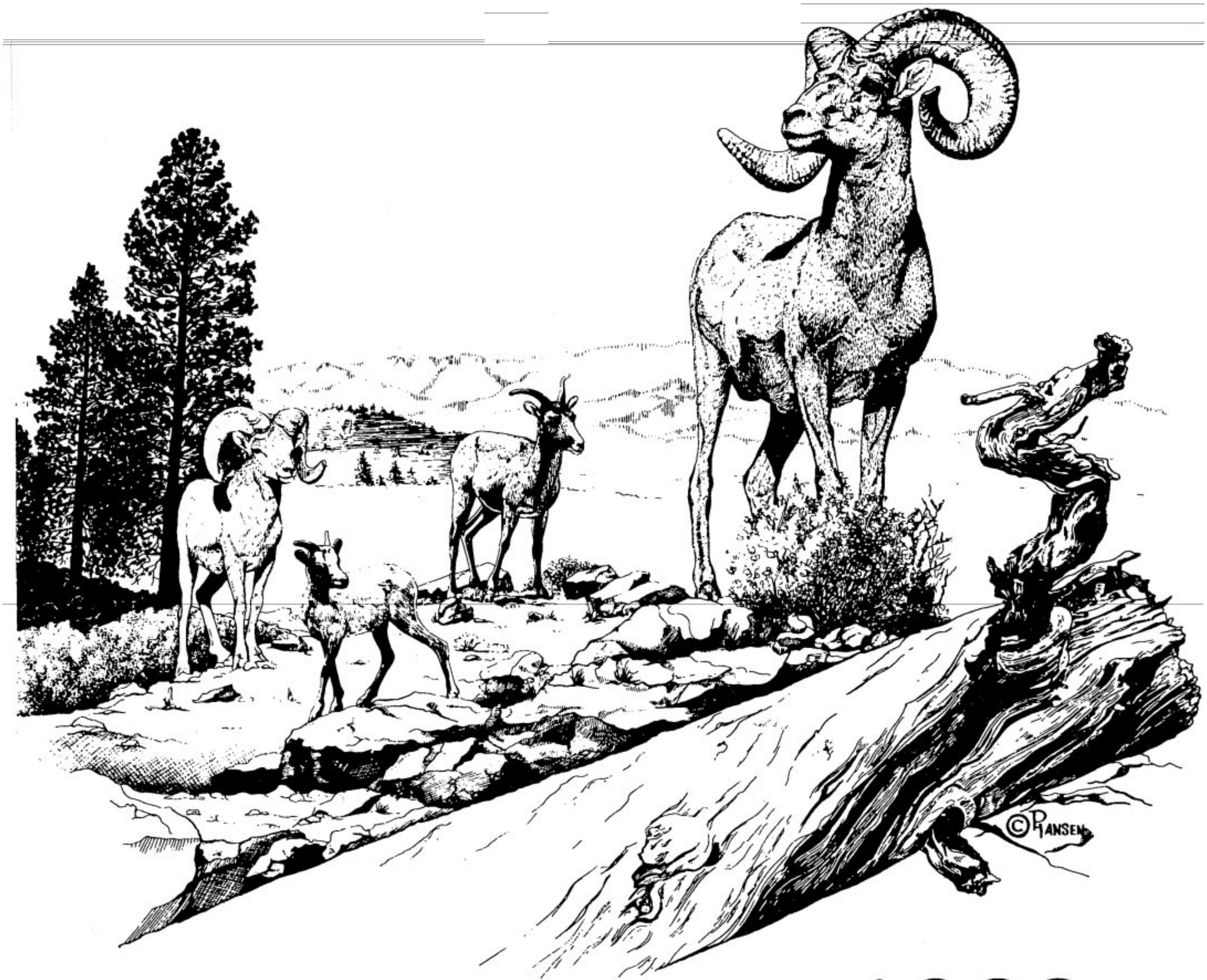
