biased measures of overall activity because sheep are more likely to be active when they come to drink. Consequently, we recorded those observations as ad libitum field notes. In contrast, the activity of sheep that are first observed away from waterholes is an unbiased sample of behavior that can be quantified. When sheep were observed away from waterholes, their activities were noted at 2-minute intervals to quantify the percent of time spend in each activity. All of the November observations and 1 set of observations in July were recorded as 2-minute fixed interval samples and compiled into histograms.

RESULTS

We spent 9 nights at waterholes from 29 June to 29 July. All of the nights had at least a quarter moon. We observed sheep activity at waterholes on 2 of the 4 nights of observation before summer rains. After the summer rains began, no sheep were observed at the waterholes on the 5 nights of observation, but nighttime activity was noted away from waterholes. Daytime maximum temperatures during the summer observation period were 39-42°C and the nighttime minimum temperatures were 19-29°C. During the November observations, the maximum daytime temperatures were 19-25°C and the nighttime minimums were 4-16°C.

During the summer sheep tended to visit the area around waterholes more often within 2 hours after dark and before sunrise, but some activity occurred in the middle of the night. Most of the activity around waterholes had to do with getting a drink. Typically, an individual or small group would come into view near the water and scan the area for some time before walking down to the water to drink. On 29 June 1983, an adult ewe visited Lazarus tank at 0247. She stood near the tank scanning the area and was joined by a class IV ram. They both drank and left the area. An hour later a different adult ewe and class IV ram came to the tank but did not drink. After scanning the area for 5 minutes they bedded for 15 minutes. Finally the ram got up and forced the ewe to stand with a front-leg kick. The ewe rose and urinated and the ram sniffed the urine and lip-curled. All these interactions took place before 0415 and it wasn't until 0430 that the eastern sky began to lighten. Later, between 0430 and sunrise at 0530, a group of 4 rams joined the ewe and ram at the waterhole. The 5 rams huddled and jousted and 2 of the rams clashed 3 times.

After the summer rains began our observations were limited to 2 nights. There were clashes at 2307 and 0515 and a sheep (not classifiable) was seen on walking on a talus slope at 0500 one night. On 22 July we were able to observe a mixed group of 2 ewes with their lambs and a class IV ram for an hour after sunset until they left the area. When all of the 2-minute interval observations were combined into a histogram (Fig. 1) they indicated significant amounts of activity early in the night during the summer. The histogram (Fig. 1) suggests a trend to less activity as the night goes on, but 42-78% of the observations were of active sheep.

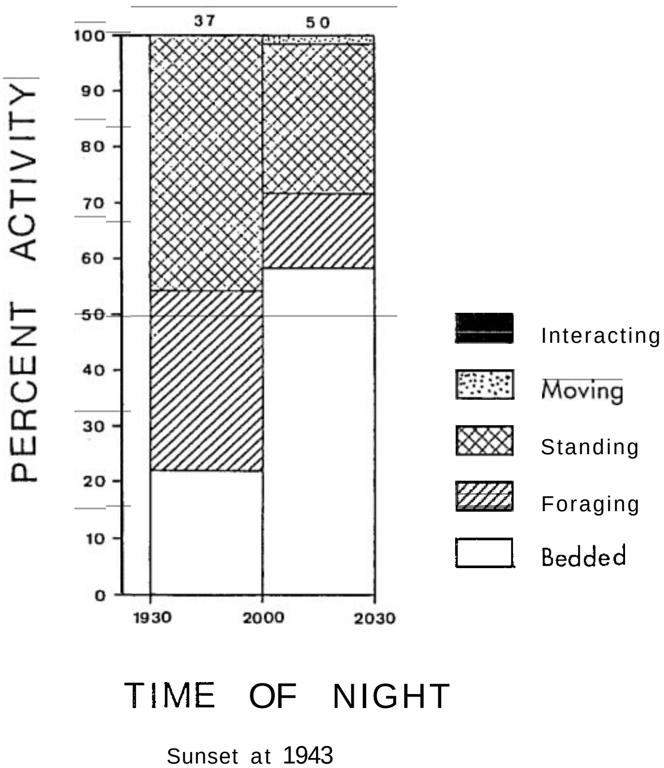

Figure 1: Nighttime activity pattern for a mixed group of bighorn sheep in July 1983.

In contrast to the summer observations, the November observations were not biased towards waterhole activity, and they were better suited for depicting general activity patterns. The most striking feature of the activity budget for 7 hours after sunset (Fig. 2) was that the sheep always maintained a high level of activity. They spend 14-55% of iheir time bedded and 15-75% of their time foraging. The interactions, which made up 0-5% of the sheep activity, included ewes displacing ewes from beds and foraging spots and rams approaching ewes in low stretch postures or running chases. Ewes urinated for rams and rams performed lip-curls.

DISCUSSION

When our summer nighttime observations away from waterholes (Fig. 1) were compared with the daytime summer activity budgets reported by Olech (1979) and Chilelli and Krausman (1981), we found that the amount of activity in the hour after sunset is comparable to

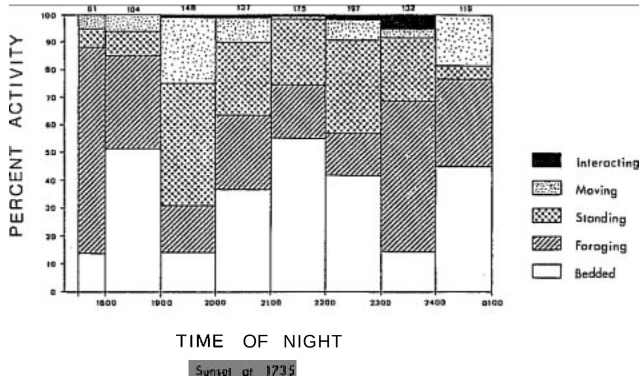

Figure 2: Nighttime activity pattern for bighorn sheep in November 1983.

most daytime hours. Fifty kilometers east of our study area, in the Harquahala mountains of Arizona, sheep were most active during the fall (Chilelli and Krausman 1981). Our fall nighttime observations were very similar to their daytime observations in that the amount of time spent bedded was very low. Chilelli and Krausman showed a pattern of activity that decreased until midday then increased again until dusk. All of their observations do now show such a pattern. Instead there appears to be a 3-4 hours cycle of more and less bedding. This cycle may relate to individual sheep filling and emptying their rumen, but the cycle of more and less time foraging does not strictly complement the bedding cycle. It would be premature to suggest such a pattern without several long observation periods of the same individuals.

There are significant limitations to these data, and we caution against unjustified conclusions. On a per hour basis, our sample sizes compare with other behavioral studies of desert bighorn sheep (Olech 1979), Chilelli and Krausman 1981), but the difficulties of finding and watching bighorn sheep at night limited the number of nights we were successful. In the summer we spent 9 nights at waterholes and saw sheep on 4 of those nights. The unbiased data away from waterholes consists of a mixed group on one night. In November, we were successful in collecting data on 5 of 14 attempts. Even though these are labor intensive data, more information on nighttime activity is needed to describe the 24-hour activity patterns of sheep and how they may change from season to season. The difficulty of using a night-viewing scope to determine nighttime activity patterns may outweigh the amount of detail one can obtain by direct observation. Future studies should focus on easier techniques, such as activity-sensing collars even though some behavioral detail would be lost.

Despite the limitations, these observations of activity by desert bighorn sheep at night are important for several reasons. First, the extent and diversity of nighttime activity indicates that we should not assume that an animal has not been active simply because it has not moved appreciably from its location at dusk. Bighorn in our study did not usually move far from day to day. The fact that a sheep is sighted bedded at a particular location one evening and is then seen near the same location the next morning reveals nothing about its activity during the night. Observers should be cautious when making statements of activity based on periodic sightings of animals.

A second important aspect of our observations relates to the extent to which bighorn sheep are diurnal. Bailey (1980) lists diurnal habit as one of the ways bighorn sheep are maladapted to a desert environment because they cannot escape high summer heat gains. In contrast, others cite nocturnal activity by bighorn as an adaptive trait (McCutchen 1981, Hansen 1982). Our observations add another level of complexity to the question. Desert bighorn are active at night during the hot summer months, as might be expected from a diurnal animal forced to avoid daytime heat loads, but they are also active at night in November when water and heat stresses are low or absent. Being active at night probably is a general behavioral pattern in desert bighorn sheep and is not just a response to summer heat stress.

Finally, the extent of nighttime activity by bighorn sheep has management implications when viewed in the context of energy expenditure. Energetic needs of penned bighorn sheep have been determined (Turner 1973), but problems arise with regard to generalizing the results to experiments that calculate energy requirements by measuring daily consumption of prepared rations; they may not estimate the energy budgets of freeranging animals well. Models using equations of weight-specific cost of locomotion in combination with activity budgets may give more realistic estimates of energy budgets (Taylor et al. 1970, Taylor 1973). With information on forage availablity and nutritive value, these models of energy requirements will significantly enhance our understanding of the ecology of desert bighorn sheep. However, without information about activity budgets of sheep at night, attempts to estimate daily energy requirements would seriously underestimate the true values.

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SIMULATED EFFECT OF TRANSPLANT REMOVAL FROM THE RIVER MOUNTAINS BIGHORN HERD II

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Abstract. A computer simulation model was developed in 1980 to aid in managing the River Mountains herd, the most heavily harvested herd of desert bighorn in the nation. A series of simulations are presented for different removal strategies in 1984. The simulations demonstrate the importance of reliable population estimates, the major influence of climate and herd density, and the need to develop a long-term managment plan for this herd.

A simulation model was developed (Leslie 1980) to aid in making proper management decisions regarding numbers of sheep to be removed from the River Mountains herd, and the frequency of removal. The original model suggested that a transplant comprised of a random selection of ewes was the most pragmatic for the parent herd and for the transplant.

The original model did not take climatic variability and herd density into account; both were hypothesized to affect lamb survival. Subsequently, we analyzed interrelationships of numerous climatic variables, and herd density with lamb survival. We found that fall precipitation one year prior to October lamb counts (when the ewe was gravid with the observed lamb) and herd density account for 87% of the variability in lamb survival over the past 13 years. The resulting regression model greatly improved our ability to predict lamb survival (Leslie and Douglas, 1981, 1982), and was incorporated into the 'revised model.

Simulations of various removal strategies were conducted in 1982, and demonstrated that the herd recovered more rapidly during years having low population density and high precipitation in the preceding fall. Nevertheless, the simulations showed that recovery of the population from removal of 40-60 animals was not complete within a couple of years. This is noteworthy because 123 sheep were removed from 1982-83, and removal of 70 additional animals is planned for 1984.

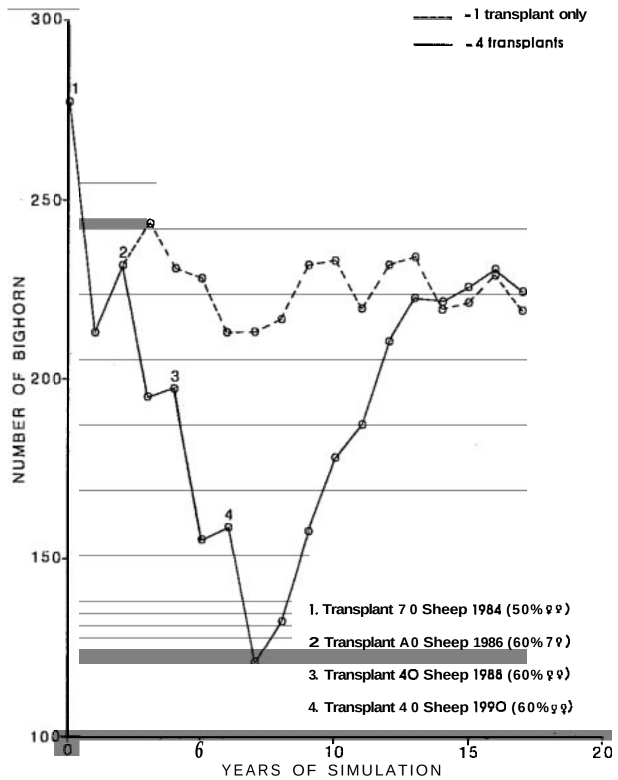
Meaningful simulations are possible only when input data (samples) are accurate and representative of the population. Since 1979, too few marked animals remain in the River Mountains herd to permit calculation of a reliable population estimate and confidence intervals from helicopter or waterhole observations. This situation was partly corrected in 1983 with the marking of 21 animals; 13 previously marked sheep were still alive in the summer of 1983.

RESULTS

Waterhole counts in the summer of 1983, following removal of 35 rams and marking of 21 other animals, resulted in a total of 330 sheep being observed over a three-day period. A percentage of the total was considered to be repeat observations, based on the percentage of marked individuals seen one or more times. These data were used to calculate a Lincoln Index population estimate of 286 $\pm$ 108 animals ($\pm$95% confidence interval). Data from the October, 1983 helicopter survey yielded a population estimate of 330 $\pm$ 132 animals. Mortality at the rate of about 17% per year occurs between the time of the survey and the actual transplant removal date (McQuivey, 1978). Likewise, there are new births. Therefore, excluding lambs, the waterhole data would diminish from a population estimate of 286 to 238 $\pm$ 108, and the helicopter date from 330 to 287 $\pm$ 132. These numbers are only gross approximations; the real population number probably lies within the 95% confidence interval of 130-419 animals.

Simulated removal experiments were run using population sizes of 278 and 206, which were thought to be reasonable levels within the 95% confidence interval. The model requires assignment of males and females to each of 10 age classes. Population structure of rams was based on 1983 helicopter age estimates; ewes were distributed randomly through all age classes. Numbers of lambs from 1983 were added to the one year age class of each sex. Mortality factors are incorporated within the model.

Figure 1



Simulations in Figure 1 show the probable response of the River Mountains herd at the higher density (278) if 70 individuals were removed from random age classes in 1984. The dotted line shows population recovery with no additional removals after 1984. The solid line shows response of the herd following removal of 70 animals in 1984, and removal of 40 animals in 1986, 1988, and 1990. Clearly, removal of 40 animals in alternate years cannot be conducted for many years without dramatic consequences for the herd.

Response of the herd at the lower density (206) following removal of 70 individuals in 1984, and 40 animals in each of 1986, 1988 and 1990 is more dramatic (Fig. 2). Comparison of Figures 1 and 2 shows that the small population recovers somewhat more rapidly from transplant removal than the larger population. This is related to herd density, one of the important parameters affecting lamb survival.

Carrying capacity (K) for the River Mountains is believed to be 250 animals, although specific data to establish a "K" are lacking. Theoretically, an undisturbed population should increase in size until it reachesthe carrying capacity of the habitat, then numbers should fluctuate around that density, with minor corrections depending upon factors controlling the population. A population's most rapid growth occurs at one-half the carrying capacity (K/2), a population density at which resources are relatively more abundant for all animals. In reality, carrying capacity fluctuates widely from season to season depending upon vagaries in climatic variables.

Thus, the simulation in Figure 1 demonstrates response of a population above long-term carrying capacity at a density of 278 animals. Upon removal of 70 animals, this population would contain 214 animals at the end of the second year. A population starting at 206 animals would contain about 150 individuals at the end of the second year (Fig. 2). The latter simulation places the population closer to K/2 (25012 = 125) than does the former simulation. Therefore, a slightly more rapid recovery of the smaller population would be expected.

Leslie and Douglas (1982) demonstrated that population recovery is more rapid when herd density is low and precipitation is high. The first three years of the present simulations have high levels of fall precipitation, and the fourth and fifth years are above the critical level. Years 7, 12, 15 and 18 are the only years having less than one inch of previous fall precipitation. Thus, simulated recovery is probably more rapid than could be expected.

It is important to note that the larger population recovered to the carrying capacity (250) in 20 years (not graphed), but did not reach the starting point of 278 animals even after 35 years. The small population recovered to the starting number in 5 years following the 1984 removal of 70 animals, but then took 15 additional years to reach carrying capacity.

Figure 2

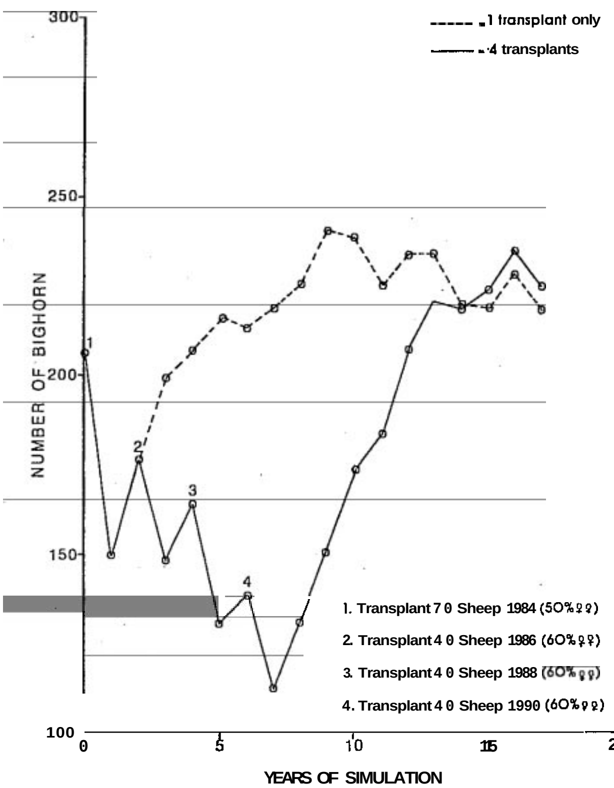


Figure 3

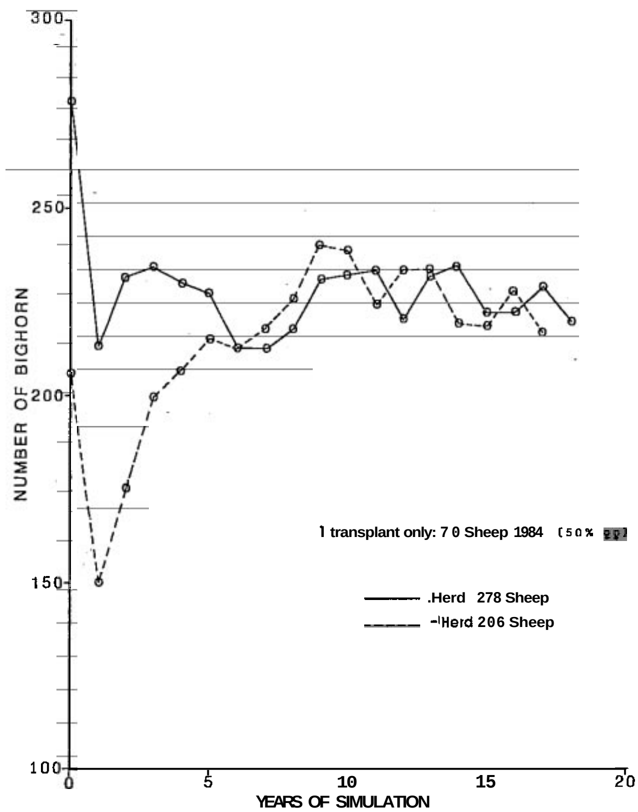
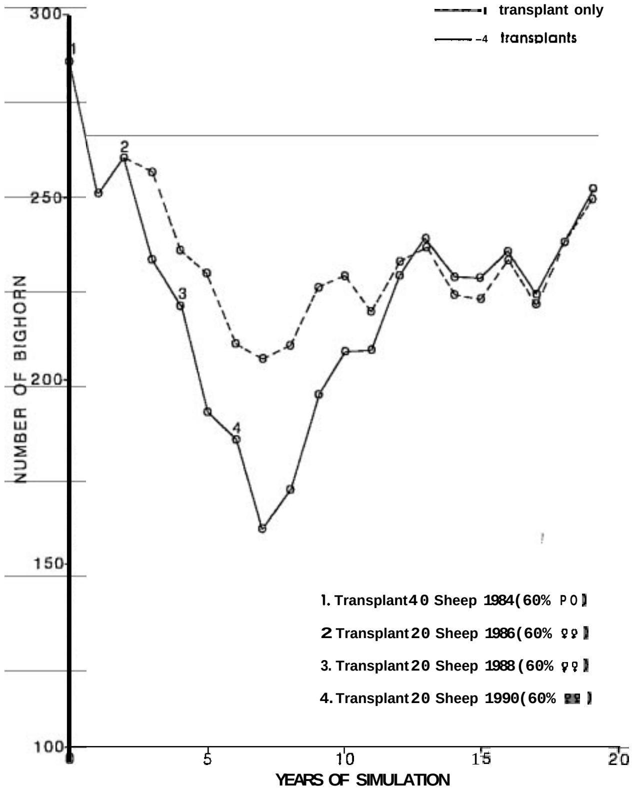


Figure 3 demonstrates the recovery at high and low population densities following only the 1984 removal. Both populations reach a density of about 225 animals, then remain at that level for many years.

Because the previous simulations severely impact the population, a somewhat more conservative set of simulations was examined (Fig. **4):** removal of 40 animals in 1984, followed by three additional removals of 20 animals each in 1986, 1988, and 1990. The dotted line represents herd recovery following the 1984 removal of 40 animals only. Both simulations begin with a high density herd. Because the herd is at or above carrying capacity for the first three years, it would be expected to drop below carrying capacity even if undisturbed. Consequently, the first two transplant removals approximate what nature would have done to the herd (although different age groups might have been involved). Additional removal of 20 animals in alternate years drives the size of the population steadily lower. It should be noted that years 1 through 7 have more than adequate precipitation for promoting growth of winter and spring vegetation. Drier years would lead to an even more pronounced drop in population density, plus longer recovery time. In these simulations, it took the herd 19 years to reach 250 following four removals.

Figure 5 demonstrates the same scheme as Figure 4, but starts with the low density herd. Again, the dotted line represents herd recovery with only 40 animals removed in 1984. The herd recovered to the starting number in the second year following removal. Population numbers tend to fluctuate around 225 until there is a response to higher levels of precipitation in years 17, 19 and 20. Four transplant removals in years 1, 3, 5 and 7 (total of 100 animals) are shown by the solid line. Three years were required following the last removal before the population recovered to the starting density. Carrying capacity was reached 13 years after the last removal.

Figure 4



DISCUSSION

The simulations conducted for this report enable us to consider possible ramifications of several removal schemes. Simulated removal of 70 animals in 1984 suggests that the high density herd will require about 20 years to recover to carrying capacity. This may not be undesirable, because a herd at or above carrying capacity does not have good lamb survival even in moist years. A more reproductive population at lower density is shown to better sustain removals, it the numbers removed are moderate and the population is allowed time to recover between removals (e.g., Figs. 2 and 5). From 1979 through 1983 the herd had not been allowed time to recover between removals; animals were removed every year except 1981, for a total of 163 removed.