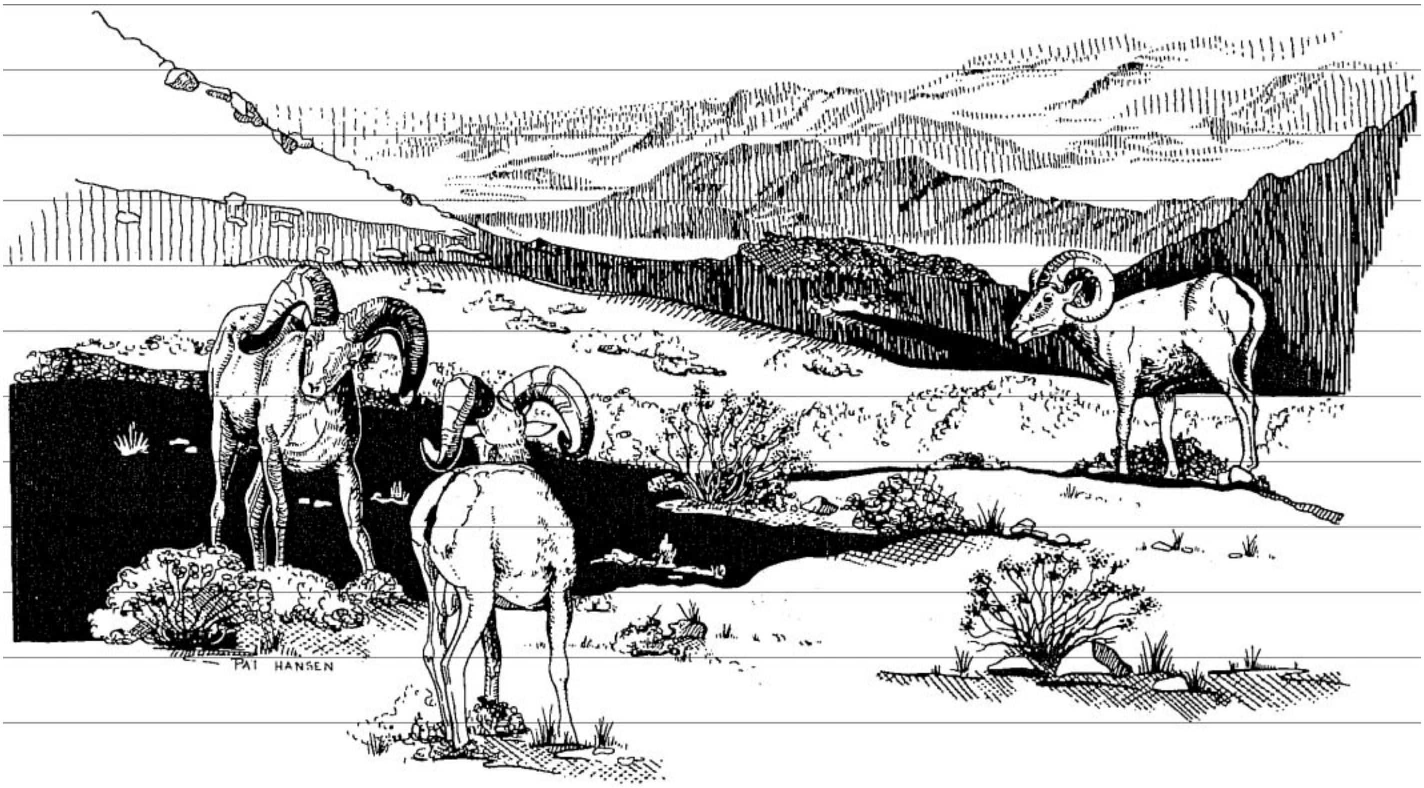
DESERT BIGHORN COUNCIL



1983 TRANSACTIONS

Desert Bighorn Council 1983 Transactions

A Compilation of Papers Presented At the 27th Annual Meeting, April 6-8, 1983, Silver City, New Mexico



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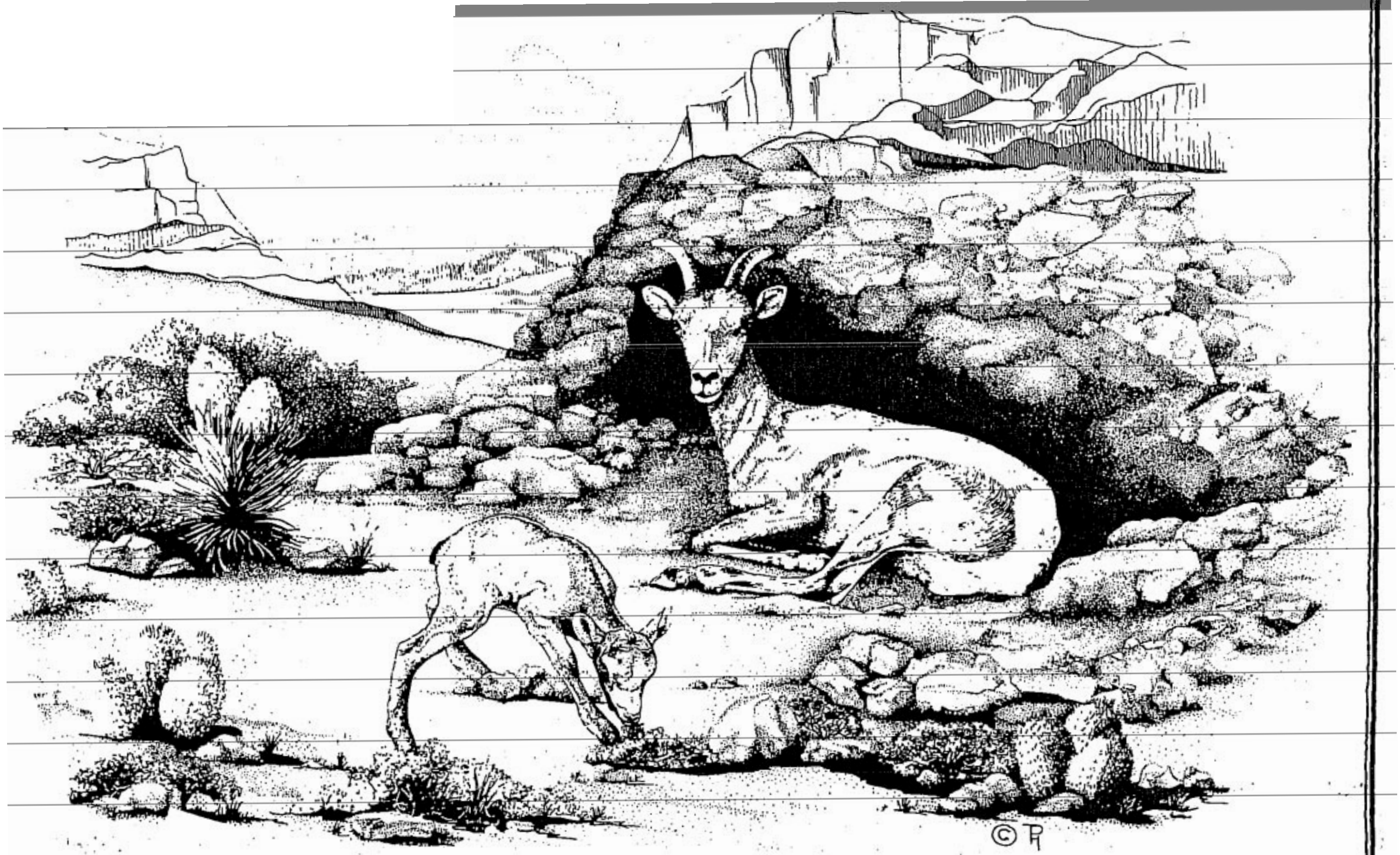