A crucial concept in evaluating these simulations is where we choose to set the initial population level. Management strategy should be affected considerably by where we believe the population is in relation to carrying capacity. The best data available indicate a July 1984 population of about 237-287 animals, with a 95% confidence interval of 130-419 (all data corrected proportionately for 17% annual mortality). Note that the lower limit of the confidence interval is lower than the low population number used in the simulations. From the data available, we cannot know what the population number really is. We can only determine what ball park it is in, and that ball park is uncomfortably large.

Simulations reducing herd density to levels near K12 show more rapid recovery from removals than simulations with the herd closer to K. At K12 (about 125 animals) the population is able to achieve its highest rate of increase in years having good precipitation. If held near this level, and assuming continuing harvesting, there will eventually be more animals in the younger age classes, and fewer in old age classes. However, if there were several years of low precipitation, a population at low density could experience a critical decline in numbers, and a very prolonged recovery following return to years having higher precipitation.

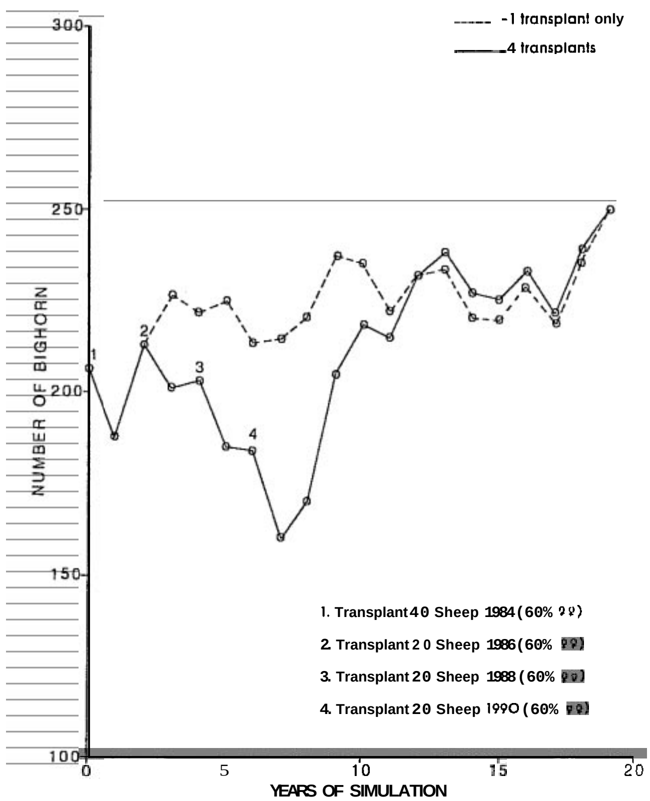
The River Mountains herd of desert bighorn is one of the most productive and heavily harvested herds in the nation. Since 1973 the herd has supplied more than 300 sheep for transplant to about 9 mountain ranges in Nevada, and to localities in Utah, Colorado and Texas. Despite the major importance of this herd, there has never been a coherent management plan for it (written or unwritten). Nor is there actual agreement on a basic management strategy by the NPS and Nevada Department of Wildlife, the two management agencies concerned.

Major philosophical questions concerning long-term management strategies for the River Mountains herd must be addressed before it can be managed safely, effectively, and consistently. There are important trade-offs for different management strategies that should be recognized and discussed. Until the NPS has a coherent management strategy for the River Mountains herd, and long-term objectives for harvesting and preserving it, the NPS will by necessity continue to operate in a reactive fashion to demands other agencies place on the herd. The simulations contained in this report suggest that such a strategy could quickly lead to major problems for the River Mountains herd.

MANAGEMENT RECOMMENDATIONS

1. Over the past few years, we have tended to become complacent about numbers of lambs being removed with adult ewes. This practice should be stopped immediately, because it could be detrimental to the River Mountains herd. Removal of 35 ewes and 35 rams in 1984 could total 100 animals when lambs are included.
2. The River Mountains herd cannot sustain the high number and the frequency of transplant removals it has experienced in the past several years. We (Leslie and Douglas) tried to clarify this in 1982, and the situation has deteriorated since then. One simulation indicated that a lower density herd might recover quickly from

Figure 5



moderate removals when high levels of precipitation pertain. All other simulations demonstrate that the herd generally does not recover from removal of 40 animals in a couple of years. The River Mountain herd is seldom given even a couple of years to recover; removals are increasing in numbers and in frequency. A continuation of this trend could drastically reduce the size of the population within relatively few years. If that low population level coincided with drought conditions, the River Mountains herd could become a part of history.

3. More animals *must* be marked to increase the accuracy of population estimates. Reliable population estimates are of critical importance to making accurate predictions and responsible management decisions. The 95% confidence interval we are working with is too large. Because of this fact alone, removal strategies should be conservative. The removal of 193 animals between 1982-1984 could never be mistaken for conservative management.
4. A long-term, interagency management strategy for the River Mountain herd should be devised to replace the short-term reactive strategy that now prevails.
5. The River Mountains herd could easily provide the wildlife management field with a classic example of bighorn population management. At present, we may well be embarked on a demonstration of how to destroy the best herd in the west. Removal strategies should be designed to test hypotheses, rather than to just move more and more animals. Data such as weight, body measurements, blood and fecal samples, etc., should be taken routinely from sheep being handled. For example, knowledge of whether our transplant schemes might be resulting in smaller lambs and lighter animals being transplanted could be a major aid in analyzing reasons for success or failure of such transplants. Monitoring of parasite load via fecal samples should be routine.
6. Desert bighorn should not be removed from a viable herd on National Park Service lands unless adequate monitoring of the transplanted sheep can be implemented. Reasons for successful transplants, or for failures, can be determined only after adequate numbers of transplanted groups are studied. Transplanting of desert bighorn, although widespread, is still in its infancy. Long-term data are simply not yet available for transplanted desert bighorn, and the possibility exists that many transplants may be new relict groups that will not be viable over an extended span of time.

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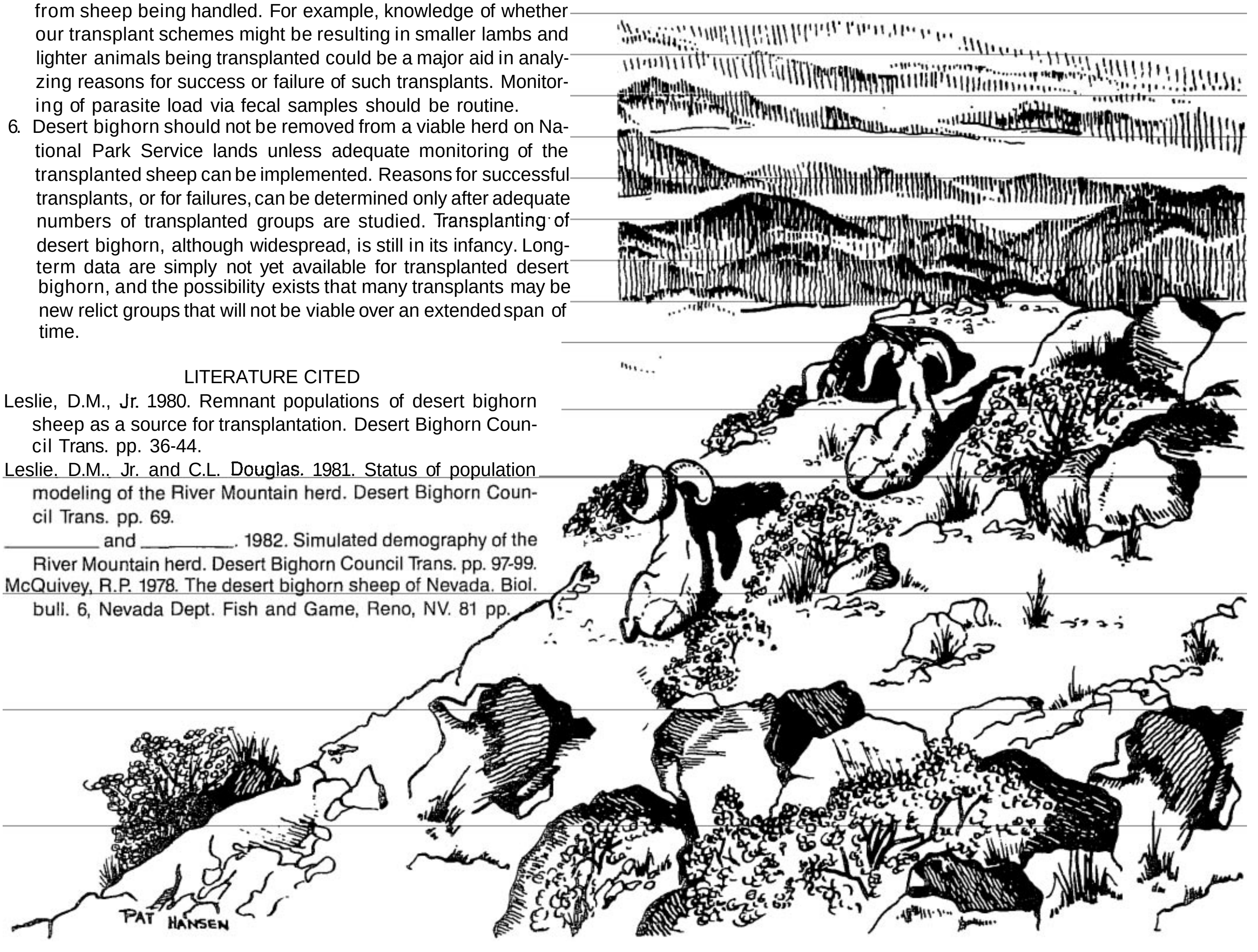

A MANAGEMENT UPDATE, KOFA NATIONAL WILDLIFE REFUGE

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Abstract. Kofa National Wildlife Refuge was established in 1939 and managed jointly by the U.S. Fish and Wildlife Service (FWS) and the Bureau of Land Management (BLM) until passage of the Game Range Amendment to the National Wildlife Refuge Administration Act in 1976, at which time sole administration was given to the FWS. Population estimates of bighorn sheep (Ovis canadensis mexicana) were 100 at the time the refuge was established. In 1984 the population is between 800 and 1000. Management activities for bighorn sheep include cattle and burro removal, waterhole development, intensive aerial surveys and transplants. Threats to bighorn sheep habitat include mining, power and pipeline development, and increasing public use.

INTRODUCTION

Kofa Game Range (KGR) was established by executive order 8039 on January 25, 1939 by President F.D. Roosevelt for the protection of a small band of desert bighorn sheep. The KGR was jointly administered by the U.S. Fish and Wildlife Service (FWS) =-ndthe Bureau of Land Management (BLM) from 1939 to February 27,1976, when an amendment to the National Wildlife Refuge Administration Act transferred sole jurisdiction of the area to the FWS. Federal game ranges and wildlife ranges were designated as part of the National Wildlife Refuge System by the Act, and KGR became Kofa National Wildlife Refuge (KNWR). KNWR encompasses 267,300 hectares of Sonoran Desert, including the Kofa Mountains, Castle Dome Mountains, and parts of several minor mountain ranges. Refuge lands have been instrumental in maintenance of the Ovis canadensis mexicana race of desert bighorn sheep in southwestern Arizona. The expanding population (from 100 sheep in 1939 to 800-1,000 in 1984) demonstrates the success of KNWR. KNWR bighorn population now serves as a reservoir from which desert bighorns are transplanted. Since 1979, 94 sheep have been removed from the refuge for transplants into historic habitat in Arizona, Colorado, New Mexico, and Texas.

The success of KNWR's bighorn sheep population is attributed to protection and management activities. These activities consist of: restriction of public use by regulation and intensive law enforcement patrol, removal of livestock and feral burros, rehabilitation and upgrading of water sources, intensive bighorn sheep surveys, and monitoring existing mining activities.

Public Use: Following the passage of the "Game Range Amendment" in 1976 and transfer of sole administration to FWS, regulations were instituted to control public access and use. Off road vehicle travel was prohibited. Vehicles are now restricted to approximately 300 miles of designated roads. Possession of firearms and other weapons is restricted to the October-February period when hunting seasons are open. Visitor use of the area is not discouraged but is closely regulated. Hunting programs on KNWR are cooperatively managed by the refuge staff and Arizona Game and Fish Department (AZGFD) personnel. Refuge lands provide approximately 25 percent of the available bighorn sheep permits in Arizona.

Cattle and Burros: Under joint FWS-BLM management the number of active grazing allotments varied from 1-4. Grazing from 1976 to 1983 was administered by annual permit. The number of permittees had dropped to one permit for 350 head of cattle year-round on approximately 187,000 acres of refuge lands by 1978.

Based on a determination that continuous grazing by cattle and an uncontrolled population of feral burros was not in the best interest of native wildlife, an Environmental Impact Statement (EIS) process was initiated in 1978. Several alternatives were proposed in the EIS for the reduction or elimination of cattle grazing and for the elimination of burros. The preferred alternative was elimination of cattle grazing by July 30, 1982 and elimination of wild burros by September 30, 1981. The record of decision was signed July 23, 1981. The permittee was reduced to 250 head of cattle year-round. FWS was given 3 years to evaluate the effects of the cattle reduction and removal of burros before making a final decision. During that period, the grazing permittee negotiated an agreement with the Trust for Public Lands (TPL) to buy the interests of the grazing permit. An agreement was signed by all parties on January 25, 1983 calling for a complete removal of cattle by June 30, 1983.

As cattle were removed from the refuge, corrals, loading shutes and cattle traps were dismantled. Boundary fences were extended and strengthened where BLM has adjacent grazing allotments. Large open water storage tanks, which are hazardous to birds, are being replaced with 600 gallon closed tanks plumbed to ground level drinking troughs. A float valve system regulates flow of water with excess water overflowing back into the well. In compliance with the EIS process, FWS entered into an agreement with BLM to remove burros from KNWR by live capture. During the summer months of 1982, burros were captured at water sources and sold to the public. As authorized in the EIS process, refuge personnel remove remaining burros by shooting. Less than 15 burros remain on KNWR.

A long term study began in 1983 to document changes in vegetative and wildlife resources in areas heavily grazed by cattle and burros. Response in vegetation is being measured on randomly selected transects using a line intercept method (Canfield 1941). Small mammals, birds and reptiles are surveyed along vegetative transects. Desert bighorn sheep and mule deer are counted on separate aerial surveys in November and January, respectively. Information from the study will aid the FWS and other land managing agencies in future determinations as to compatibility of livestock grazing in similar desert areas.

Water Development: Water development has received high priority on KNWR in past years. Challenged by recommendations in 1979 from the FWS Washington Office and Regional Office to reduce emphasis on water hauling, the refuge staff began looking for ways to increase water dependability. Since 1979, 27 water sources have been developed or have undergone rehabilitation. Cleaning and sealing of run-off catchments was continued. Emphasis was placed on reducing evaporation by using sunshades. Framework of the new sunshades consists of welded pipe covered with corrugated sheet metal. Low maintenance cost and high durability are expected benefits of this type of construction. Improvement of water quality by shading the water to reduce algal blooms is an important secondary benefit of the sunshades. Feral animal enclosures have been constructed at most water sources on the periphery of KNWR to restrict ingress of cattle or burros from adjacent areas. The overall design of 50.8, 96.5 and 106.7 cm rail spacing on exclosures is based on a study at Desert National Wildlife Refuge (Helvie 1971). Bighorn sheep and deer appear to have no problem going through the exclosures, while cattle and burros do not challenge the pipe rail fences.

Table 1. Summary of aerial bighorn sheep surveys on Kofa NWR, **1980-83.**

Year	Survey Hours	RAMS Yrlg.	I*	II*	III*	IV*	EWES Yrlg.	Adult	Lambs	Uncl.	Total
1980	25.0	18	20	24	46	17	3	192	31	1	352
1981	36.1	9	31	31	39	33	20	209	44	1	417
1982	46.9	6	22	32	47	34	9	225	51	1	427
1983	44.8	24	22	44	30	27	16	244	50	1	458

*From Geist (1979)

Improved Bighorn Sheep Surveys: Traditional bighorn sheep surveys, such as the spring lamb count in March and the waterhole count in June, have been conducted on KNWR for many years. These surveys yield information of doubtful value as an estimator of population size. Fall helicopter surveys were directed toward upgrading bighorn sheep population information; however, staff members had questions about observation rates from helicopters. As a result, KNWR's first comprehensive aerial survey was preceded by a paint ball marking study (Furlow et. al., 1981).

The first comprehensive aerial bighorn sheep survey on KNWR was conducted in November 1980, using a Bell 206 BIII helicopter and three observers. Observers were personnel from KNWR and AZGFD. The intention of the survey was to contour fly all sheep habitat within the refuge boundary. In 1980 available time between refuge deer hunts was short and several smaller mountain ranges associated with the Kofa Mountains were not flown. During the period 1981-83 all available bighorn sheep habitat on KNWR was surveyed. Results appear in Table 1.

The paint ball siudy and subsequent aerial sheep surveys have resulted in revision of refuge estimates of bighorn sheep. The 1979 refuge leaflet estimated the population conservatively at 250. The 1984 version estimates the population conservatively at 800. There probably are 1,000 plus desert bighorn sheep on KNWR today, a ten-fold increase in estimated sheep since the refuge was established.

Transplants: KNWR has cooperated with AZGFD efforts to transplant bighorn sheep into historic habitat since 1957. Nineteen bighorns were transplanted from KNWR between 1957 and 1978. During the last 5 years, 94 sheep have been removed from the Kofa and Castle Dome Mountains for transplant purposes. Transplant data 1979-83 is summarized in Table 2. The refuge continues to support transplant efforts by AZGFD and other State's game departments.

Table 2. Transplants from Kofa NWR, **1979-83.**

Year	Number Transplanted* Rams	Ewes	Receiving Location
1979	4	6	Colorado/Texas
1980	7	17	Arizona/New Mexico
1981	5	12	Arizona
1982	4	10	New Mexico
1983	8	16	Arizona

*Does not include 5 transplant mortalities.

Threats and Conflicts: With the removal of cattle and feral burros, two of the most damaging influences on refuge resources have been reduced as potential threats. Future threats and conflicts are mining, powerline/pipeline corridors, and increasing public use.

As a result of wilderness proposals for KNWR, mineral entry was withdrawn pending a comprehensive mineral survey. Valid existing claims predating the withdrawal action (February 21, 1974) are allowed to operate normally. New claims filed after February 21, 1974 are declared null and void and claimants are subject to legal prosecution. Most mining claims on KNWR are not worked for mineral value but are bought and sold in an endless progression of real estate transactions. The refuge negotiates low impact access with each claim holder on a case-by-case basis.

Decisions on KNWR wilderness proposals are awaiting the results of a mineral study by U.S. Geological Survey. The potential exists for reopening KNWR to mineral entry in the future. A new wave of mining claims and road building requests will result if mineral entry is reopened.

Powerlines and pipelines present another threat to bighorn sheep management. During 1981-82 a 500 KV powerline was constructed across the northern end of KNWR. The powerline followed the path of an underground pipeline, with the Kofa Mountains to the south and the New Water and South Plamosa Mountains to the north. Evaluation of the impact of the 500 KV powerline on bighorn sheep is still in process. There is concern about the cumulative effect of additional powerlines and pipelines on bighorn sheep movement.

Public use on KNWR is moderate at the present time. Hunting, sightseeing, camping, and backpacking are the most common activities enjoyed by visitors. Roads on KNWR are generally undeveloped and limit the amount of visitor use in the interior of the refuge. The relationship between visitor use and bighorn sheep living space is a potential conflict which must be evaluated.

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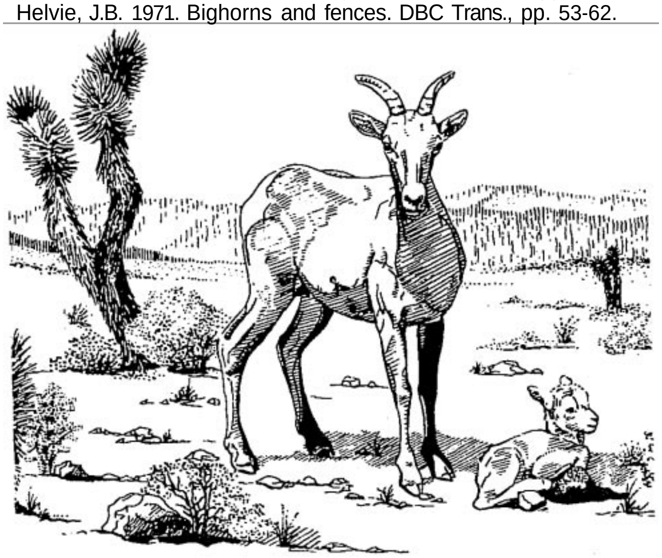

INTERMOUNTAIN TRAVEL CORRIDORS AND THEIR MANAGEMENT IMPLICATIONS FOR BIGHORN SHEEP

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Abstract. Travel corridors of radio-collared desert bighorn sheep (Ovis canadensis mexicana) were studied in southwestern Arizona. In general, primary corridors were routes with minimum distances between mountains and an overstory of creosote (Larrea *tridentata)*-ocotillo *(Fouquieria* splendens) habitat. This habitat provided the safest crossing site. Primary corridors connect high use areas. In contrast, secondary travel corridors crossed broad stretches of unsuitable habitat and did not often directly connect high use areas. Knowledge of intermountain travel and the distribution of resources within a mountain complex is necessary to mitigate the impact of travel corridor disruptions effectively.

INTRODUCTION

Intermountain travel by desert bighorn sheep has been documented with the use of radio-telemetry (McQuivey 1978, Witham and Smith 1979, Cochran and Smith 1983, King and Workman 1983). Movement patterns often connect isolated mountains. Although movement patterns are being studied, little is reported on travel corridor habitats. One objective of this study is to describe primary and secondary travel corridors and discuss their implications on management of bighorn sheep.

Travel corridors are preferred routes through marginal and low use habitats which connect adjacent areas. Corridor preference should reflect the suitability of the area's topography and vegetation for bighorn sheep. Corridor use may reflect seasonal or dispersal movements. Traditional routes which connect vital use areas such as lambing and rutting grounds have been considered critical habitat (Wilson, et al. 1980).

This study was funded by the U.S. Army (Contract #DAAD01-82-C-0039).

STUDY AREA

The wildlife resources in the North Cibola section of the U.S. Army Yuma Proving Grounds (YPG) was inventoried in 1982-83. This area is 32km south of Quartzsite in southwestern Arizona. The topography varies from relatively flat terrain to sharply sloped desert mountains. The area contains no permanent or intermittent streams but is drained by a number of ephemeral desert washes. Artificial water catchments and natural tinajas supply water to wildlife. The precipitation pattern is bimodal with late summer and mid-winter peak precipitation patterns. Mean annual rainfall is 8.5cm. The mean monthly temperature for this area is 23°C with extremes from -6° to 51°C (Higgenbotham, et al. 1979).

This area occurs on the Lower Sonoran Zone (Lowe 1964). The two major plant communities are creosote-bursage (Ambrosia spp.), and paloverde (Cercidium spp.)-mixed cacti. The creosote-bursage community is represented by two plant associations. The creosote-white bursage (Ambrosia dumosa) association occupies the flat broad valleys, while the creosote-ocotillo association is located on the rolling loose-rock hills which are adjacent mountains and bajadas. The second plant community also has two main plant associations. The paloverde-saguaro (Carnegia gigantea) association occupies the steep mountains and their lower hills. The paloverde-ironwood (Olneya tesota) habitat is found on the long, gently sloping bajadas.

METHODS

Nine desert bighorn sheep (4 males - 5 females) were captured in November 1982 by darting from a helicopter and were fitted with radio collars (Wilson et al. 1973). Bighorn sheep were located weekly from fixed-wing aircraft when military activity and weather permitted until August 1983. The plant association of each location was determined during the flight. Home range size was determined by the minimum area method (Mohr 1947). Only convex polygons were used in home range calculations (Jennrich and Turner 1969). Travel corridors were determined as the closest probable route which separated 2 consecutive radio locations in different mountains.

This was based on sheep preference for vegetation types which occurred along a straight line connecting the consecutive locations. This indirect evaluation was used because the sheep were not monitored continuously.

The 4 main plant associations were analyzed by 70 line-intercept transects. Plant species composition, density, and percent cover of perennial species were determined along 100m transects (Eberhardt 1978). Confidence intervals were calculated by utilizing a t-test to detect statistically significant differences among means (Steel and Torrie 1960:25).

Plant association boundaries were delineated on topographical maps during ground and aerial surveys. Percent vegetation type in the study area was determined by a nonplanimeter method (Macum and Loftsgaarden 1980). The vegetative structure of the 4 main plant associations were analyzed by 70 line-intercept transects. Transect locations were determined by a stratified randomization design which distributed the sample throughout the study area regardless of corridor sites.

RESULTS

Two hundred and forty-seven locations were made during the study period. Ewes accounted for 164 locations. Only 84 ram locations were made because 2 rams left the primary study area. Rams had a mean home range of 274.8 sq. km (range 167.6 - 440.9 sq. km), while ewes utilized a mean of 28.0 sq. km (range 8.5 - 66.5 sq. km) (Figure 1). The larger home ranges of rams reflected the extent that other mountain ranges were used. Twenty intermountain trips were detected. Rams made from 1 to 7 trips per individual, while only 1 ewe made 2 movements. All telemetry locations were in the mountainous paloverde-saguaro habitat except for two in creosote-ocotillo sites. In the 4 months following the study, the most mobile ram (#3) made 7 more intermountain trips and a ewe (#8) made 4 trips (Miller, pers. commun.). Lines which connect consecutive sheep locations for all recorded intermountain travels are shown in Map 1. Some consecutive locations were made at more than I-week intervals.

Vegetation transects revealed distinct differences among the 4 major habitats. The number of plant species per transect, percent cover, and plant density of the plant associations are shown in Figure 2. All pairwise comparisons of plant associations displayed statistically

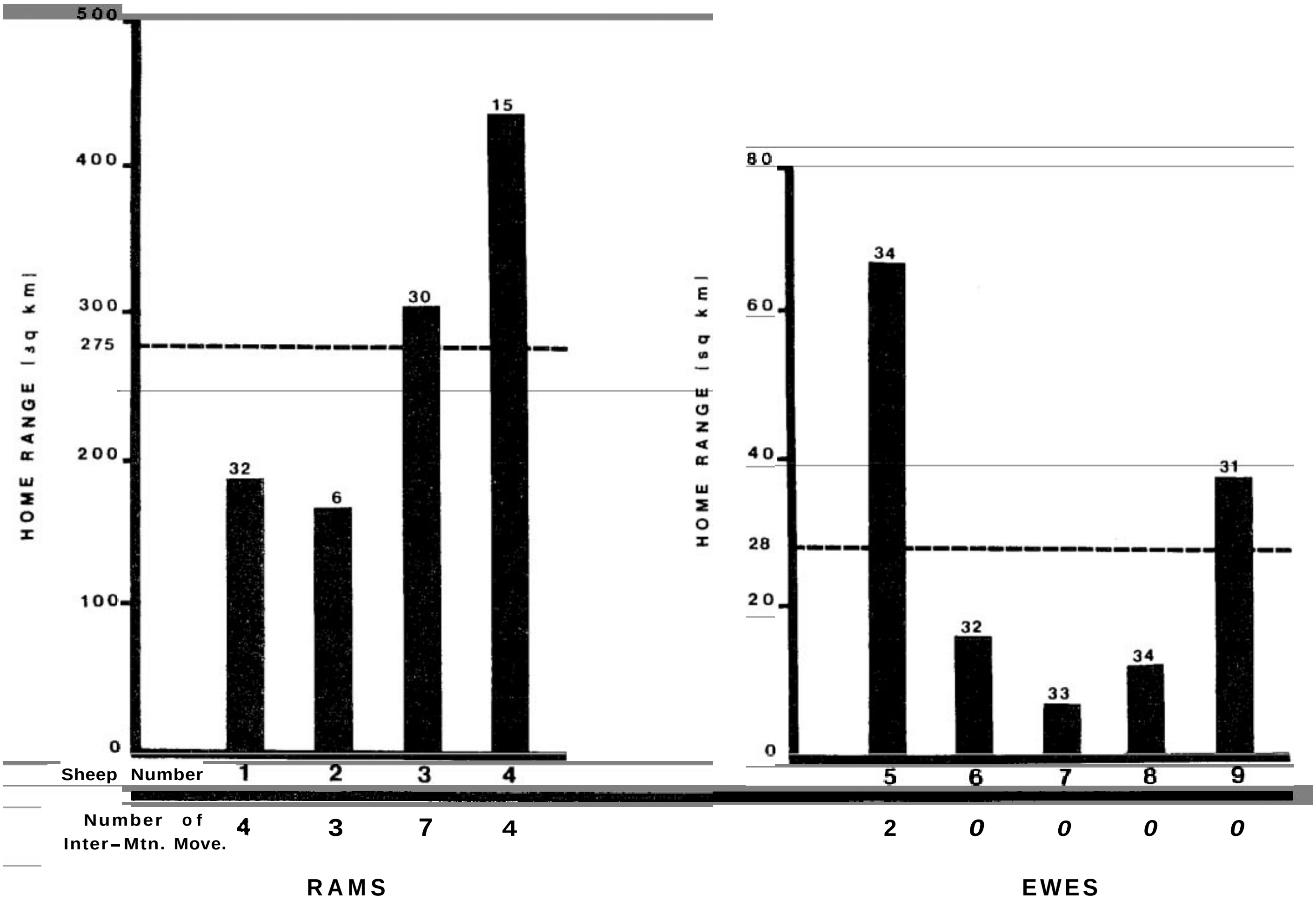
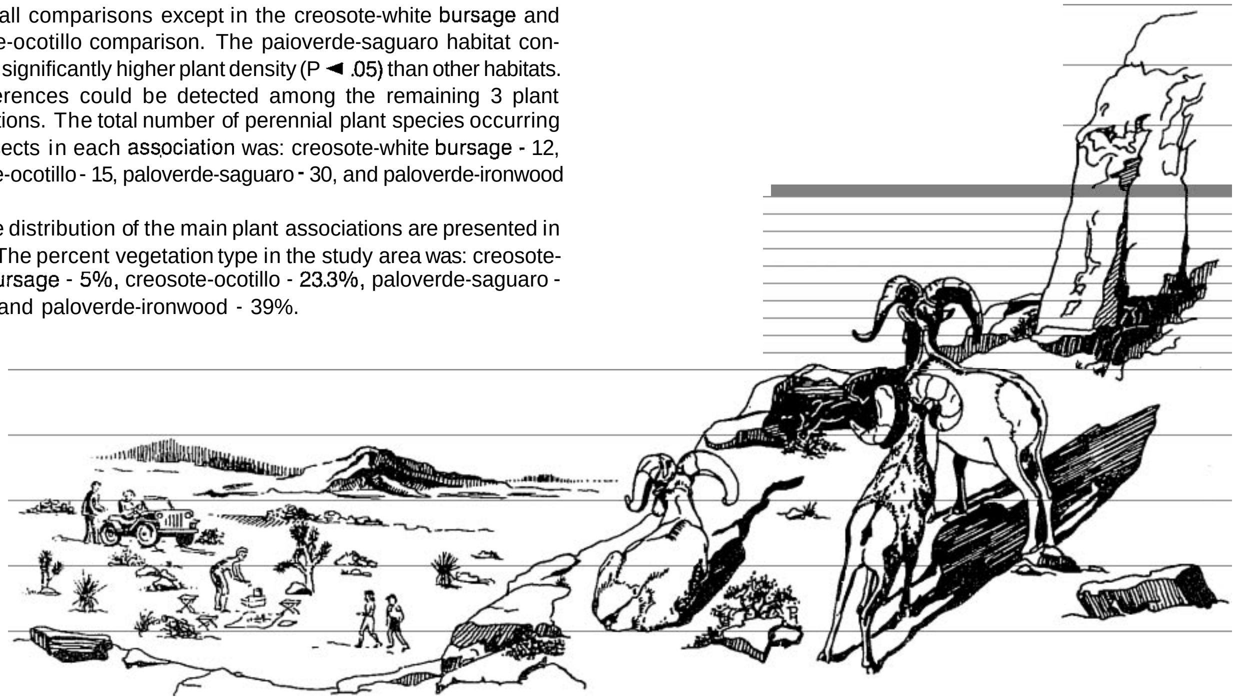


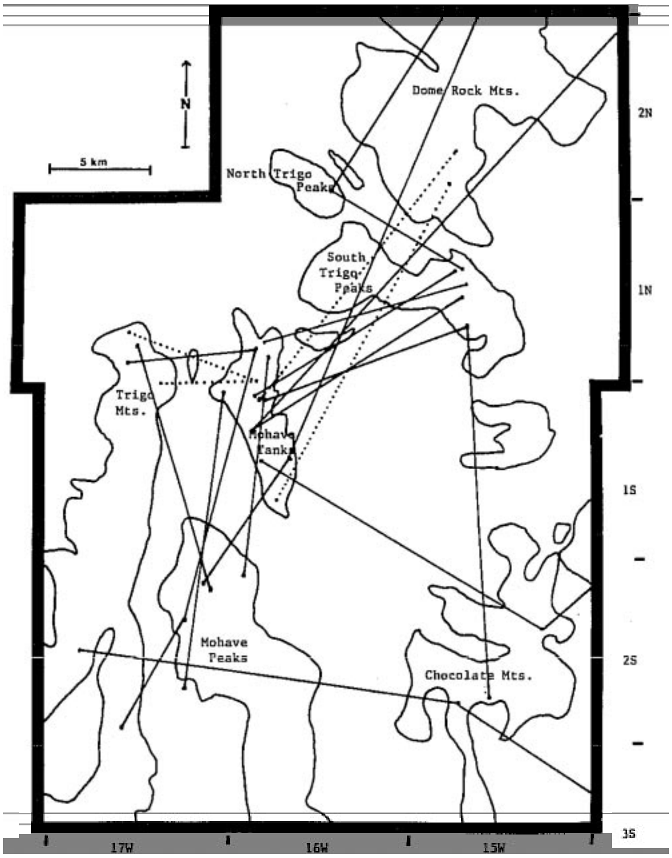
Figure 1. Bighorn home range sizes and number of intermountain movements observed on YPG study area. Mean home ranges are represented by broken lines. The number of radio-locations is located at top of bars.

significant differences in the number of species per transect (P 4.10). The percent plant cover was also significantly different (P 4.05) among all comparisons except in the creosote-white bursage and creosote-ocotillo comparison. The paioverde-saguaro habitat contained a significantly higher plant density (P ◄ .05) than other habitats. No differences could be detected among the remaining 3 plant associations. The total number of perennial plant species occurring on transects in each association was: creosote-white bursage - 12, creosote-ocotillo - 15, paloverde-saguaro - 30, and paloverde-ironwood - 24.

The distribution of the main plant associations are presented in Map 2. The percent vegetation type in the study area was: creosote-white bursage - 5%, creosote-ocotillo - 23.3%, paloverde-saguaro - 31.8%, and paloverde-ironwood - 39%.



Map **1.** Lines connecting consecutive sheep locations. Solid lines represent rams, while ewes are shown by dotted lines. The outlined mountains are labeled in Map **3.**



DISCUSSION

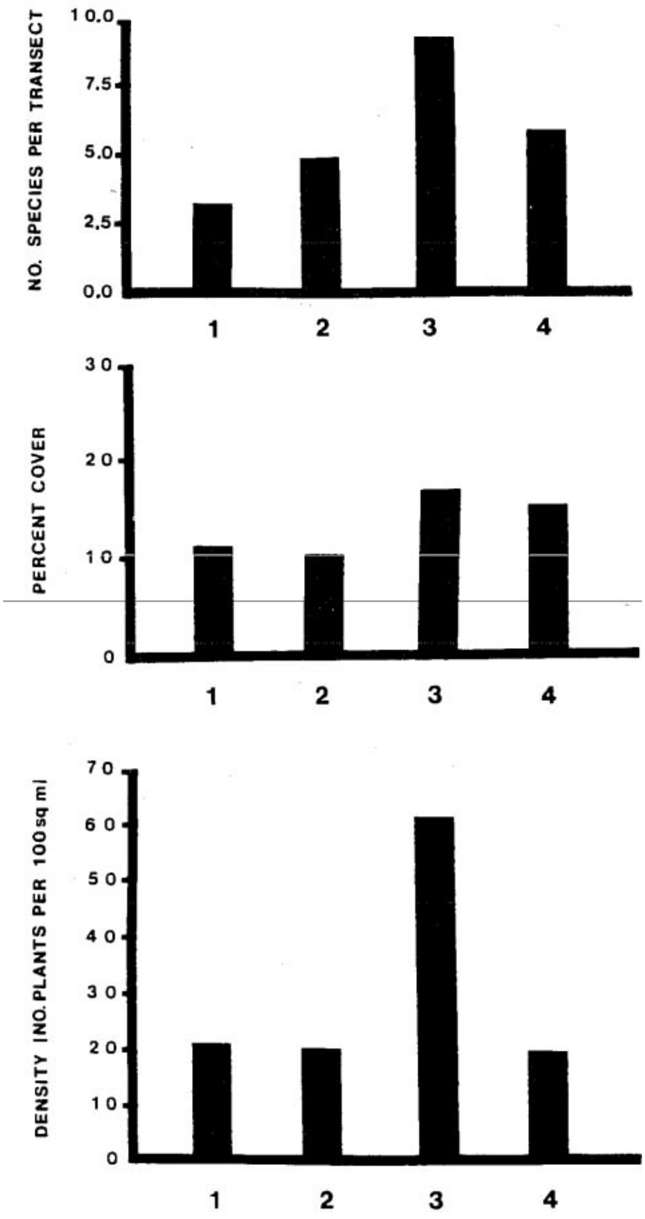
The home range sizes and number of intermountain movements indicate a very mobile ram and a relatively settled ewe population in a region where vegetation habitats are distinctly different. Rams generally would remain in a specific area for several weeks, then move into another area. All radio-collared rams made long movements after they were collared. Ewes remained in the same general areas for the entire study. The smallest home range for a ram was over 250% larger than the largest ewe home range.

A distinct preference was displayed for the mountainous paloverde-saguaro habitat. This plant association occurs on 31.8% of the study area but contained 99% of the radio locations. The creosote-ocotillo habitat which covered 23.3% of the area had the remaining 2 locations. Although the other 2 habitat types contained no radio locations, temporary transient use is indicated in Map 1.

Primary travel corridors occur where the topography and associated vegetation type provides a natural crossing between mountains which minimizes the distance out of preferred habitat. Primary corridors directly connect mountains with high sheep use.

The location of intermountain movements in this area suggested low hills with creosote-ocotillo and paloverde-saguaro habitats are primary travel corridors. The creosote-ocotillo association generally occurs in an open, hilly area where the vegetation produces little cover for predators. This rocky terrain provides sheep areas to escape from predators. Seasonal foliation of ocotillo could stimulate movement

Figure 2. The number of plant species per transect, percent cover, and plant density recorded on line-intercept transects. The following plant associations are indicated by their respective number:
1) Creosote-White **Bursage** Flats,
2) Creosote-Ocotillo Rolling Hills,
3) Paloverde-Saguaro Mountains, and
4) Paloverde-Ironwood **Bajada.**



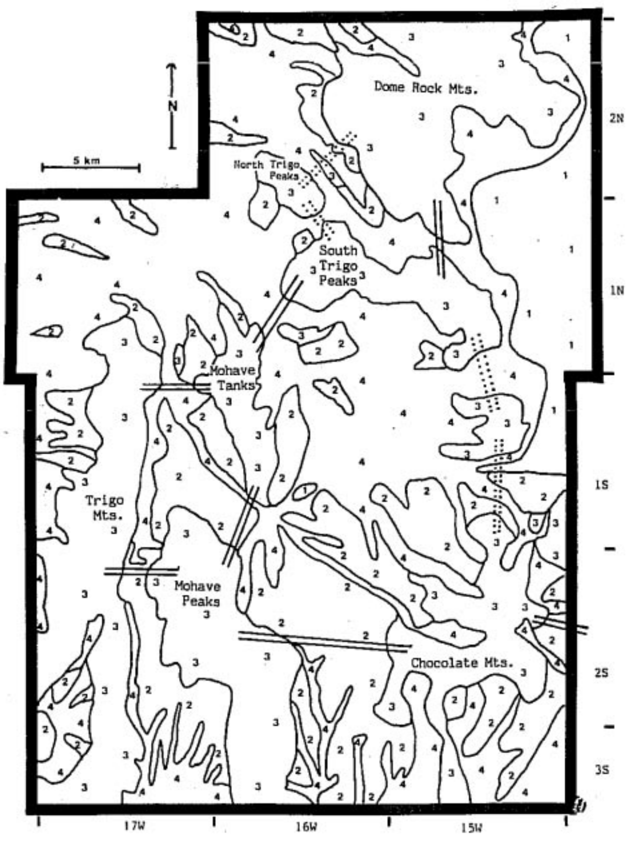
into the rolling hill habitat. The 2 radio locations in this habitat occurred during an ocotillo foliation period and probably did not represent an intermountain move. The distribution of paloverde-saguaro and creosote-ocotillo habitats and suggested intermountain corridors in the study area are presented in Map 2. Mountain ranges which are linked by primary travel corridors should be managed as a single unit.

Secondary travel corridors are routes which have broad stretches of undesirable habitats, e.g. paloverde-ironwood, and do not directly connect high sheep use areas. Both secondary corridors in Map 2 contain a small isolated mountain. Although these mountains may be used frequently by individual animals, they do not have permanent water sources or lambing grounds which characterize high use areas. In general, secondary corridors have less use than primary corridors.

Travel corridors should not be considered as a narrow defined area between mountains in which all sheep movements occur. Instead they represent zones where greater intermountain travel occurs. The zone of concentrated travel depends on the width of the preferred habitats between mountains and the amount of nonpreferred intermountain habitat that must be crossed. For example, the Mohave Tank-Mohave Peak corridor is illustrated at the minimum intermountain distance (Map 2). However, sheep would be expected to use a much wider crossing zone because of the extensive creosote-ocotillo habitat between the mountains and a relatively constant distance of nonpreferred habitat.

Map **2.** The relationship of travel corridors and plant associations occurring in the YPG study area. Primary corridors are represented by solid lines, whereas secondary routes are shown by dotted lines.

Code	Plant Association
1	Creosote-Bursage
2	Creosote-Ocotillo
3	Paloverde-Saguaro
4	Paloverde-Ironwood



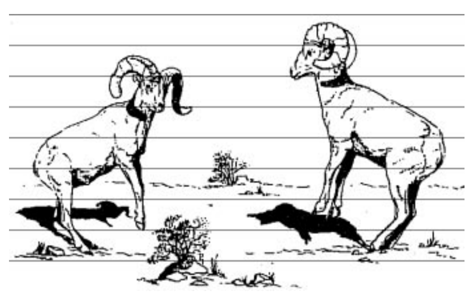
Primary and secondary travel corridors do not account for all observed intermountain travel, although in this study the majority of intermountain movements occurred in travel corridors. Sheep have been observed to cross broad open creosote flats and bajadas to reach distant mountains (Miller, pers. commun.). Since these areas lack some of the corridor characteristics, these movements may reflect a straight-line travel behavior. This would suggest a convenience tradeoff between the distance to the closest corridor and the minimum distance between mountains. Many broad areas that separate mountain ranges have occasional sheep use but often lack distinct boundaries and preferred habitat features such as escape cover. Therefore, these areas should be investigated for potential crossings and not overlooked when investigating impacts of construction projects such as canals and interstate highways.

Management Implications. Desert bighorn survival depends on effective management. Wilson (1980) stressed the importance of unimpaired travel routes. Remote mountain ranges can be lost as permanent or seasonal sheep habitat if isolated from an entire mountain complex by corridor disruption. Interference could be permanent — such as interstate highways, water canals, or housing developments. Seasonal disruption could occur from increased winter desert activities, e.g. long-term camping. Seasonal influences may reduce the traditional use of specific areas but only be detectable over long periods, whereas the impact on permanent distribution should be readily detected.