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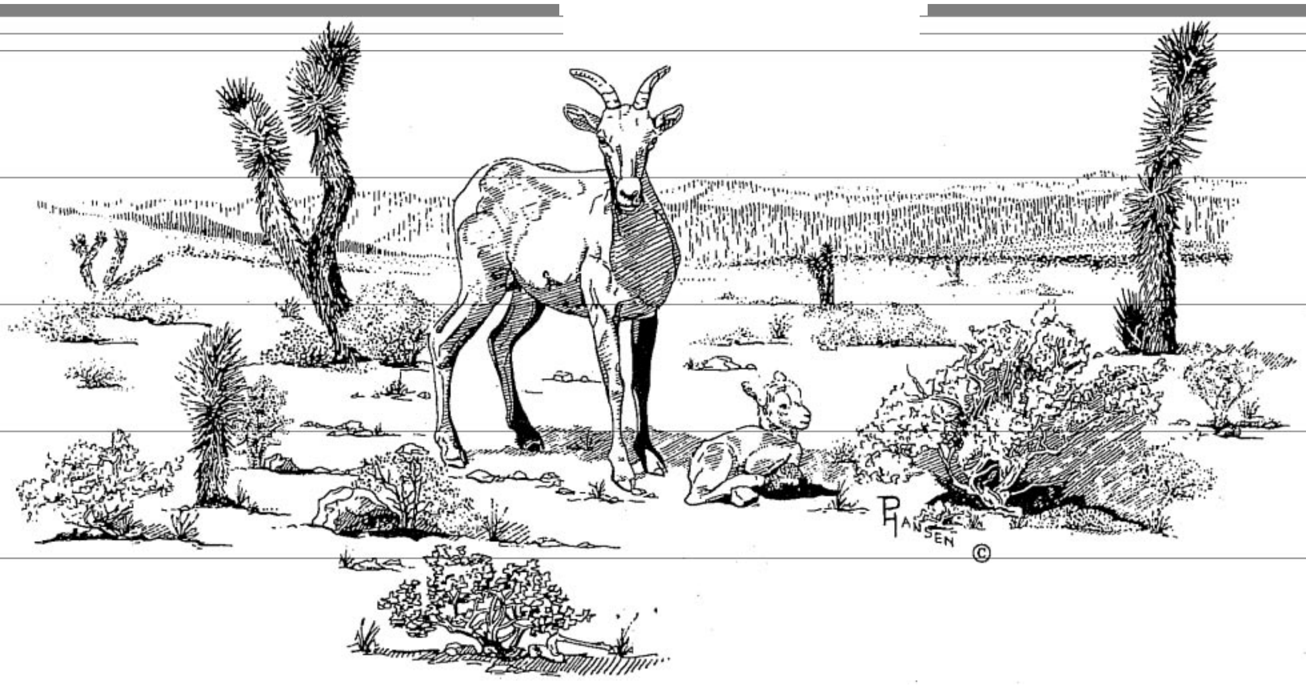
DESERT BIGHORN COUNCIL MEETINGS AND OFFICERS
1957-1983 ANNUAL MEETINGS

Year	Location	Chairman	Secretary-Treasurer
1957	Las Vegas, Nevada	M. Clair Aldous	
1958	Yuma, Arizona	Gale Monson and Warren Kelly	
1959	Death Valley, California	M. Clair Aldous	Fred Jones
1960	Las Cruces, New Mexico	Warren Kelly	Fred Jones
1961	Hermosillo, Sonora, Mexico	Jon Van Den Akker	Ralph Welles
1962	Grand Canyon, Arizona	James Blaisdell	Charles Hansen
1963	Las Vegas, Nevada	Al Ray Jonez	Charles Hansen
1964	Mexicali, Baja Calif., Mexico	Rudolfo Hernandez Corzo	Charles Hansen
1965	Redlands, California	John D. Goodman	John P. Russo
1966	Silver City, New Mexico	Cecil Kennedy	John P. Russo
1967	Kingman, Arizona	Calud Lard	John P. Russo
1968	Las Vegas, Nevada	Ray Brechbill	John P. Russo
1969	Monticello, Utah	Ralph and Buddy Welles	W. Glen Bradley
1970	Bishop, California	William Graf	W. Glen Bradley
1971	Santa Fe, New Mexico	Richard Weaver	Tillie Barling
1972	Tucson, Arizona	George W. Welsh	Doris Weaver
1973	Hawthorne, Nevada	Warren Kelly	Doris Weaver
1974	Moab, Utah	Carl Mahon	Lanny Wilson
1975	Indio, California	Bonnar Blong	Lanny Wilson
1976	Bahia Kino, Mexico	Mario Luis Cossio	Lanny Wilson
1977	Las Cruces, New Mexico	Jerry Gates	Peter Sanchez
1978	Kingman, Arizona	Kelly Neal	Peter Sanchez
1979	Boulder City, Nevada	Bob McQuivey	Peter Sanchez
1980	St. George, Utah	Carl Mahon	Peter Sanchez
1981	Kerrville, Texas	Jack Kilpatric	Peter Sanchez
1982	Borrego Springs, California	Mark Jorgensen	Rich Brigham
1983	Silver City, New Mexico	Andrew Sandoval	Rick Brigham