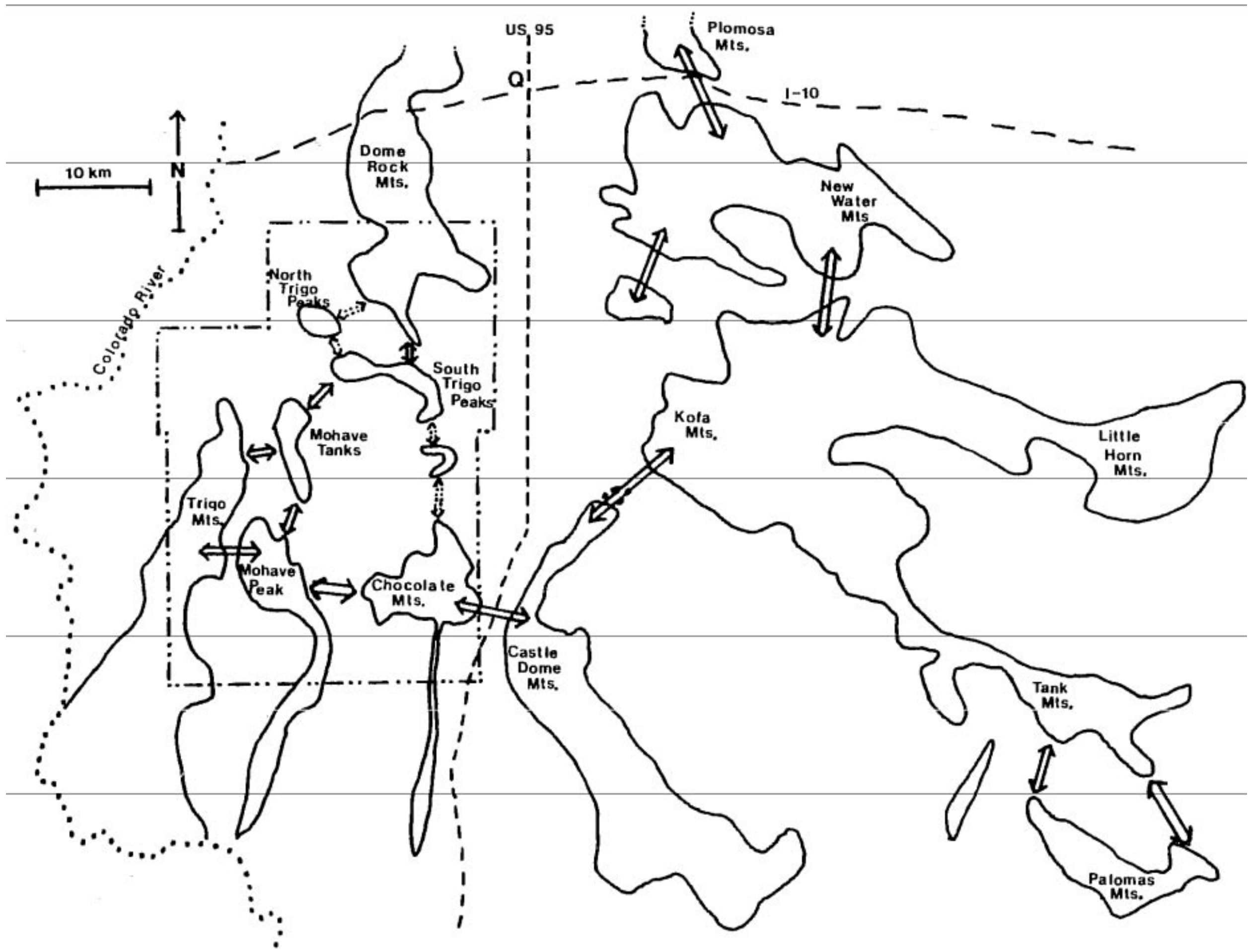
The YPG study area is located in a complex of mountain ranges (Map 3). Immigration of sheep into this mountain complex is restricted because of the surrounding broad open plains and the Colorado River. All indicated travel corridors were detected by field studies (personal observations, Witham and Smith 1979). Since the quality of individual mountains may vary as a function of rainfall distribution, unimpaired travel among the different ranges is essential to maintain the area's sheep population. This area presently has three major permanent corridor disruptions. Sheep in both the Dome Rock and Plamosa Mountains have greatly reduced movements because of Interstate 10. A less obvious impact resulted from U.S. 95 which separates the Chocolate and Castle Dome Mountains. This highway cuts directly through the creosote-ocotillo habitat which connects the two mountain ranges. Although collared rams have crossed this corridor, increased highway traffic during winter months may reduce sheep use. This is crucial because this is the only primary corridor between mountains east of U.S. 95 and those to the west.

The potential impacts from corridor disruption can be minimized if the travel routes within a mountain complex and the resources of individual mountains (lambing grounds, seasonal and permanent water) are known. By determining which resources are likely to be lost, habitat modification of specific mountains could alleviate the impact. The construction of water catchments adjacent to corridors may enhance sheep use of a specific travel corridor. Sheep use of permanently disrupted primary corridors may be enhanced by overpass and tunnel travel structures. The effectiveness and economics of various bypass structures needs study.

Although travel corridor habitats are not long-term use areas, their crucial importance lies in being the most suitable habitat between isolated mountains. In this study area, the creosote-ocotillo and paloverde-saguaro hills provide primary corridor habitats. The disruption of primary travel corridors would isolate potentially valuable areas and reduce the sheep population of a desert mountain complex.



Map 3. Travel corridors occurring within a mountain complex. The YPG study area is encompassed by the dash-dot line. Primary corridors are represented by solid arrows, whereas secondary routes are shown by dotted arrows.



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STATUS OF AOUDAD IN NORTH AMERICA

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Abstract. The aoudad (Ammotragus *lervia)* has become established in North America and has dispersed into present and historic bighorn sheep (Ovis canadensis) range. The aoudad presents a threat to the native species. The present status of aoudad populations in New Mexico, Texas, California, and Mexico is reported. Harvest strategies used to control aoudad populations are not completely successful.

INTRODUCTION

The history of the establishment and dispersal of aoudad in North America has been documented (Barrett 1966, Dvorak 1980, Rangel-Woodyard and Simpson 1980, Simpson and Krysl 1981, Morrison 1983). The aoudad has expanded its range and poses a threat to native ungulates through competition for food and space (Bird and Upham 1980, Johnston 1980, Krysl et. al., 1980). The most serious threat is posed to the native desert bighorn sheep, which is classified as endangered in New Mexico. Recent sightings of aoudad in New Mexico and Texas indicate that range expansion is still occurring. Control of aoudad populations has been attempted by shooting and manipulation of harvest strategies in New Mexico and Texas. This paper reviews the status of free-ranging aoudad populations and the results of control attempts.

New Mexico: From the first release in New Mexico in 1950 (Ogren 1965), aoudad have expanded their range to the eastern half and all but the high mountain areas of the northern half of New Mexico. A documentation of the aoudad's method of population dispersal may be found in Dickinson and Simpson (1980). Aoudads that invaded the San Andres and Manzano Mountains, areas with bighorn sheep currently present, were eliminated by biologists of the New Mexico Department of Game and Fish (NMDGF). The aoudad population at the southern end of the Guadalupe Mountains has also been reduced by shooting. Aoudad were first hunted in New Mexico in 1955 under a limited permit system (Morrison 1980). This hunt was held in the Canadian River Gorge (CRG) of northeastern New Mexico, with a limit of one aoudad with a minimum horn length of 38.1 cm. The hunt in the CRG has been held each year since 1955 (except during 1963-1966). The Largo Canyon (LC) population was hunted under the same system from 1972 through 1983. The Hondo Valley (HV) population in southeastern New Mexico has been hunted sporadically since 1967. In 1979, the NMDGF began an attempt to control aoudad numbers by sport harvest. The Guadalupe Mountains in southeastern New Mexico and the Mount Taylor area in westcentral New Mexico were opened for an unlimited permit, either-sex hunt. This season was open concurrent with deer (Odocioleus spp.) seasons in the fall and again for nine days in January. In 1980, the entire state, with the exception of the CRG and LC management units, was open to aoudad hunting, using the unlimited permit, either-sex strategy. This management scheme was used through the 1983 seasons. In February 1984, the new big game regulations eliminated the LC management unit and added that area to the statewide hunt. The limit for the statewide hunt was increased to two aoudads of either sex, and the January season was extended to 23 days. The NMDGF plans to recommend the elimination of the CRG management unit in 1985 and the addition of that area to the statewide hunt. Since the first aoudad hunt (1955) in New Mexico, 2,165 animals have been harvested by 5,221 hunters (Morrison 1983). More than half of these (1,157 aoudads or 53.4%) have been harvested during the unlimited permit hunts (Morrison 1983). Although budgetary limitations prohibit surveys for population estimates, interviews with landowners and federal agency personnel familiar with aoudad range indicate a reduction in numbers in some areas. The NMDGF feels that aoudad numbers have been reduced in the Guadalupe Mountains and surrounding area by sport harvest. The removal of aoudad in the San Andres and Manzano Mountain ranges by shooting has controlled their dispersal to those areas. The NMDGF will continue to monitor population levels and attempt to control aoudads by sport hunting. All reports of aoudad sightings will be investigated, and any animal found in occupied bighorn sheep range will be killed.

Texas: The first release of aoudad in Texas was made in Palo Duro Canyon (PDC) in 1975 (Dvorak 1980). In that year and in 1958, the Texas Parks and Wildlife Department (TPWD) released 44 aoudad (Dvorak 1980). In 1963, the first hunt was held in PDC with all permits going to landowners (Dvorak 1980). From 1963 through 1980, the same harvest strategy was used in the PDC area. Because of the low harvest rate and the continued increase in aoudad numbers, the limited permit system was eliminated in 1981 (Dvorak 1982). Helicopter censuses are conducted every three years in the PDC to monitor aoudad numbers. The aoudad in PDC have also been infected by an arterial nematode *(Elaeophora* schneiderii), and this may have a detrimental effect on population numbers. Population estimates have gone from 1,600 in 1980 (Dvorak 1980) to 800 in 1983 (C. Winkler, pers. comm.), indicating a 50% decline in population numbers. Other populations of free-ranging aoudads occur in the trans-Pecos region of Western Texas. This area is historic desert bighorn range and is where TPWD is attempting to reestablish populations of desert bighorn sheep. Recent reports have placed aoudad in virtually every desert mountain range in the trans-Pecos (C. Winkler pers. comm.). Hunting for aoudad in the area is on private land and the harvest is controlled by landowners. Currently, TPWD does not have any plans for extensive control efforts (C. Winkler pers. comm.).

California: The California aoudad herd is a result of escapes from the Hearst Ranch near San Simeon (Barrett 1980). In 1953, approximately 85 head escaped from a game-proof fence and started a wild free-ranging herd (Barrett 1980). Distinct breeding bands are presently located at four locations in California: Red Rock, Glazier Ridge, Vulture Rock, and Cline Peak (D. Weaver, pers. comm.). Although these herds receive very little hunting pressure, they do not appear to be expanding their range. Apparently, the major factor preventing further dispersal is the animals' failure to utilize the chaparral habitat surrounding their range (Barrett 1980, Johnson 1980, D. Weaver pers. comm.).

Mexico: Very little is known about the status of free-ranging aoudad populations in the Republic of Mexico. Rangel-Woodyard and Simpson (1980) reported on three releases made by private landowners in the Sierra Madre Orientals during the mid-1970's. Two of these releases were in the State of Nuevo Leon and one was in the State of Coahuila. The Bolson de Mapimi, the southern extension of the Chihuahuan Desert, may prevent the spread of the aoudad into the Sierra Madre Occidentals, the home of the desert bighorn. In the State of Chihuahua, there is a herd of 200 aoudad contained within a 2.2m-high fence on 800 ha. of private land. The status of aoudad in Mexico needs immediate investigation to access the potential threat to native wildlife.

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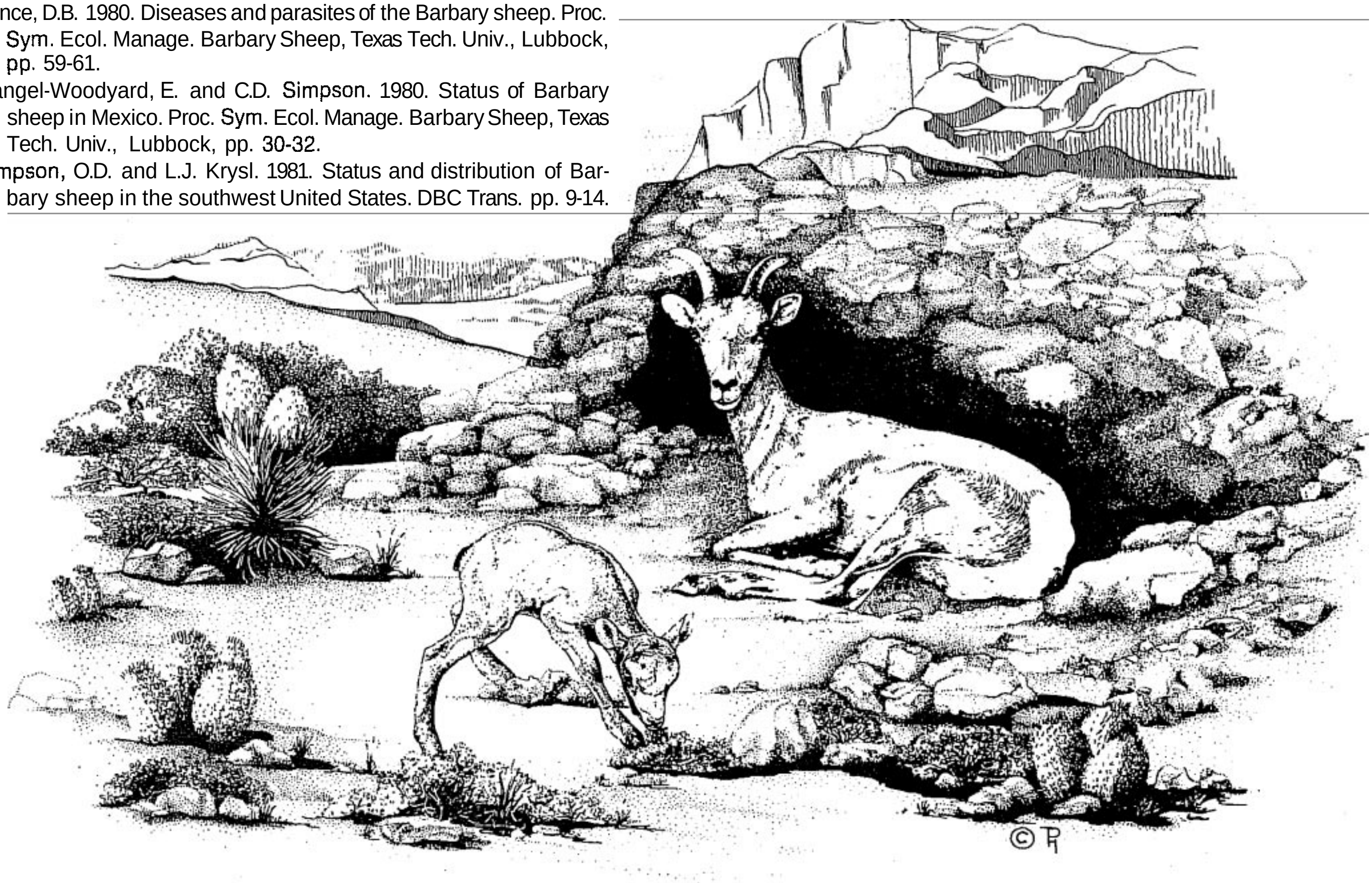

DROP NET CAPTURE OF BIGHORN SHEEP IN ARIZONA

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Abstract. Over a 4 day period, 54 desert bighorn sheep (Ovis canadensis nelsoni) were captured on the south shore of Lake Mead. All sheep were captured with a 15.8x15.8 meter drop net. Apple pomace and alfalfa hay were used to attract the sheep to the drop sites. The sheep were released in 3 states: 34 animals were released in the Grand Wash Cliffs, Arizona; 10 sheep were released in Big Dominguez Canyon, Colorado; and 10 were released into an enclosure near Van Horn, Texas. No mortalities or major injuries occurred.

INTRODUCTION

Drop net traps using apple pomace and alfalfa as bait have been used to capture Rocky Mountain Bighorn (Ovis canadensis *canadensis)* in Colorado since 1971 (Schmidt et. al. 1978). In recent years, this technique has been used to capture desert bighorn sheep in Nevada (McQuivey 1982) and California (Jessup et. al. 1982). In August 1981, the first summer drop net capture on the shores of Lake Mead was accomplished (McQuivey 1982). No anesthetic drugs were used and no mortalities or injuries were noted. Because transportation of sheep was done by boat and vehicle, no helicopters were necessary.

In recent years, all major sheep captures in Arizona have been done by helicopter darting using M-99 and Azaperone. In November 1981, 30 sheep were captured by this method and removed from the Black Mountains south of Lake Mead (deVos 1982). By the summer of 1982, sheep numbers in the area were estimated to be 600-760 (Welsh 1982), providing sufficient animals for additional transplants. Because of past success with the drop net by other state agencies, this technique was chosen as the preferred capture method.

METHODS AND MATERIALS

Preparation for the capture began in February 1983. Apple pomace and alfalfa were to be used as attractants. To provide odor-free storage and easy handling, the apple pomace was packed and sealed in 19 liter plastic buckets. Pomace which had already been fermented and compacted was obtained from pits in Cedar City, Utah, and Ft. Collins, Colorado. The 4,530 kilograms of pomace (258 buckets) was stored under refrigeration at the Coors Beer Warehouse in Kingman, Arizona.

In early June, a 15.8 meter square drop net was borrowed from Utah. Net poles and support equipment were fabricated from 2.54 cm. diameter steel pipe. A "mini-blaster" detonator and blasting galvanometer were also obtained. Net support ropes were 0.8 cm. braided polypropylene, and were cut with Atlas "zero delay" electric blasting caps. The caps were inserted into the center of 5 support ropes (one at each corner and one at the center pole). Each cap was wired in series using 18 gauge bell wire.

On 28 June the net was complete. Test firings revealed the net dropped better when no side braces were used.

A student intern began prebaiting on 5 June after a preliminary shoreline survey detected sheep concentration areas. All baiting was done by boat from a marina near the bait sites. Each bait station consisted of about 0.8 kilograms of pomace covered with a "flake" of alfalfa. Twenty-five bait stations were established along an 11 kilometer stretch of shoreline from Fishfinder Cover to Wishing Well Cove.

Sheep occasionally sampled hay and pomace from 8-10 of the 25 stations, but did not take bait regularly at any time in June. Sheep were first observed eating hay and pomace on 30 June in Sidewinder Cove.

In early July, afternoon temperatures were reaching 46º C. Bighorn were observed in greater numbers and were seen drinking more often. By 9 July, 10 bighorn were consuming bait daily at Sidewinder Cove. Apple pomace was increased to 1.5 kglsheeplday to entice more sheep to the area. Other bait stations close to Sidewinder were eliminated. By 15 July, sheep were also using bait daily at Indian Canyon and James Bay. Bait was also increased at these locations. Gradually all but 6 bait stations were eliminated and by late July sheep were taking bait daily at 3 of the 6 stations. Thirty-three animals were seen each morning in Sidewinder Cove, 14 were feeding in Indian Canyon, and an unknown number were feeding each afternoon at James Bay.

Fortunately, satisfactory net sites existed at 2 of the 3 potential trap areas. But at Indian Canyon only rocky, steep terrain was available. A small elevated saddle was located nearby. The bait was moved a little each day and within a week the sheep were successfully moved to the elevated net site.

RESULTS

Saturday, 31 July, was chosen as the first trapping day. The net was put up in Sidewinder Cove 3 days earlier to accustom the sheep to the net. For 3 days all 33 sheep fed under the net without hesitation, and personnel were stationed at the net site to keep recreationists away from the capture site.

On 31 July, 0730 hours, the net was dropped on 22 bighorn. All sheep were quickly blindfolded, hogtied, and moved to a staging area. Here each sheep was marked with an orange "allflex" eartag. The sheep were then sexed, aged, and 4 were fitted with radio collars.

Folding aluminum stretchers were used to carry sheep to boats 100 meters away. After a 20 minute boat ride, the sheep were loaded onto a stakebed truck at Callville Bay. The truck bed was enclosed with a plywood roof. A drive net on the inside of the stakebed sides allowed free air circulation. A few sheep appeared to have labored breathing. These sheep were cooled with water prior to loading on the stakebed truck.

Within 7 hours of capture, all 22 sheep were released at Squaw Canyon in the Grand Wash Cliffs in northwestern Arizona.

The net was reset in the same location, and the next morning 10 more sheep were captured. All 10 were transported by vehicle from Arizona to Big Dominguez Canyon in southwestern Colorado.

The net was then moved to Indian Canyon where it was reset on a small sloping saddle. With no room for a conventional net set up, the uphill side was staked directly to the ground. The downhill side was supported with 3 poles. The center pole and support poles were rewired with blasting caps in series. The next morning (2 August) the net was dropped on 12 sheep. Eleven were caught and 1 was released. The remaining 10 sheep were transported to an enclosure near Van Horn, Texas.

The net was then moved to James Bay and reset. On 3 August 12 additional sheep were caught. Two sheep were radio collared. These sheep were released in the Grand Wash Cliffs 2 miles north of the July 31 release.

A total of 54 sheep, 10 rams, 34 ewes, and 10 lambs, were captured in 4 days. Nine of the 10 lambs were male (Table 2).

Table 2. Record of desert bighorn sheep captured at Lake Mead in Arizona during 1983.

Date	Capture Location	Ram	Ewe	Lamb	Total	Release Area
7-31	Sidewinder Cove	5	14	3	22	Grand Wash Cliffs, AZ
8-1	Sidewinder Cove	2	6	2	10	Dominguez Creek, CO
8-2	Indian Canyon	1	7	2	10	Enclosure-Van Horn, TX
8-3	James Bay	2	7	3	12	Grand Wash Cliffs, AZ
Totals		10	34	10	54	
Capture Ratio			**29:100:29**			

DISCUSSION

Bighorn sheep were not easily baited. Eight weeks of effort was necessary before the sheep were ready for drop net capture.

Apple pomace was easily stored and handled in sealed plastic buckets. No refrigeration is needed if the pomace is not exposed to the air.

Four sheep bloated during the 20 minute boat ride to the marina. This problem may be avoided by using hobbles instead of hogtie ropes to restrain the sheep.

The drop net technique resulted in the capture of an ideal ram:ewe ratio (29:100) for free release (Wilson et. al. 1982). Most sheep were from the same herd.

A detailed cost analysis revealed expenses for this capture were $39,000 or $722 per sheep. Only about $2,000 was spent on equipment and housing for capture crews and baiting. The majority of expense was in the form of wages (20,640), subsistence (4,080) and vehicle costs (12,560) for 22 paid employees.

Costs could be reduced by using fewer paid employees and more volunteers. Costs could also be reduced by capturing two or more times in the same day. Two nets would save valuable set up time and allow successive captures in different locations.

ACKNOWLEDGEMENTS

This sheep capture was truly a cooperative effort. Apple pomace, drop net, detonator, and galvanometer were provided by the Utah Division of Wildlife Resources personnel in Cedar City. Apple pomace was also donated by Colorado Division of Wildlife personnel. Money to purchase equipment and defer capture costs was provided from a $10,000 donation courtesy of the Foundation for North American Wild Sheep and the Arizona Desert Bighorn Sheep Society.

A trailer pad, assistance to Chris Mendoza (student intern), and transport of capture crews were provided by the park rangers and supervisory personnel from the Lake Mead National Recreation Area. Volunteer veterinarian services were provided by Jerry Zitterkopf and Tom Boggess. Volunteer capture crew members included personnel from the Lake Mead National Recreation Area, Bureau of Land Management personnel from Kingman and St. George, Arizona Desert Bighorn Sheep Society, Nevada Bighorn Unlimited, and wives and friends of Department personnel.

Low cost housing for capture crews was provided by Rich Ham, manager of the Callville Bay marina. Five months of free refrigerated storage of 258 buckets of apple pomace was donated by Jack Matheson of Mohave Coors, Kingman.

Advice and information on drop net capture and use of apple pomace was provided by Dan Dalany, Nevada Department of Wildlife, Floyd Cohles, Utah Division of Wildlife Resources, and Bob Tully, Colorado Division of Wildlife.

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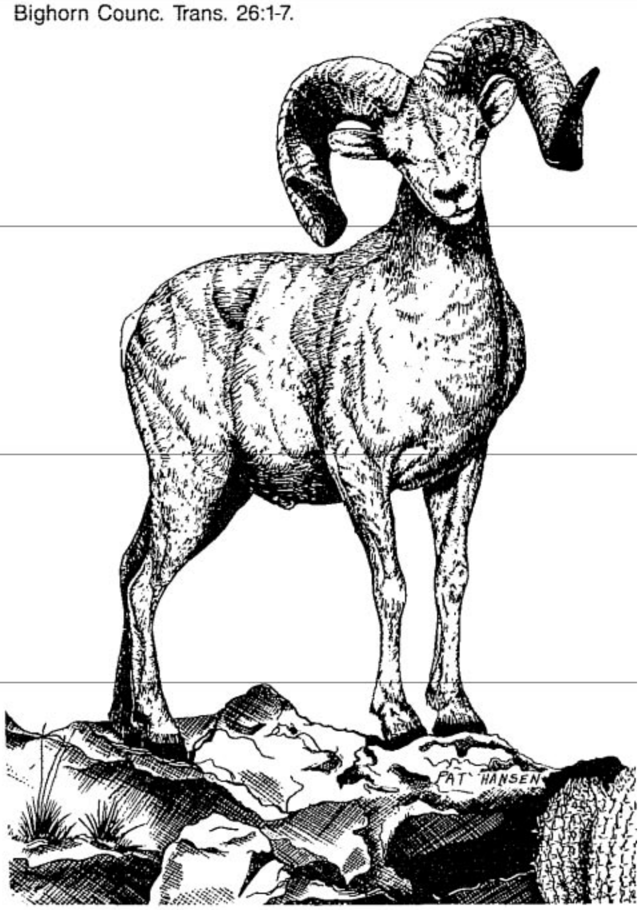

STATUS OF INVESTIGATIONS OF DESERT BIGHORN SHEEP IN SONORA, MEXICO

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Abstract. The Bighorn Research Institute and the Centro Ecologico del Desierto captured eighteen desert bighorn (Ovis canadensis *mexicana*) from the Posada-Pico Johnson area of Sonora, Mexico, and nearby Tiburon Island. Twelve were transported to the Centro Ecologico del Desierto, and six were radio-collared and released for continued studies. Forty-five bighorn were counted by helicopter on Tiburon Island, and the population was estimated to be 100 - 120 animals.

INTRODUCTION

Bighorn sheep (Ovis canadensis) have decreased to alarmingly low numbers since the colonization of North America by Europeans. About 20,000 bighorn remain in the contiguous United States (Buechner 1960, Trefethen 1975). Fortunately, large populations of desert bighorn occur in the Mexican state of Baja California *(O.* c. weemsi and O. c. cremnobates), but much lower numbers occur in the state of Sonora *(O.* c. mexicana). There are an estimated 5,000-7,000 desert bighorn in Baja California (Alvarez 1976) and 1,000 in Sonora (Valverde 1976). However, wild sheep have been extirpated in the remainder of northern Mexico (Leopold 1959; J. Trevino, Wildlife Biologist, Chihuahua, Mexico, pers. commun.).

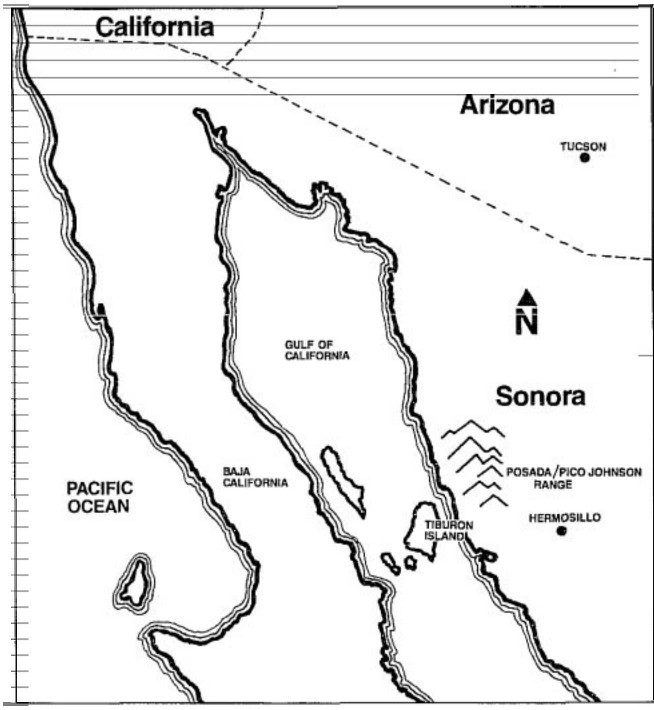
These bighorn populations represent an important wildlife resource to Mexico. About 100 permits per year are given to Americans who pay large sums for the privilege of hunting bighorn in Mexico (Jorge Mendoza, Office of Terrestrial Fauna, Mexico, pers. commun.). These populations also represent an important reservoir for restocking bighorns to areas where they have been extirpated. Desert bighorn from Sonora have been used for restocking in New Mexico (Montoya and Munoz 1976).

It is imperative that studies be undertaken to develop judicious management policies for these populations to insure their survival. Except for a few cursory studies (Dominguez 1976, Foneca and Gonzalez 1976), there has been no intensive research conducted in Mexico. Therefore, the Bighorn Research Institute and the Centro Ecologico del Desierto began studies on desert bighorn in the Posada-Pico Johnson area in the state of Sonora and on Tiburon Island. The bighorn population of Tiburon Island was introduced from an original stock of 20 animals from the Posada-Pico Johnson range in 1975 (Montoya and Gates 1975). The population of the Posada-Pico Johnson range is estimated at 300 (Valverde 1976).

STUDY AREA

The Posada-Pico Johnson area is north of Kino Bay in Sonora, and Tiburon Island is just offshore, divided from the mainland of Sonora by a channel 1.5-6.5 km (1-4 mi) wide (Figure 1). The island is 1210 km² (467 mi²) (Carmony and Brown 1983). The habitat is Sonora desert, with an annual rainfall less than 200 mm. Dominant plant species include: Larrea tridentata (creosote bush), *Encelia* farinosa (brittle-bush), Cercidium microphyllum (little-leaved palo verde), Carnegiea *gigantea* (saguaro), Olneya tesota (desert ironwood), *Prosopis* glandulosa (mesquite), Opuntia sp. (cholla and prickly pear), Fouquierra splendens (ocotillo), and Simmondsia chinensis (jojoba).

Figure 1. Location of the Posada-Pico Johnson Range and Tiburon Island.



REPORT OF CAPTURE

Eighteen bighorn, sixteen from the Posada-Pico Johnson Range and two from Tiburon Island, were captured between 30 January and 4 February 1984 (Table 1). Twelve from the Posada-Pico Johnson Range were transported to a 4 ha (10 ac) pen at the Centro Ecologico del Desierto, a new zoo-research facility in Hermosillo, Sonora. The additional four from the Posada-Pico Johnson area and two from Tiburon Island were fitted with radiocollars and released.

Thirteen bighorn were captured by moving animals with a helicopter into standing linear nets, two with a net gun fired from a helicopter, and three by chemical immobilization from a helicopter using a CO_2 Cap-Chur rifle. For chemical immobilization, the drug M99 (Etorphyine hydrochloride) was used in conjunction with Azaperone and Rornpun (Table 2). Reversal of the narcotic effects of M99 was accomplished by an intravenous injection of M50-50 (Diprenorphene).

Table 1. Bighorn captured in Mexico, 30 January to 2 February 1984.

Eartag #	Sex	Age	Capture Method	Capture Site	Release Site
none	f	1 yr	net gun	Posada Mtn	Posada Mtn
2	m	4 yrs	drive net	Posada Mtn	Posada Mtn
4	f	7 yrs	drive net	Noche Buena Mtn	Centro Ecologico
5	f	2 yrs	drive net	Posada Mtn	Centro Ecologico
E290 & 6	f	10 yrs	darted/helicopter	Tiburon Isl	Tiburon Isl
7	f	2 yrs	drive net	Posada Mtn	Centro Ecologico
8	f	5 yrs	drive net	Posada Mtn	Centro Ecologico
18	f	8 yrs	drive net	Posada Mtn	Centro Ecologico
20	f	5 yrs	drive net	Posada Mtn	Centro Ecologico
52	f	5 yrs	drive net	Posada Mtn	Centro Ecologico
55	m	1 yr	drive net	Posada Mtn	Centro Ecologico
56	m	6 yrs	drive net	Posada Mtn	Centro Ecologico
57	f	5 yrs	drive net	Posada Mtn	Centro Ecologico
58	f	1 yr	darted/helicopter	Noche Buena Mtn	Centro Ecologico
61	f	6 wks	drive net	Posada Mtn	Posada Mtn
62	m	3 yrs	net gun	Tiburon Isl	Tiburon Isl
64	f	6 yrs	darted/helicopter	Noche Buena Mtn	Noche Buena Mtn
65	f	6 yrs	drive net	Posada Mtn	Centro Ecologico

Table 2. Drug dosages used in capture dart and reversal injection for three bighorn captured by chemical immobilization with a CO_2 Cap-Chur rifle.

Eartag #	Capture Dart	Reversal Injection
6	4 cc (4 mg) M99 3/10 cc (12 mg) Azaperone 4½ mg Rompun	5 cc (10 mg) M50-50
58	4 cc (4 mg) M99 4/10 cc (16 mg) Azaperone 7 mg Rompun	4 cc (8 mg) M50-50
64	4 cc (4 mg) M99 3/10 cc (12 mg) Azaperone 4½ mg Rompun	5 cc (10 mg) M50-50

Captured bighorn were blindfolded and hobbled, and sex, age (Cowan 1940), physical measurements, and general condition were recorded. Ear tags were placed on all animals.

Blood was collected from each animal by jugular puncture for hematologic, serologic, immunologic, blood chemistry and virus isolation analyses. Fecal samples were collected to evaluate parasitic diseases, and nasal swabs were collected to survey respiratory pathogens. All medical samples were flown daily to veterinary laboratories in the United States. Results of medical sampling were presented by DeForge et al. (1984).

All animals were given Dual-Pen injections IM (4 cc for ewes, 5 cc for rams, 2 cc for the lamb), 7-way clostridium toxoid SQ (2½ cc for rams and ewes, 1¼ cc for the lamb), and MU-SE Selenium -Vitamin E IM (1 cc for rams and ewes, 1/2 cc for the lamb). Animals destined for the Centro Ecologico were given an oral worming medication and an IV injection of Rompun as a tranquilizer (15 mg for the adult male, 10 mg for adult ewes and the yearling ram, 5 mg for a 2 yr old ewe.

Once or twice each capture day, three-quarter ton stake bed trucks covered with plastic tarps transported the animals 145 km (90 mi) to the Centro Ecologico in Hermosillo. No animal was kept in the truck more than a few hours before transport.

Two adult ewes appeared to have adverse reactions to Rompun, possibly brought on by the stress of being driven into the drive net. After injection and transport by sling to base camp, they appeared depressed and fatigued, mucus membranes showed pallor, respiration was slowed, and pulse rate was decreased. Yohimbine was administered to reverse the effects of Rompun, and 5% dextrose - 0.9% sodium chloride was infused IV. One ewe also was given atropine and dexamethesone. Both ewes responded to treatment, and physiological parameters returned to normal after approximately 30 min.

One ewe developed bilateral ruptures of the gastrocnemius muscles several days post capture. She was transported to Glaze Veterinary Clinic in Kerrville, Texas, for treatment. She has since recovered and has been returned to the Centro Ecologico.

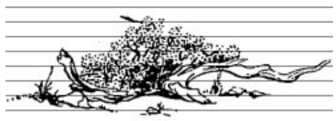
All other bighorn moved to the Centro Ecologico show no adverse effects from the capture and transport operation. No bighorn mortality was recorded. One ewe lambed on 10 March in the enclosure.

Survey of Tiburon Island: Tiburon Island was surveyed for three hours by helicopter on 2 February 1984. A total of 45 bighorn was sighted on the island survey (Table 3). From this data, we estimated the bighorn population on Tiburon Island to number approximately 100-120 animals. This estimate was based on over 300 hours of experience in bighorn helicopter surveys. Thirty-nine Tiburon Island mule deer (Odocoileus *hemoinus* sheldoni) were also counted.

No running water has been documented on the island; however, several seeps and large tinajas were observed in the areas where the bighorn were found.

Table 3. Bighorn counted on Tiburon Island, 2 February 1984.

		Numbers Counted
Ewes		19
Rams		12
Cl. II	4	
Cl. III	6	
Cl. IV	2	
Yearlings		3
Lambs		11
TOTAL		45



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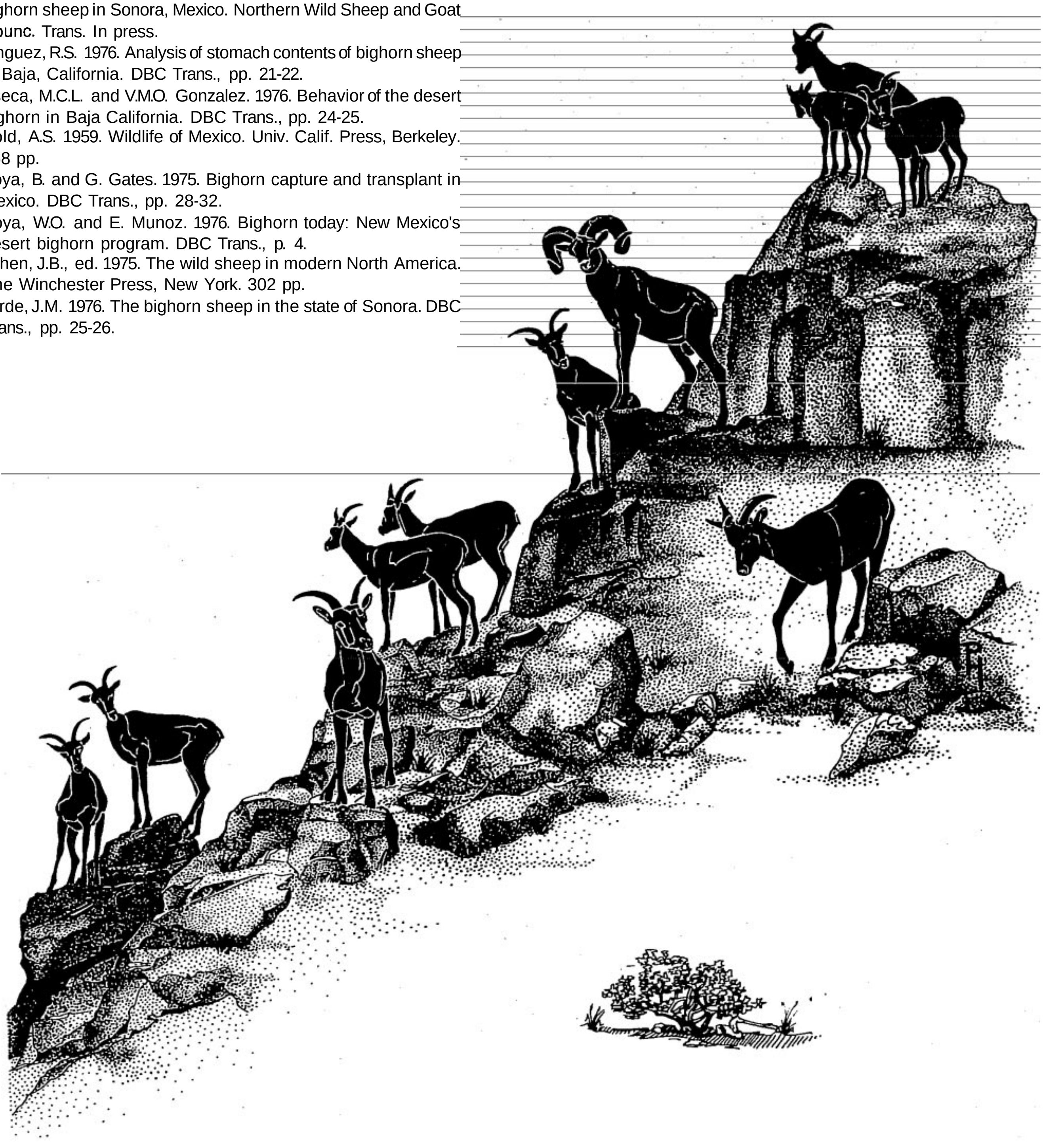

POPULATION ESTIMATE OF PENINSULAR DESERT BIGHORN SHEEP IN THE SANTA ROSA MOUNTAINS, CALIFORNIA

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Abstract. The bighorn population of the Santa Rosa Mountains was surveyed by helicopter in May and October 1983; the population size was estimated to be 347 ± 122 using the Lincoln-Peterson method and 32 collared animals. This estimate was based on the October count, since that count did not include non-surviving lambs that were present in the May count.

INTRODUCTION

The bighorn population of the Santa Rosa Mountains, Riverside County, California, was estimated to number 350 in 1953 (Jones et. al. 1957), 500 in 1970 (Weaver and Mensch 1970), 500 in 1974 (Weaver 1975), and 500 in 1979 (California Fish and Game files). These estimates were based on field surveys, waterhole counts conducted by the California Department of Fish and Game and Anza-Borrego State Park personnel beginning in the mid-1950's, and/or annual helicopter surveys conducted by the California Department of Fish and Game beginning in 1977. Although these estimates were given by personnel quite experienced with this bighorn population, quantitative statistical methods were not used in deriving these population estimates.

As part of a study of high lamb mortality in the north end of the Santa Rosa Mountains, some bighorn have been collared north of Dead Indian Canyon since 1981 (DeForge and Scott 1982). A capture in 1983 increased the number of collared bighorn to 32 animals, about half of the population in this northern portion of the range. These marked animals have enabled helicopter surveys to be used to estimate the population size by the Lincoln-Peterson method (Brower and Zar 1977).

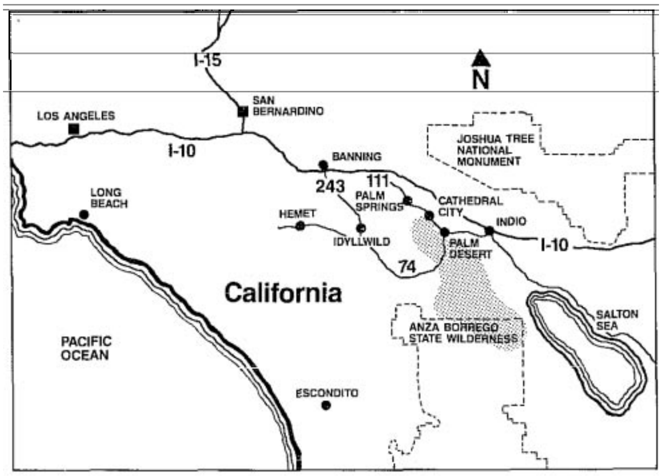
STUDY AREA

The Santa Rosa Mountains are approximately 35 miles in length and extend in a southeasterly direction from Palm Springs into Anza-Borrego State Park (Figure 1). The bighorn that occupy this range are of the peninsular subspecies *(Ovis* canadensis *cremnobates),* classified as rare by the California Fish and Game Commission since 1972.

METHODS

The Santa Rosa Mountains were surveyed by helicopter on May 9 - 10 and again on October 27 - 28, 1983. Twelve and thirteen hours of helicopter time were spent in the two surveys, respectively. The range of bighorn throughout these mountains is known from previous work of the California Department of Fish and Game (Bureau of Land Management and Calif. Dept. of Fish and Game 1980). Bighorn were not tracked with radio telemetry for seven days prior to the helicopter surveys so that the probability of finding collared animals in the north end of the range would not be greater than the probability of finding uncollared animals throughout the range.

Figure 1. Location of bighorn range in the Santa Rosa Mountains (stippled area).



RESULTS AND DISCUSSION

Numbers of bighorn counted from helicopter surveys of the Santa Rosa Mountains in May and October were 253 and 163 respectively (Table 1). Due to the bighorn's range being more concentrated in May than October, more animals were sighted on the May count. The data indicated that 64.7% of the population was counted in May and 46.9% in October. McQuivey (1978) found that 39.6% to 51.5% of the bighorn population in the River Mountains of Nevada was counted in aerial surveys using pilot and observers familiar with the area and sheep censusing techniques. More helicopter time spent per land area may be the reason that a larger percent of the population was observed in the Santa Rosa Mountains.

Table 1. Numbers of bighorn sheep observed during helicopter surveys of the Santa Rosa Mountains in **1983.**

	May 9 & 10	Oct. 27 & 28
Total counted in the whole range	253	163
Ewes	131	97
Rams	52	43
Yearlings	6	5
Lambs	64	18
Total counted north of Dead Indian Canyon	45	27
Total collared bighorn	17	32
Collared bighorn counted	11	15

Lincoln-Peterson estimates of the population were 391 ± 134 for the May sampling and 347 ± 122 for October (Table 2). By projecting the percentage of each sex-age class from the count data, the approximate numbers of ewes, rams, yearlings, and lambs were determined. The major difference between the May and October counts was the number of lambs (Table 2). Sex and age ratios from these counts are presented in Table 3.

Table 2. Bighorn population estimates with 95% confidence intervals from helicopter surveys of the Santa Rosa Mountains in 1983 based on the Lincoln-Peterson method. Estimated number in each sex-age class are based on the percentage of each class in actual count.

	May 9 & 10	Oct. 27 & 28
North of Dead Indian Canyon	70 ± 21	58 ± 14
Whole Range	391 ± 134	347 ± 122
Ewes	202	206
Rams	80	92
Yearlings	9	11
Lambs	99	38

Table 3. Bighorn sex and age ratios from helicopter surveys of the Santa Rosa Mountains in 1983.

	May 9 & 10	Oct. 27 & 28
Rams: 100 ewes	40	44
Lambs: 100 ewes	49	19
Yearlings: 100 ewes	5	5

The decline observed in the lamb/ewe ratio from May to October is indicative of the disease epidemic that has been causing high lamb mortality in the north end of the range since 1977 (DeForge et al. 1982). These data indicate that the disease problem may occur throughout the entire Santa Rosa Range.

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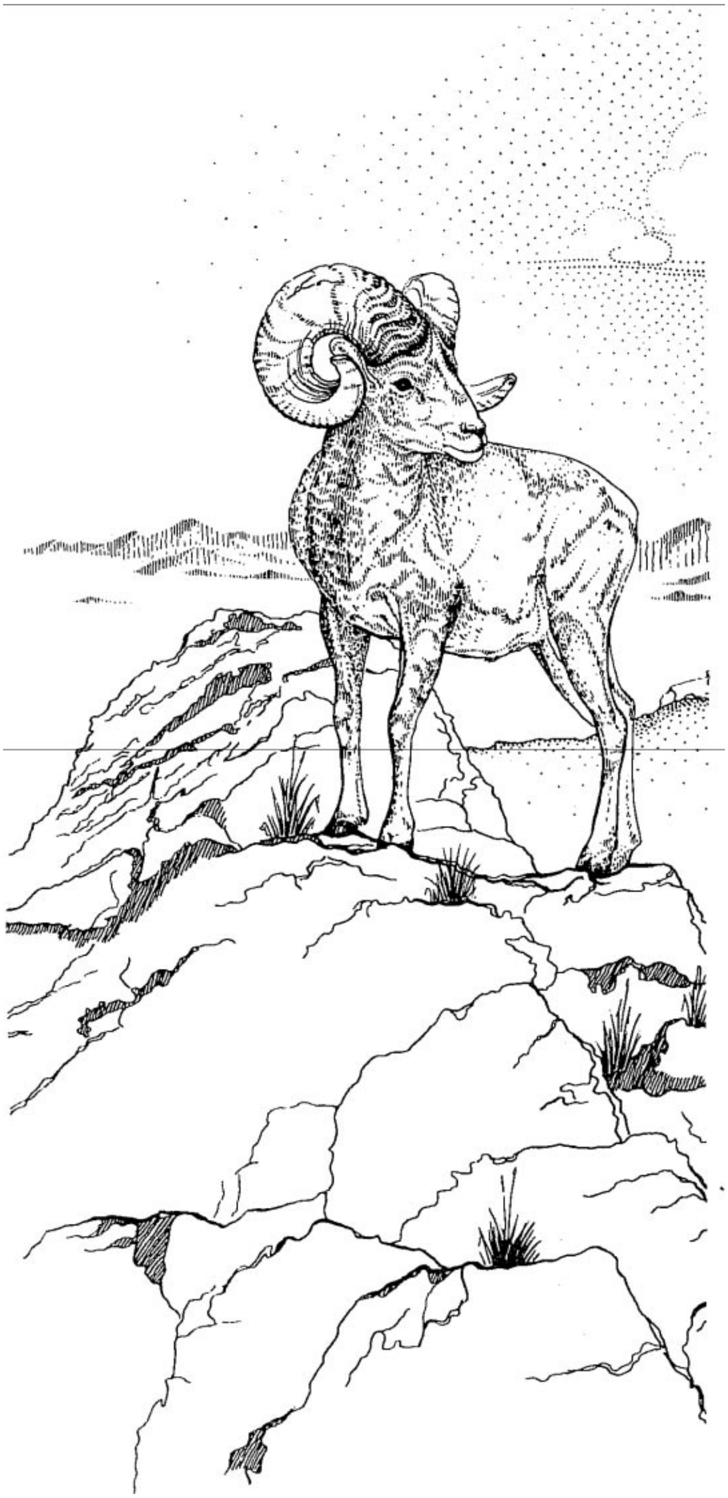

STATUS OF DESERT BIGHORN SHEEP IN NEVADA — 1983

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Abstract. Intensive aerial surveys resulted in the observation of 1,195 bighorn with a ratio of 66 rams and 37 lambs per 100 ewes. Generally, populations in the state are at high levels with some populations stable and others slightly increasing. Trapping and transplant activities resulted in the capture of 107 bighorn sheep this year with reintroductions accomplished in both the Gold Butte and Pilot Peak areas of Nevada.

HELICOPTER SURVEY RESULTS

A total of 1,195 desert bighorn sheep were observed during 70.4 hours of intensive helicopter surveys on 13 different mountain ranges within Nevada between September 12 and October 15, 1983. This year's surveys resulted in record high counts in the Meadow Valley Range, Pintwater Range, and Stonewall Mountain area.

The 1,195 bighorns were comprised of 589 ewes, 389 rams and 217 lambs for an average ratio of 66 rams and 37 lambs per 100 ewes; as compared to the previous five-year average of 1,407 observed with an average of 58 rams and 30 lambs per 100 ewes. A summary of 1983 survey results are presented in Table 1.

The age class structure of Nevada's bighorn sheep population based on the estimated ages of rams observed during the current year's survey is within the statewide long-term norm and suggests that 35.0 percent of the sheep are between one and three years of age, 37.5 percent between four and six years of age, and 27.5 percent seven years of age and older.

POPULATION TRENDS

Generally, desert bighorn populations within the state are at high levels. Monitoring of recent reintroductions indicate these populations are stable or increasing. Due to favorable precipitation patterns, which resulted in excellent range condition, lamb production and survival, as documented during aerial surveys, is above the long-term average (30 lambs per 100 ewes) for the second consecutive year. Record high counts from some mountain ranges, coupled with relatively stable ram to ewe ratio and high lamb production and survival rates, indicate Nevada's bighorn populations are continuing to expand. The 1983 statewide desert bighorn sheep population is estimated at 5,173 animals comprised of 2,716 ewes, 1,497 rams and 960 lambs, which represents a 4.1 percent increase over the 1982 estimate of 4,969 animals.

HUNTING AND HARVEST TRENDS

A total of 111 tags including 99 resident, 11 nonresident and one bid tag, auctioned for the sum of $25,000, were available for the 1983 Nevada Trophy Desert Bighorn Sheep season.

A record 2,250 applications were received this year indicating interest for hunting bighorn sheep remains high. A total of 1,305 (averaging *13.1* applications per tag) were received for the 99 resident tags while 954 (averaging *86.7* applications per tag) were received for 11 nonresident tags. The number of total applications received represents a *32.6* increase from last year.

A total of 94 bighorn rams were harvested during the 1983 season for a success rate of 82.8 percent for residents and 100.0 percent for nonresidents with overall success at 84.6 percent. The 1983 harvest represents the highest success and most rams ever harvested during any single season in Nevada. This year's harvest brings the total number of rams harvested in the state, since hunting was initiated in 1952, to 1,082 animals.

The average age of rams harvested was 7.6 years which is comparable to the previous five-year average. Ages ranged between five and 13, with 34.0 percent of the rams harvested under the age of seven and 19.1 percent ten years of age or older. A total of eight animals scored sufficient points to be considered for the Boone and Crockett Record Book.

Hunters reported observing an average 37 bighorn each and 5.1 sheep per hunter day of effort which is comparable to the last few seasons. The average number of days expended by hunters (7.3) decreased from last year (8.4). The percentage of legal rams reportedly observed by hunters (43.1%) represents an increase over last year (40.8%) and is above the five-year average of 34.6 percent. Hunter observational statistics support aerial survey data in showing populations at relatively high levels.

TRAPPING AND TRANSPLANTING ACTIVITIES

As part of a continuing program for the reintroduction of bighorn sheep into areas of historic distribution, the Nevada Department of Wildlife with the cooperation of various state and federal agencies was able to accomplish a number of reintroductions and augmentations this year.

The Nevada Department of Wildlife in cooperation with the National Park Service conducted trapping operations in both the Black Mountain and River Mountains of Clark County, which resulted in the capture of a total of 107 desert bighorn sheep *(Ovis* canadensis *nelsoni)* during the summer of 1983.

A total of 57 bighorn sheep were trapped and transplanted from the Black Mountains of Clark County, Nevada during the period of July 21 through August 16, 1983. Bighorns captured from the Black Mountains were reintroduced in both the Gold Buttes of Clark County, Nevada (20 sheep), and Pilot Peak, Mineral County, Nevada (22 sheep). Additionally, 15 bighorn were given to Texas Parks and Wildlife Department for their state's propagation and introduction program.

In the River Mountains a total of 31 bighorn sheep rams were trapped and transplanted during the period of July 2 through July 19, 1983. Transplanted rams were utilized to augment previous reintroductions in the Stonewall Mountains — 10 rams, Hot Creek Range — 6 rams and Toquima Range — 4 rams, as well as to bolster populations in the Monte Cristo and Silver Peak Ranges with 7 and **4** rams respectively. In addition to the 31 transplanted rams, 29 bighorns comprised of 4 rams, 17 ewes, and 8 lambs were also captured during trapping operations. The 21 yearling age and older animals were marked with individually identifiable collars and released, along with the 8 lambs, back into the herd to facilitate population studies.

All trapping in the Black Mountains and River Mountains was accomplished using 70' by 70' drop net traps. Table 2 lists the composition and disposition of transplanted animals.

Table 1. Record of bighorn sheep observed during Fall 1983 helicopter surveys.

Mountain Range	Survey Time	Total Observations	Number of Ewes	Number of Lambs	Number of Rams	Ratio Ram/Ewe/Lamb
Mormon	8.7	127	60	20	47	78/100133
Virgin Mountains	4.6	8	4	1	3	—
Meadow Valley	5.2	79	49	14	16	331100129
Arrow Canyon	4.8	91	47	19	25	531100140
Las Vegas	5.6	45	22	9	14	64/100/41
Pintwater	5.2	120	59	12	49	83/100/20
Desert	4.9	17	6	6	5	—
Sheep	15.0	346	173	61	112	651100135
East Desert	1.8	49	22	6	21	951100127
River Mountains	4.0	204	100	52	52	521100152
McCullough	5.8	17	5	2	10	—
Highland	2.4	14	7	—	7	—
Stonewall Mtn.	2.4	78	35	15	28	801100143
TOTALS	**70.4**	**1,195**	**589**	**217**	**389**	**661100137**

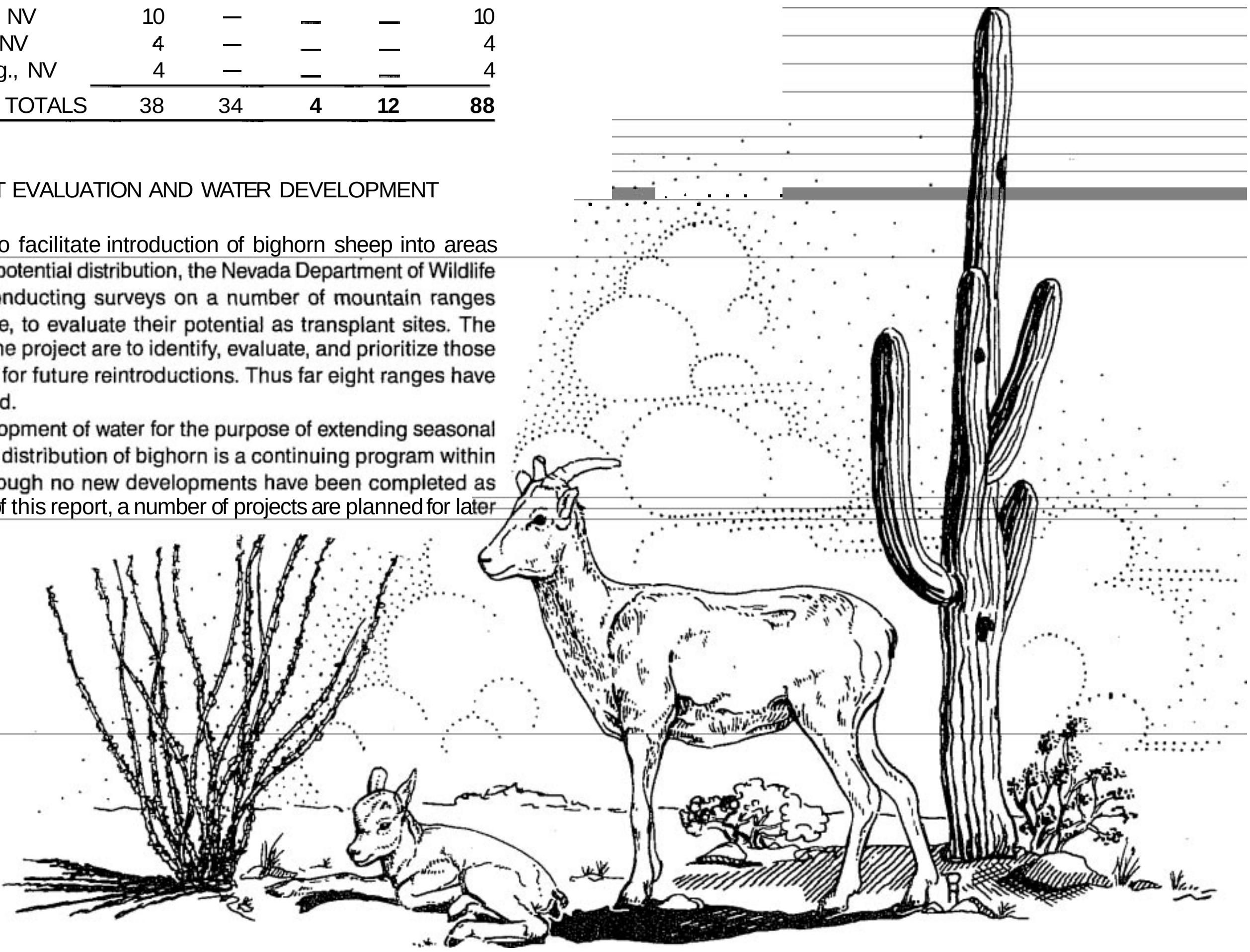
Table **2.** Record on Desert Bighorn Sheep trapped and transplanted during **1983.**

Location	Rams	Ewes	Lambs Rams	Lambs Ewes	Total
Gold Butte, NV	2	9	3	6	20
Pilot Peak, NV	4	14	1	3	22
Dierra Diablo, TX	1	11	—	3	15
Monte Cristo Rg., NV	7	—	—	—	7
Hot Creek Rg., NV	6	—	—	—	6
Stonewall Mt., NV	10	—	—	—	10
Toquima Rg., NV	4	—	—	—	4
Silver Peak Rg., NV	4	—	—	—	4
TOTALS	38	34	**4**	**12**	**88**

HABITAT EVALUATION AND WATER DEVELOPMENT

In order to facilitate introduction of bighorn sheep into areas of historic and potential distribution, the Nevada Department of Wildlife is currently conducting surveys on a number of mountain ranges within the state, to evaluate their potential as transplant sites. The objectives of the project are to identify, evaluate, and prioritize those areas suitable for future reintroductions. Thus far eight ranges have been evaluated.

The development of water for the purpose of extending seasonal utilization and distribution of bighorn is a continuing program within the state. Although no new developments have been completed as of the writing of this report, a number of projects are planned for later this year.



STATUS OF BIGHORN SHEEP IN CALIFORNIA[1]

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Abstract. Bighorn sheep number approximately 4,000 in California. There is an apparent upward trend in most areas. Bighorn remain fully protected with the Peninsular and California bighorn listed as rare by the California Fish and Game Commission. Three Nelson bighorn reintroductions were made in 1983.

LEGAL STATUS

All bighorn have been fully protected for over 100 years. Additionally, the peninsular and California subspecies were listed as rare by the Fish and Game Commission in 1972. In 1983, Assemblyman Frank Hill introduced a very controversial bill to remove the Nelson bighorn from the fully protected status and mandate that the Department of Fish and Game develop management plans for each bighorn herd.

This bill has passed in the Assembly and has been held up in the Senate. Support for the bill has come from several Audubon Society Chapters, the National Wildlife Federation, the Wildlife Management Institute, the Wildlife Society, two county boards of supervisors, various hunting groups, and the Desert Bighorn Council. Opposition to the bill comes from humane groups and the Sierra Club, that claim it is only a trophy hunting bill and that bighorn are declining.

TREND AND ESTIMATES

The general trend for bighorn within the state appears to be upward. This is attributed largely to several consecutive years of above normal precipitation, and to the more than 40 water catchments that with volunteer help the Department of Fish and Game has installed in the desert mountain ranges.

We have located a population of bighorn in the Newberry Mountains where we thought they had been extirpated. The area was checked in early 1970's, and no bighorn sign could be found in areas where they were known to exist in the 1950's. We have also found bands of ewes using areas that were assumed to be ram-only areas.

The notable exception to this positive trend is in the north end of the Santa Rosa Mountains of Riverside County, where there has been six years of almost no lamb survival. The Desert Bighorn Research Institute is investigating this problem under a memorandum of understanding with the Department of Fish and Game. The adjacent San Jacinto Mountains near Palm Springs has had a decline in the bighorn population during the same period.

Overall, bighorn population estimates are up. We estimate there are 2,800 Nelson bighorn, 900 Peninsular bighorn, and 300 California bighorn.

TRAPPING AND TRANSPLANTING

In 1983 California made its first transplant of desert bighorn. Three capture and relocations were made totaling 71 bighorn.

In July a helicopter/drive-net operation was successful, and 15 ewes and 6 rams were moved to the Whipple Mountains near Parker Dam. This was a cooperative effort with the BLM. Nine bighorn were trapped in the Old Dad Peak area and 12 from the Marble Mountains 35 airline miles to the south.

Both of these ranges had a surplus of bighorn and densities that we could not expect to hold. The Old Dad Peak area had increased from an estimated 25 bighorn in 1969 to more than 200. In July of 1982, 135 animals were classified from a helicopter count and the lamb ewe ratio was an excellent 75:100. Likewise the Marble Mountains had increased from an estimated 20 animals to over 100 animals. Helicopter flights made during the construction of a big game guzzler in this range produced a count of 95 animals.

The Old Dad Peak area is very difficult terrain to drive-net bighorn in. Our first choice was to use the water source for trapping and a permanent trap was built. Then it rained. We then attempted to bait with fermented apple pulp and alfalfa hay. We were unsuccessful in getting acceptance of the bait. We were successful in getting our desired number of sheep by drive netting and using the two mountain ranges; however, only one objective had been met. We still wanted to reduce the population in these ranges before nature did it for us and possibly with catastrophic results.

In December of 1983 the same two mountain ranges and method provided 25 bighorn (17 ewes, 8 rams) for release on China Lake Naval Weapons Center, Eagle Crag Mountains. Seventeen animals were captured in the Old Dad Peak area and 10 from the Marble Mountains. The later capture included two rams that were sent to augment the Whipple Mountain population. The U.S. Navy provided helicopters, and the bighorn released in the Eagle Crags were transported in crates to the interior of the range. We feel we should trap both populations again this year to use the population that has exceeded their water supply (which is three catchments).

The third capture and relocation effort was completed on November 29, 1983. This was a cooperative effort with the U.S. Forest Service in the San Gabriel Mountains. It has been determined that over 700 bighorn occupy the San Gabriel Mountains. There was one historic area within the range that had no bighorn. A site in Little Creek was baited for 31 consecutive days at exactly 7:00 a.m. It was necessary to use a helicopter to take the bales of alfalfa and drums of apple pulp to the baiting area. The net was dropped on 28 animals. Some of the larger rams were released at the trap site. There was one mortality: a ewe strangled under the net. The sheep were transported to the remote release site in crates on a line under the helicopter.

The Whipple Mountains reintroduction is a unique effort. Here there will be three releases made to try to establish three ewe bands in the range in an effort to get more of the bighorn habitat used. To do this, a temporary enclosure around a water source is being used. The first enclosure was 6,000 feet of fencing enclosing a mountain and adjacent to a lake. Mortalities including one adult ram that attempted to escape by swimming and drowned in 8' of water. It was located by its signal even though it was under water. One lamb disappeared and one ewe was killed by coyotes. One ram died from pneumonia 72 hours after the release. It apparently aspirated some rumen contents in the capture process.

Those animals flown to their release site in crates and released a few at a time have for the most part regrouped into small bands, but a few have wandered away from the area it was hoped they would utilize.

FUTURE

We have several bighorn populations that are doing well and can provide animals for reintroductions. Reintroductions are expensive, and we are limited by the dollars available. We are planning for 8 reintroductions in the next 3 years. Water catchment and maintenance will continue. In the long run I believe we can more than double the bighorn population in California. It will take time, money, and dedication to that goal.

[1] Supported by Federal Aid in Wildlife Restoration Project W-51-R Big Game Investigations.

UTAH'S DESERT BIGHORN SHEEP STATUS REPORT, 1984

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Abstract. Historic accounts attest to the fact that desert bighorn sheep have persisted in Utah from Pleistocene times to the present. Utah has twelve geographic areas that support desert sheep populations. Four areas are self-sustaining and eight are transplanted. Four hundred and ninety-nine sheep were counted during the annual winter trend counts. Utah has sold 198 permits since 1967. Overall hunter success has been 42 percent. Two research programs are nearing completion with a third study to begin the summer of 1984. Forty-one sheep were captured for transplant and research purposes during January, 1984. Utah's management goals remain unchanged; they are formulated to insure a future for desert bighorn in Utah.

INTRODUCTION

Bighorn sheep are not strangers to the State of Utah. Rocky mountain and desert sheep were fairly common to the early explorers and settlers of the Utah Territory. Historic accounts testify to the fact that both subspecies of sheep were prevalent and widespread at the time of settlement in the mid-1840's. Some skeletal remains found at various places in the state date back to a late Pleistocene period. Evidence indicates the bighorn were used extensively as a source of food and clothing to the prehistoric inhabitants of what is now Utah.

Father Escalante was the first white man to record bighorn sheep in Utah. In 1776, he documented the fact that sheep were in great abundance along the Colorado River. While most sheep populations in Utah have declined drastically since settlement times, bighorns have persisted along the breaks of the Colorado River. They have survived in spite of the competition of unrestricted grazing of decades past, poaching, and harassment from the uranium boom, and an ever increasing disturbance of the recreationing public (Dalton and Spillett 1971).

At the present time, Utah has twelve geographic areas that support desert bighorn populations. All the areas are historic bighorn range but only four herds are self-sustaining; the other eight areas have been transplanted.

POPULATION TRENDS

In November and December 1969, annual winter aerial serverys were initiated to determine productivity and population trends. These data continue to provide the basis for describing annual population levels, estimating population levels, and monitoring individual herd dynamics. During the 1983 survey, several objections were noted.

On the Potash unit the sheep continue to press towards the east. At least 30 head of sheep were observed in Long Canyon, which is on the northeast end of the unit. The reason for the buildup on the north end is still uncertain, but it is felt that it may be connected with the sheep trapping activity being done in the adjacent Canyonlands National Park.

Table 1. Bighorn management units.

Unit	Status
San Juan, North	Established historic population.
San Juan, South	Established historic population.
Potash	Established historic population.
Escalante Canyon	Transplant completed in 1978; sheep are now established.
Westwater	Transplant completed in 1978; success still uncertain.
San Rafael Swell	Transplant completed in 1981; population doing well.
Kaiparowits Plateau	Transplant completed in 1982; population doing well.
San Rafael Reef	First transplant in 1983; an additional 16 animals added in 1984.
Canyonlands	Established historic population.
Mase (Canyonlands Nat'l. Park)	Transplanted in 1982; appears successful.
Zion Canyon	Transplanted in 1973; sheep are widely scattered; success is uncertain.
Capitol Reef (Water Pocket Fold)	Transplanted in 1984; now being monitored.

The sheep in Canyonlands National Park varied according to the area flown. Bighorns in the Island unit were scattered and hard to find; sheep in the Needles were concentrated mainly in the Salt Creek drainage.

Bighorns in the North San Juan unit were widely scattered and difficult to locate. The main concentration on the South San Juan unit was in the Blue Canyon area.

In addition to areas surveyed on an annual basis, other areas east of the Colorado River (Lake Powell) were surveyed this year. Although not a lot of sheep were observed, biologists are optimistic that there are self-sustaining sheep populations in these areas.

In 1984, an aerial census was taken for the first time in the Escalante and Kaiparowits Plateau transplant areas. Sheep were observed in both areas (Table 2). One of the positive things noted by biologists was the fact that most sheep observed were unmarked, indicating good reproduction.

Table 2. Desert bighorn sheep aerial surveys, five year average, 1978-1982.

Unit	Rams	Ewes	Lambs	Total	Lambs Per 100 Ewes
North San Juan	49	68	38	155	56
South San Juan	28	42	18	88	43
Potash	19	22	13	54	59
Canyonlands	71	75	37	183	49

Table 3. Desert bighorn sheep aerial survey, **1983.**

Unit	Rams	Ewes	Lambs	Total	Lambs Per **100** Ewes
North San Juan	38	37	20	95	54
South San Juan	23	35	18	76	51
Potash	33	28	21	82	75
Canyonlands	99	71	36	206	51
Escalante Can.	6	3	2	11	66
Kaiparowits	4	16	9	29	56
Total	203	190	106	499	56

HUNTING

Desert bighorn sheep have been legally hunted in Utah since **1967.** That year, ten trophy ram permits were issued. A trophy ram is defined as a ram seven years or older and/or attaining a Boone and Crockett score of 144 points minimum.

Since 1967, Utah has sold 211 permits (this includes 4 trophy ram permits sold to the highest bidder). Eighty-nine sheep have been harvested for a hunter success rate of 42 percent. Table 4 shows the harvest trend summary by unit.

Table **4.** Harvest trend summary, bighorn sheep, **1967-1983.**

Unit	Permits Sold	Ram Harvest	Percent Success
North San Juan	121	44	36
South San Juan	77	36	47
Potash	7	5	71
Special Bid Permit	4	4	100
Total	**198**	**89**	**42**

TROPHY RAM PERMIT

In 1980, the Board of Big Game Control authorized the sale of one trophy ram permit to the highest bidder. A minimum bid was set at $20,000. Since that time a trophy ram permit has been sold each year. At the time of this writing, the fifth ram permit has been sold for the 1984 season at $35,000. It is with these monies that Utah conducts much of the transplant and research work on bighorns. Without such a source of revenue, bighorn sheep projects would be greatly curtailed.

RESEARCH

Two research projects are ongoing in Utah. Mike King, a Ph.D. candidate, is completing his study on land changes and development and their impacts on desert sheep.

Bill Hull, a M.S. candidate, is finalizing his study on nutritional requirements of bighorn.

A third study designed as a follow up study to Mike King's work is underway; field work should start in the summer of 1984.

TRANSPLANTS

Since 1973 when Utah made its first transplant in Zion National Park, a total of 171 animals have been relocated. To date, all animals have been released into areas of historical habitat.

The most recent transplant was made into Water Pocket Fold, an area of Capitol Reef National Park and the San Rafael Reef. Twenty-two sheep (3 rams, 12 ewes, 7 lambs) were moved from Canyonlands National Park to Capitol Reef in mid-January, 1984. Three sheep were instrumented and all adults were collared so movement could be monitored.

An additional sixteen bighorn were captured on the Potash unit and moved to the San Rafael Reef to complement a previous transplant to that area.

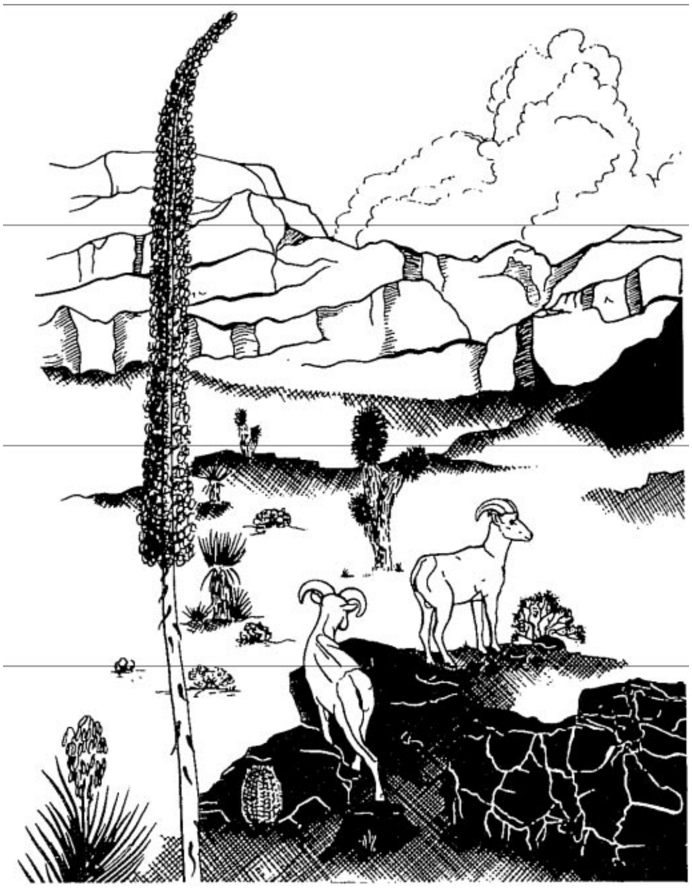
Three sheep (2 rams and 1 ewe) were given to the state of Texas to aid in their breeding program.

CAPTURING METHOD

All sheep captured during the 1983-84 season were caught using a tangle net. This method has proven far superior to the tranquilizer dart method. Capture time has been reduced to .73 hourslsheep, thus reducing the cost/animal substantially. Very little injury to the bighorn has been encountered using this method.

SUMMARY

Utah will continue to meet its management goals by attempting to reduce impacts on present desert bighorn habitat and populations. At the same time we will continue expanding the present distribution of sheep into suitable habitat through selected transplants and natural reproduction. Future demands, both recreational and energy related, will have their impacts, but by increasing our understanding of the life history, behavior, and habitat requirements of this unique animal, we feel we can meet our goals and insure a future for the desert bighorn sheep in Utah.



ARIZONA BIGHORN SHEEP STATUS REPORT — 1984

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Abstract. The 1983 survey total of 1901 classified bighorn observations represented a 51% increase since 1981 and an 11% increase since 1982. Sheep populations appear to have increased in many areas. Survey data indicate a 15% increase in rams per 100 ewes since 1982. Survey statistics and managers' opinions indicate that many populations have increased in recent years.

Arizona's 1983 bighorn season consisted of 48 permits. Forty-seven hunters took 44 rams for a 94% success rate. This was the highest hunter success rate in the 31-year history of permitted bighorn hunting in Arizona.

Arizona's progress in transplanting sheep continued in 1983. Fifty-four bighorn sheep were captured with a drop-net in Unit 15B. Thirty-four of these were released at 2 sites in the Grand Wash Cliffs with the remainder going to Texas and Colorado.

In addition 34 sheep were captured in the Kofa and Plomosa Mountains and released at 2 sites in Horse Mesa east of Phoenix.

Previous transplants include Aravaipa Canyon, Virgin Mountains, Muleshoe Ranch, Redfield Canyon and Goat Mountain. All appear to be sustaining transplanted numbers or increasing.

An increase in observed numbers of Rocky Mountain bighorn may lead to a limited hunt in 1984.

Research has been completed on several bighorn studies including Aravaipa Canyon, the Catalina Mountains and the Arizona Public Service — Southern California Edison powerline project. Few new studies have started.

Planning to improve bighorn management continues by the Arizona Game and Fish Department. Transplanting will continue. The authorization of a raffle and auction for 1 bighorn permit each will fund substantial sheep management and research efforts.

SURVEYS

Arizona's bighorn sheep survey effort has been shifted increasingly to the fall and winter period in the past several years in attempts to obtain more accurate rams:100 ewes ratios, reduce spring disturbance to the young lambs, and obtain more accurate lamb survival figures.

Surveys are conducted primarily by helicopter leased through a state bidding procedure. A more stringently written contract has required a modern turbine-powered helicopter to provide greater safety and increased capabilities for capture and survey work in recent years.

The Arizona Game and Fish Department is pursuing acquisition of its own helicopter to further improve safety and decrease costs.

During the survey period, a total of 1,901 desert bighorn were observed, excluding recent transplant areas and a Rocky Mountain bighorn population. This total represents a 51% increase in classified observations from 1982 and an 11% increase since last year. It appears that populations have increased during this period, even though survey efforts and efficiency may have also contributed to the increased observation total.

Classified bighorn consisted of 553 rams, 903 ewes, 278 lambs and 167 yearlings. Population sex and age ratios calculated from these data consist of 61 rams to 100 ewes, 31 lambs to 100 ewes, and 18 yearlings to 100 ewes.

These ratios indicate a 15% increase since last year in the rams to 100 ewes ratio, and a 9% decline in lamb survival.

Surveys of Rocky Mountain bighorn in eastern Arizona netted 69 classified sheep observations consisting of 42 rams, 14 ewes, 7 lambs and 6 yearlings. Population ratios from these surveys are 300 rams to 100 ewes, 50 lambs to 100 ewes, and 43 yearlings to 100 ewes.

HUNTING

Arizona has permitted conservative hunting for desert bighorns for 31 years. In 1983, a total of 48 permits were authorized in 21 hunt areas statewide. This represented a 6-permit increase from 1982, but was still slightly below the mean permit level of 51 for the period 1978 to 1982.

Table 1. Arizona Bighorn Harvest Summary.

Year	Permits	Hunters	Harvest	Percent Success
1953	37	37	20	54
1963	81	79	31	39
1973	71	68	38	56
1979	59	59	47	80
1980	50	50	39	78
1981	45	43	34	79
1982	42	42	36	86
1983	48	47	44	94

Forty-seven of the permitted hunters participated and harvested a total of 44 rams for a hunter success rate of 94%. This was the highest hunter success rate ever recorded during the history of permitted bighorn hunting in Arizona.

A total of 2,159 applications, 31% non-resident, were received for the 48 permits for an application rate of 45 first choice applicants per permit. This represented a considerable decline from the 62 applicants per permit in 1982.

Increasing hunter success has been a relatively consistent trend since the first hunt in 1953. During the 10-year period, 1953 to 1962, hunter success averaged only 38% compared with 45% from 1963 to 1972, and 78% from 1973 to 1983. Average annual harvest increased from 16% in the hunt's first 10 years, to 36 during the second 10 years. Average annual harvest increased to only 41 for the last 11 years, despite the substantial increase in hunter success during this period. Permit levels are now set with the expectation of 100% success.

Mean age of the rams taken in 1983 was 6.5 years. The youngest taken were 3 years old. The mean Boone and Crockett score was 156 6/8 with a range from 114 6/8 to 100 0/8. Historically, Arizona has permitted hunting only for mature rams. However in 1982 and 1983, experimental hunts were held with legal bighorn being any ram.

A total of 15 permits were allocated for 4 hunt areas. Permittees harvested 13 rams for an 87% success rate. The average age of the 8 rams taken in units 15A and 15B was 5.8 years, versus an average of 7 years for the 5 rams taken in units 44B north and 44B south. Boone and Crockett scores averaged 153 3/8 (range 134 6/8 to 168 5/8) and 152 2/8 (range 126 2/8 to 172 3/8) for the two areas, respectively.

The mean age of rams taken in units 15A and 15B has been higher since the initiation of the any-ram hunt (4.3 years in 1981, 6.2 years in 1982, and 5.8 years in 1983), while the average score has remained relatively stable (154 3/8 in 1981, 153 4/8 in 1982, and 153 3/8 in 1983).

The any-ram hunt in units 44B north and south has resulted in a slight decline in mean age (7.3 years in 1981 versus 7.0 years in 1982 and 1983) and also in mean score (162 0/8 in 1981, 154 5/8 in

1982, and 152 218 in 1983). One more year is scheduled in the trial any-ram hunt program.

The Aravaipa transplant population was hunted for the fourth consecutive year in 1983. A total of 7 permits have been authorized since 1980. Hunters have had a 100% success rate to date. Rams taken have averaged 8 years of age and 176 118 Boone and Crockett points. In 1983, a 5 and a 6 year old were taken with respective scores of 176 318 and 166 618. The larger of these two rams was the second largest taken in the state in 1983. Since hunting was initiated in 1980, Aravaipa has provided the state's largest ram 2 years and second and third largest one year each.

TRANSPLANTING

Aravaipa: Aravaipa Canyon, in southeastern Arizona, was the site of the state's first transplant operation. Since the release of 22 sheep from a 100 acre enclosure in 1973, the population has expanded to around 100. The rapid population growth curve persisted for 9 years, but appears to have slowed in the last two years. Lamb and yearling survival averaged 68 lambs to 100 ewes, and 34 yearlings to 100 ewes for the first 8 years following release from the enclosure. Since that time, lambs to 100 ewes ratios have been lower, but still above expected population maintenance levels.

Dispersal of the population in the seven years since I have been monitoring it has been slow but consistent. New nursery band areas have been discovered in recent years and evidence of ram use of the south rim has been documented this past year.

Muleshoe-Redfield: Bighorn from the Muleshoe and Redfield transplants, 100 kilometers south of Aravaipa Canyon, have intermingled since their releases in 1980 and 1981. Reproduction in the Muleshoe Ranch enclosure was poor prior to the release. Adult mortality was quite high from a variety of causes including lion predation. The enclosure was opened on 13 April, 1982 to allow the remaining 6 rams and 10 ewes to exit.

In November, 1981 and January, 1982, a total of 19 bighorns (6 rams and 13 ewes) were released at Redfield Canyon in the southwest portion of the Galiuro Mountains. The Redfield release site is 23 kilometers northwest of the Muleshoe Ranch. Within months, sheep from these two releases were intermingling regularly.

Radio tracking data and visual observations during fall surveys have documented sheep use in a 59 kilometer band from 13 kilometers south of the Muleshoe to 23 kilometers north of Redfield Canyon.

Five adult mortalities have been documented since the releases; three of these were lion kills. One ram traveled 100 kilometers west and established residence on Pusch Ridge with the bighorn population in that mountain range near Tucson.

A survey in the fall of 1983 resulted in the classification of 23 sheep; 8 rams, 9 ewes, 3 lambs and 3 yearlings. The population appears to have remained stable or decreased slightly since the releases.

Goat Mountain: The population of sheep at Goat Mountain, east of Phoenix, was initiated with releases in November of 1980 and 1981. A total of 31 sheep were released at two sites. Fall surveys on Goat Mountain in 1983 resulted in the classification of 31 bighorn sheep, including 8 rams, 22 ewes, and 1 lamb. Fall surveys there in 1982 had documented 38 bighorn comprised of 9 rams, 19 ewes, 7 lambs and 5 yearlings. Attempts will be made in the summer of 1984 to closely monitor reproduction and mortality.

Horse Mesa: In December of 1983, 32 sheep (9 rams, 23 ewes) were captured in the Kofa and Plomosa Mountains and released on Horse Mesa on the south side of Apache Lake, 100 kilometers east of Phoenix. The sheep were released at two sites, 13 kilometers apart, in an attempt to imprint lambing sites. All sheep were marked with color collars and ear tags and 10 were fitted with radio collars.

One ram mortality resulted in January, 1984, as the result of a strangulated hernia.

Virgin Mountains: In 1979 and 1981, 62 bighorn were captured in units 15B and 15C. Twelve of these sheep were released in an enclosure at Hendricks Canyon. In January, 1982, 21 of 25 bighorn in the enclosure were released. In addition, 20 sheep were released in Sullivan Canyon in the Virgin Mountains and 21 at Buck Spring.

Of the 62 sheep released in the Virgin Mountains in 1981-82 (25 rams, 37 ewes), known mortality by February, 1984 was 10 rams and 9 ewes. Of the 32 radio collars placed on the released sheep, 11 (4 rams and 7 ewes) still remain active.

Known reproduction as of February, 1984 has been 10 yearlings, 13 lambs and the current undocumented lamb production.

The present population is estimated to be at least 75 sheep, including 26 rams, 39 ewes and the current lamb production.

In August, 1983, a drop-net capture, coordinated by Art Fuller, was conducted in unit 15B. The operation was extremely successful and may herald the beginning of a safer (for both capture crew and sheep), and possibly less expensive, technique for Arizona transplants.

A total of 54 bighorn were captured at four sites with 34 being released at two sites, 5 kilometers apart, in the Grand Wash Cliffs. These were 7 rams, 21 ewes, and 6 ram lambs. The present population is believed to include 8 rams, 17 ewes, and 8 lambs.

In addition, 10 sheep were provided each to Colorado and Texas (3 rams, 13 ewes, 4 lambs). Physical condition of all sheep captured was excellent.

Blue River: Twenty Rocky Mountain bighorns were released in the springs of 1979 and 1980 at the same site on the Upper Blue River. These sheep were believed to number nearly 40 and appear to have split into two use areas, one in the Blue River drainage and one in the Black River Canyon.

In addition, an increasing number of sheep have moved into Arizona from New Mexico's Rocky Mountain transplant sites near Glenwood, New Mexico.

In January, 1984, 54 Rocky Mountain bighorn were observed along the San Francisco River. In the spring of 1983, 7 Rocky Mountain bighorn were observed near Ft. Thomas, 140 kilometers west of the New Mexico-Arizona border.

The Arizona Game and Fish Department is contemplating proposal of a limited hunt in Arizona this year for the resident Rocky Mountain population.

RESEARCH

The Arizona Game and Fish Department's Aravaipa Canyon livestock-bighorn competition study has come to a formal close at this time. However, work is progressing on obtaining funding for continuation of studies at the Canyon by a graduate student. Future studies should include close monitoring to document future population dispersal and growth.

The active phase of the Pusch Ridge bighorn study in the Catalina Mountains has terminated. Substantial information has been obtained on movements and habitat selection in this population near Tucson. This population is of considerable interest because it is the eastern-most surviving sheep population, excluding recent transplants, in Arizona. Much of Arizona's unoccupied bighorn habitat is more closely related to the Catalina's in terms of elevation, rainfall and vegetation, than to currently occupied sheep ranges in the state.

This population also is suffering from the effects of Tucson's human population expansion. Much could be learned regarding human-bighorn interactions at this location. A controlled burning program has been initiated this year by the Coronado National Forest with cooperation of the Arizona Game and Fish Department and the Arizona Bighorn Sheep Society. We hope to open the brushy aspect of habitat adjacent to currently occupied bighorn range to allow expansion of the limited population there.

Another bighorn study now underway is being funded by the U.S. Army and being conducted at the Yuma Proving Grounds. It is to determine habitat utilization and movement corridors.

Other studies funded by Arizona Public Service, Southern California Edison, and U.S. Bureau of Reclamation to determine the effects of a powerline corridor and the Central Arizona Project Canal on bighorn are drawing to a close.

PLANNING

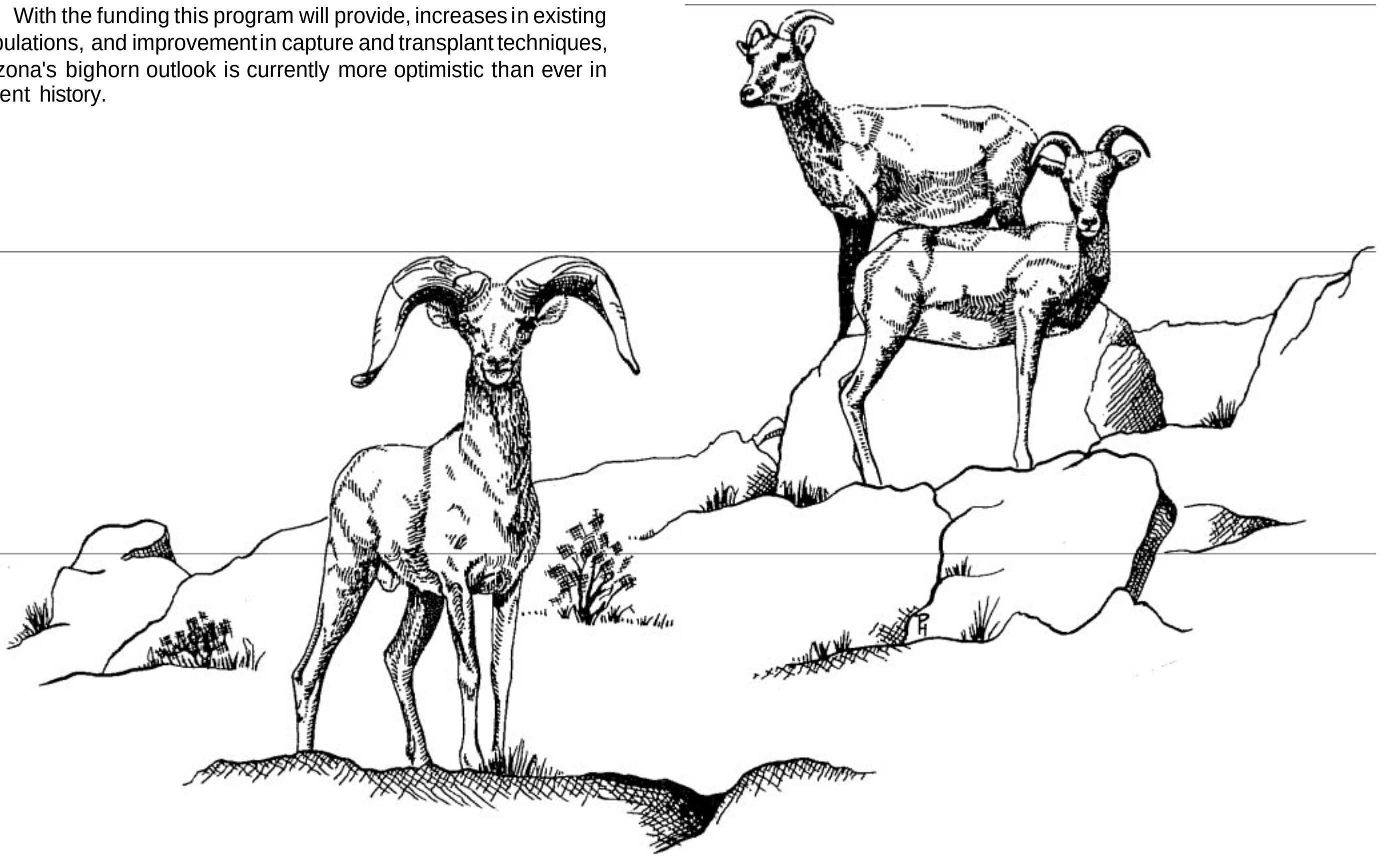
The Department has prepared management plans for all big game species within the past two years. Although substantial revision of these plans will undoubtedly occur, the current plan will give us a basis for more uniform bighorn management within the state.

The Department will continue in its aggressive transplant program. Hopefully, with the use of drop-net captures, transplants may be increased with improved safety.

A lengthy list of transplant sites await funding, available sheep, and manpower.

The Arizona State Legislature approved a proposal to permit the Arizona Desert Bighorn Sheep Society to raise funds for the Department's bighorn management and transplant program. Funding will be obtained by allowing one sheep permit to be auctioned and one permit to be raffled. Those permits were authorized for the 1984 season. The auction has already been conducted. A permit in the Kofa's was auctioned for $64,000. The raffle is to be held this fall.

With the funding this program will provide, increases in existing populations, and improvement in capture and transplant techniques, Arizona's bighorn outlook is currently more optimistic than ever in recent history.



TEXAS BIGHORN SHEEP STATUS 1984

Jack Kilpatric
Marfa, TX 79843

The most significant development, to this date, in the Texas bighorn reintroduction program was begun during the past year. Members of the Texas Bighorn Society, a private organization, built and donated to the people of Texas a brood complex at Sierra Diablo which should produce 25-30 head of sheep each year for introduction into former ranges.

The complex consists of 4 pens containing 8.4 to 10 acres each, totaling 38 acres. Each pen is a separate facility, being separated by 24 feet of neutral space from the other pens and the outside fence. Each pen has its own catch pen designed to facilitate the transfer of sheep from pen to pen or to the outside with or without handling as the need arises. The whole complex is surrounded by 10½ feet of net wire with an 18 inch electrified overhang to the outside to discourage entry by predators.

This complex was stocked in July and August with 14 ewes and 1 ram from the State of Nevada, and 7 ewes and 3 rams from the State of Arizona. Two free-ranging Texas rams were lured into the pens in late September for breeding purposes. Two additional rams were obtained from the Siaie of Utah in late January by a private individuai. As of this date 14 lambs have been produced and several more are expected. One of the lambs was very small and did not survive. Other losses include the ram from Nevada and one of the rams from Utah. It is felt that the loss of the adult sheep is a result of their failure to adapt to an enclosure situation. Results to date have been far better than expected for the first year.

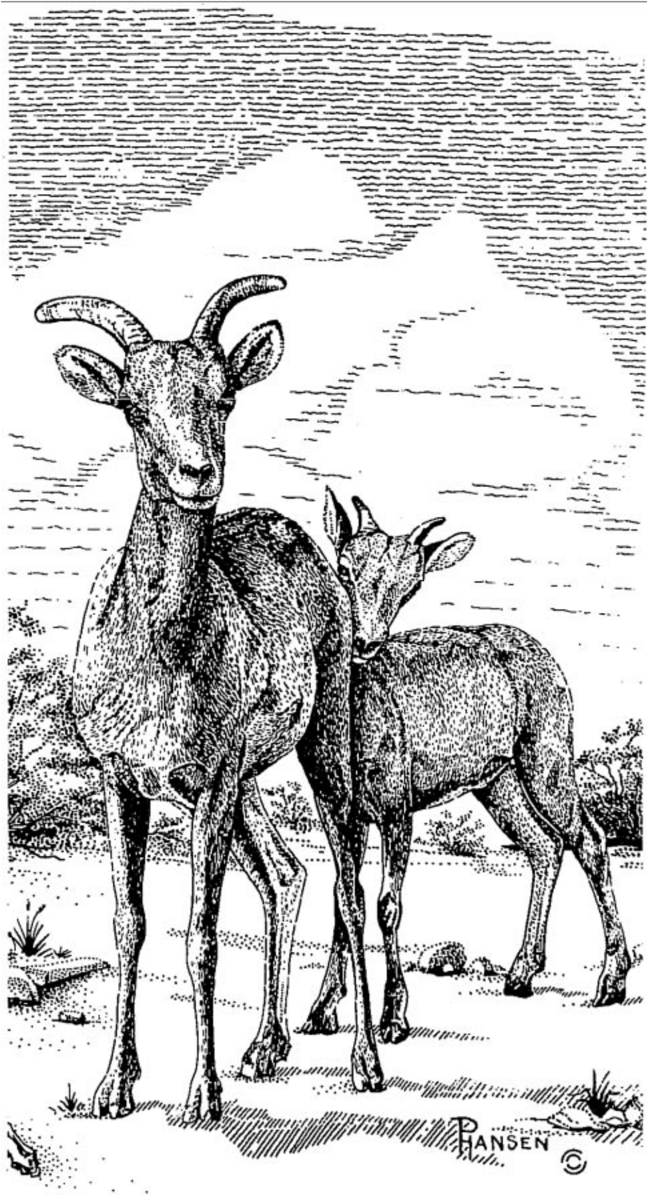
Other bighorn reintroduction efforts in Texas consists of a 600 acre brood pasture at Chilicote Ranch in the Vieja Mountains. Sheep in this facility number 17 head from a stocking of 3 rams and 4 ewes in 1978. The slow increase in this herd is attributed primarily to poor lamb survival due to predation.

The free-ranging herd in the Diablo Mountains is the result of 2 releases totaling 7 rams and 7 ewes made in 1973 and 1979. The numbers in this herd are very difficult to access, but it is estimated that 30 head make up this herd.

Texas sheep at the Glaze Veterinary Clinic number 6. These sheep, except for one ewe, are all descended from one ewe which gave birth to healthy lambs, but did not lactate. Efforts at inbreeding these sheep are being conducted to determine if the inability of the original ewe to lactate is genetically transmissible.

Sightings of bighorn have been made by Big Bend National Park personnel as a result of the 1971 Black Gap release of 21 head. However, it is felt that this release is not successful and that no more than 10 remain.

Total sheep estimates for the State of Texas is approximately 100 head. This is the high population since the reintroduction efforts began in 1956.



A REPORT ON THE REINTRODUCTION OF BIGHORN SHEEP ONTO THE NAVAL WEAPONS CENTER CHINA LAKE, CALIFORNIA

Thomas G. Campbell
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INTRODUCTION

The Naval Weapons Center is located in the Northwest Mojave Desert of Southern California, about 120 miles northeast of Los Angeles and immediately southwest of Death Valley. This military reservation, with the main base located at China Lake, encompasses 1,096,680 acres within Kern, Inyo, and San Bernardino counties.

In 1970, it was estimated that 20 bighorn sheep *(Ovis canadensis nelsoni)* occupied the Center's ranges, along with 800 feral burros (Weaver & Mensch, 1970). By 1980, no recent sign of bighorn sheep were recorded (DeForge, 1981). During this time, the burro population increased from 800 to over 5,000 animals. Since 1980, over 6,200 burros have been removed from the Center's ranges. An ephemeral cattle lease was also eliminated on the southern portions of the ranges in 1982.

In April 1983, the Navy Natural Resources Specialist met with California Dept. of Fish and Game and other biologists to evaluate the feasibility of reintroducing desert bighorn onto the Naval Weapons Center. An agreement was made between the Navy and the Dept. of Fish and Game to reintroduce sheep into the Eagle Crags Mountain on the Center's Mojave B (South) Test Range. On 2 through 6 December 1983, 25 desert bighorn were captured in the Old Dad Peak, Kelso Peak, and Marble Mountains and released into the Eagle Crags Mountains. This paper presents preliminary results of the on-going monitoring program of the China Lake sheep.

METHODS

Radio collared sheep were located by searches conducted on foot, in jeeps, and by helicopter and fixed-wing aircraft. Precise locations were determined by triangulation whenever possible. To minimize stress during the first months following release, visual observation was usually limited to incidental sightings. This period also coincided with the lambing season. The status and uses of water sources by sheep and other animals were noted during the surveys.

RESULTS AND DISCUSSIONS

Of the 25 sheep released in the Horn Tip Spring area of the Eagle Crags Mountains, 17 were fitted with radio collars. Four of the collared sheep were adult males, 12 were adult females, and one was a subadult female. Since the release, a total of 10 aerial, 14 jeep, and 5 foot surveys have been conducted. The collared sheep were located 243 times during the 29 surveys. Although aerial surveys locate more sheep, ground surveys using triangulation techniques gave a more accurate location.

Summarized below are the results of the surveys from the date of release through 26 April 1984:

1) After analysis of the data, it became apparent that some sheep were being recorded much more regularly than others. Sheep remaining near the release site are more accessible for ground surveys and, therefore, are recorded more often. But even some of these sheep suddenly vanish, only to turn up in another area far removed from the release site. An outstanding example is sheep 175, a 4-year-old male that remained near the release site for about one month, then disappeared. He was relocated three months later in Butte Valley, Death Valley National Monument. This is a movement of over 30 air miles from the release site (Figure 1).

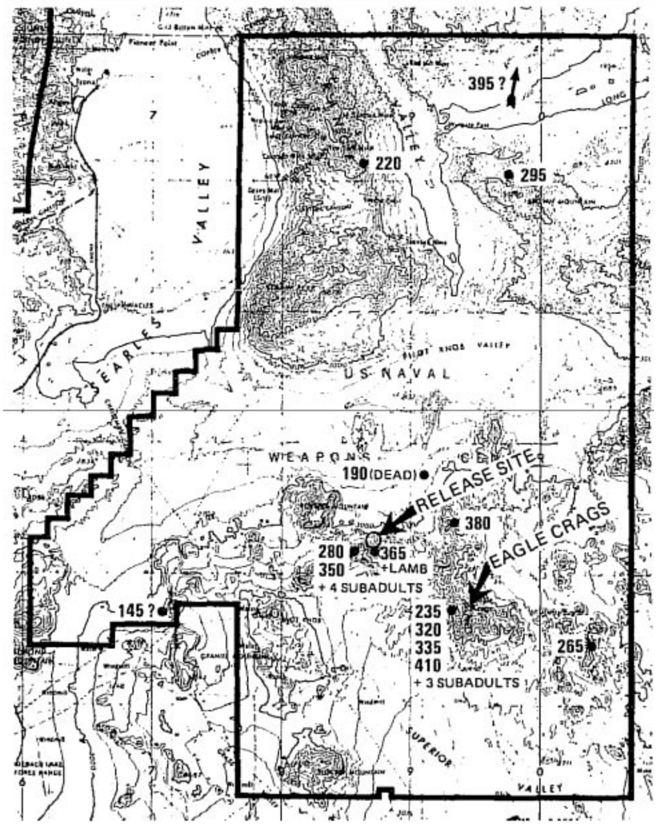

Figure 1.

2. Four other sheep have shown similar but not as dramatic behavior. Animals 295,220,205 and 395 moved more than 12 miles to the north. This included crossing Randsburg, a 4-8 mile wide valley.

a) Sheep 295, a 3-year-old female, remained at the release site for three months then disappeared. One month later, she was relocated near the southern end of the Panamint Mountains, over 20 miles away.

b) Sheep 220, a 4-year-old male, disappeared from the release site after 3 months and was later located north of Layton Pass in the Slate Range, over 17 miles away.

c) Although not yet confirmed, sheep 205, a 5-year-old female, and 395, a 3-year-old female, are thought to have moved north into the Panamint Mountains.

3) There have been two confirmed mortalities (sheep 190 and 250) and one unconfirmed mortality (sheep 145) out of the 25 sheep reintroduced into the Eagle Crags Mountain.

a) On 8 January 1984, sheep 190, a 4-year-old female, was recovered almost totally consumed by coyotes on an isolated knoll (known as Ship Rock) in Randsburg Wash. Ship Rock is approximately 7 miles northeast of the release site.

b) Sheep 250, a 3-year-old female moved to the Straw Peak area in the southern portion of the Slate Range within two weeks of release. She remained there for 3 months. On 15 April 1984 an aerial survey picked up a mortality signal from her in the Panamint Mountains just west of Manly Peak. Her carcass and the remains of a lamb were recovered below Manly Peak in a canyon immediately south of Redlands Canyon. The lamb appeared full term according to the description provided by Monson and Sumner (1981). Both mother and lamb appeared to have been dead for 3 to 4 weeks. No evidence of predation was noted. The apparent simultaneous deaths would suggest the ewe had trouble giving birth resulting in both their deaths.

c) The collar of sheep 145, a 1-year-old female, was recovered 10 miles west of the release site in Randsburg Wash. The collar was found on the valley floor covered in dirt at the base of a creosote bush. This animal may have been able to shed its collar. Because of her age the collar had been installed loosely at the time of capture to allow for subsequent growth.

4) Of interest is the fact that most of the exploratory animals and all of the mortalities were sheep captured from the Old Dad Peak area. It is known that Old Dad sheep have a tendency to leave mountainous terrain and are often found on the flats (V. Bleich, 1984 pers. comm.). In contrast, seven of the eight Marble Mountain sheep (all ewes) have remained at or near (within five miles) of the release site.

5) Fortunately, the rest of the data gathered is much more positive. Seven of the 8 uncollared subadults are still located in good sheep habitat near the release site. During an aerial survey on 2 April 1984, 4 of the uncollared sheep were seen with sheeps 280, a 2-year-old male, and 350, a 3-year-old female, among the rocky peaks just west of the release site. Three other uncollared sheep and possibly a lamb were observed with sheep 235, a 3-year-old female, and 320, a 4-year-old female in Eagle Crags proper, an area about 6 miles southeast of the release site.

6) Locational data gathered on the remaining sheep are as follows:

a) Sheep 410, a 2-year-old female, is usually located in the Eagle Crags proper.

b) Sheep 380, a 2-year-old female, is usually located among a series of peaks five miles north of the Eagle Crags. This animal was observed in this area on 21 January in the company of two collared sheep (335 and 265), and with an uncollared subadult.

c) More recent surveys have shown sheep 335, a 4-year-old female, south of the release.

d) Sheep 265, a 5-year-old male, is usually found 12 miles east of the release site on rocky peaks near Mesquite Spring (west of Goldstone Lake). Sheep 265 is the individual that aspirated rumen contents through its nose during the capture operation. Apparently the animal suffered no ill-effects and is doing well.

e) Finally, sheep 365, a 3-year-old female, was observed with a lamb on 13 January at the release site. She has remained there since that time.

7) Ten or 11 of the adult females captured in December were thought to be pregnant. Even with the death of two female sheep and the loss of two or three sheep to migration, there still exists the possibility that five or six lambs could have been added to the Eagle Crags population. Lamb survival rates are not known at this time.

CONCLUSION

At this time it appears that efforts to reintroduce sheep into the Eagle Crags Mountains will be successful. Eight adults, 7 subadults, and 2 - 3 lambs are located within 6 miles of the release site. Two other individuals are regularly located on nearby peaks. It is hoped that a few of the males off exploring nearby mountain ranges will return during this year's rutting season to supplement the two groups remaining near the release site.

With the onset of summer, many of the ephemeral springs, now flowing, will dry up. Sheep movement should become more restricted and predictable. This should allow for more definitive studies to be conducted.

ACKNOWLEDGEMENT

A special thanks is extended to all those individuals representing various federal, state, and private organizations who contributed in every way to the capture, reintroduction and ongoing studies of the China Lake sheep.

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BURRO COMMITTEE REPORT'

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Management of feral burros and horses by the Bureau of Land Management (BLM), National Park Service (NPS), and the U.S. Navy are reviewed.

ARIZONA

During FY-83 (1 October 1982 through 30 September 1983), BLM removed burros from the "Arizona Strip" (55), along the Colorado River (150), and in the Black Mountains (451). The removal goals for FY-84 are similar to FY-83; so far, 145 burros have been captured along the Colorado River and 25 from the Black Mountains. They hope to remove another 25-35 burros from the "Arizona Strip" area which is estimated to contain approximately 200 burros (population estimation technique unknown).

Since the start of their burro program in 1977, BLM has removed almost 4,000 burros. They estimate that another 2,500-3,000 burros need to be removed in order to reach their management goals; BLM estimates that this may require upwards of 5 years to accomplish at current funding levels.

NEVADA

Last spring, BLM removed 357 burros out of a herd estimated to be at 486 head (population estimation technique unknown). Standard capture techniques — helicopter roundup, wranglers, and water traps — were employed in an area some 40 miles south of Hawthorne. No bighorn - burrolhorse conflicts are known to exist within the State.

NEW MEXICO

The NPS reports that burros no longer inhabit Bandelier National Monument. New Mexico Department of Game and Fish reports that a couple of small groups of burros are known to exist elsewhere within the State; their removal is being planned.

CALIFORNIA

During FY-84, BLM plans to remove 500 burros from their lands; 241 have been captured to date. Removal efforts are being concentrated on the areas surrounding Death Valley National Monument and China Lake Naval Weapons Center (NWC). A census of the Colorado River area is also planned for this year with additional removals anticipated for next year. BLM is anticipating reaching their herd management goal of 1,200-1,300 burros within the California Desert Conservation Area by end of FY-85. Due to the nearness of the initial removal program, BLM is now starting to prepare individual herd management plans; 5 have been scheduled for completion this year.

Death Valley National Monument started its 3-year program on 15 October 1983. Capture operations have been greatly facilitated due to a bill passed last year which now allows the NPS to use helicopters for rounding up burros. As of 29 March 1984, the end of the first year's roundup activity, 2,092 burros have been captured and removed; 2,051 of these came from the Butte Valley area alone. It should be noted that the 1982 aerial census counted 2,500 burros for the entire Monument. Burro removals from the southwestern portion of the Monument are almost complete. This amounts to approximately one-fifth of the total burro range in Death Valley. Trapping at water holes will take place this summer in the Black Mountains.

Originally, a consortium of animal protection groups was to take all of the burros. They have been unable to adopt out several hundred animals, and their holding facilities are full. The animal protection groups tried to get the NPS to stop catching burros and accused the NPS of capturing more burros than they said they were going to catch. The NPS continued to capture burros. Animals unclaimed by the protection groups were taken to Lancaster, Barstow, and Bakersfield, and auctioned in lots of up to 5 burros each. It is costing the NPS $26 per burro to auction them off (excluding feed costs); auction prices are between $12 and $60 each, thus keeping the auction phase of the operation in the black. A contract to build the top priority fencing project identified in the EIS, 32 miles in the northeast corner of the Monument, has been let.

A small herd of burros continues to move on and off the Joshua Tree National Monument. NPS is currently developing a plan of action for dealing with this herd.

In 1983, the Navy completed its long-term burro removal program at NWC. Between January 1980 and September 1983, the Navy removed 5,900 burros from NWC lands. Starting last fall, the program has shifted to the annual maintenance phase. This part of the program will remove stragglers as well as burros moving in from adjoining BLM and NPS lands. BLM wranglers rounded up 299 burros this year. It is estimated that 70% of these migrated in from adjoining lands. The current burro population inhabiting NWC is estimated to be less than 400 (helicopter census); less than 15 are believed to occupy the Eagle Crag Mountains.

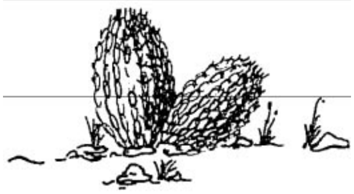
The Navy is still working on getting legislation passed to allow the use of helicopters during roundup operations. NWC will also be preparing a comprehensive grazing management plan addressing the presence of horses, cattle grazing, mule deer, and further bighorn sheep reintroductions.

The California Department of Fish and Game reports that bighorn sheep reintroductions into the Eagle Crag and Whipple Mountains were made possible due to the Navy's and BLM's burro removals.

A summary of burro removals in the Southwest from 1981 to date shows that a minimum of 12,666 burros have been removed by various land managing agencies. By year, removals have been as follows: 1981 - 3,654; 1982 - 1,943; 1983 - 4,329; and 1984 - 2,743.

FERAL HORSES

BLM continues to capture feral horses in northeastern California. The goal for FY-84 is 800; 221 have been captured to date. The feral horse herd at NWC is currently estimated (helicopter census) at 1,200. Census counts in 1983 yielded 954 head being sighted with a 20% annual growth date. A ground capture is planned for this year with 500 head as the goal.



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*Approved by Council at 1966 Annual Meeting, amended April 6, 1967.