Bighorn *Illustrations* by Pat Hansen

Typesetting & Layout by Carolyn *Buswell* & Denise Rodriguez

DESERT BIGHORN COUNCIL AWARD RECIPIENTS

BIGHORN TROPHY:

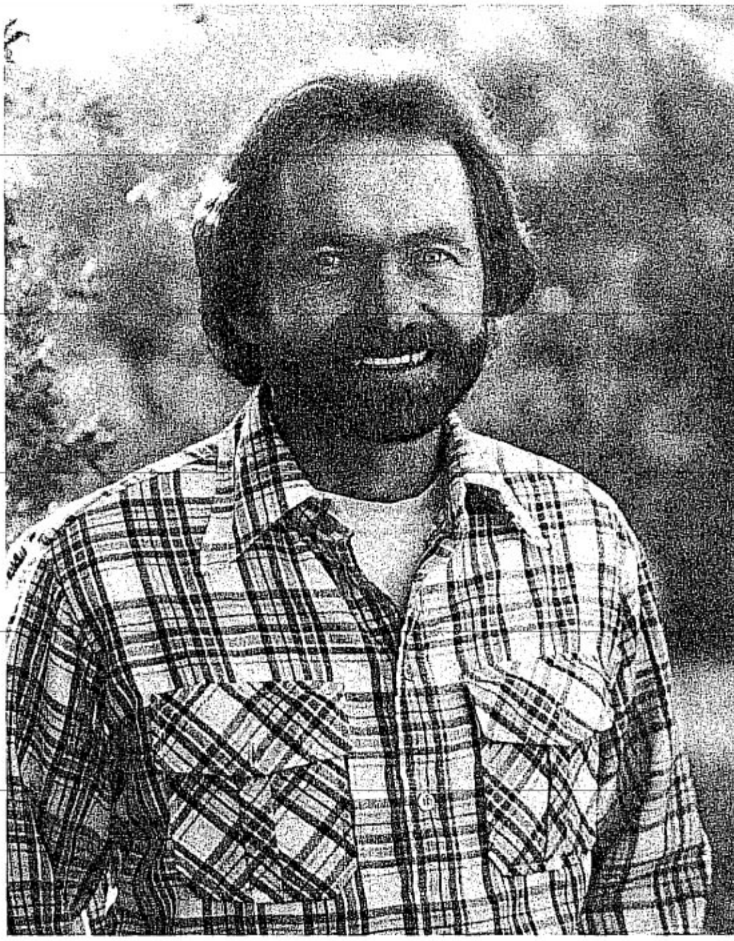
1960	Ralph and Florence Welles, U.S. National Park Service, Death Valley California
1962	Oscar V. Deming, U.S., Bureau Sport Fisheries and Wildlife, Lakeview, Oregon
1965	John P. Russo, Arizona Game and Fish Department, Phoenix, Arizona
1966	Charles Hansen, U.S. Bureau Sport Fisheries and Wildlife, Las 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

HONOR PLAQUE:

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:

1975	Gale Monson, Desert Museum, Tucson, Arizona; Lowell Sumner, Glenwood, New Mexico



— In Memoriam —
RICK F. SEEGMILLER, 1951-1983

Rick Seegmiller was born in Salt Lake City, Utah on 27 February 1951. He moved to Arizona in his childhood and developed a deep appreciation for wildlife through his family's interest in outdoor activities. Rick received an A.A. degree from Mesa Community College in 1971, a B.S. degree with distinction in wildlife biology from Arizona State University in 1974, and an M.S. degree in zoology from A.S.U. in 1977. His research activities up to that point involved mountain sheep and burros along the Bill Williams River. His results were published in the Desert Bighorn Council Transactions, North American Wild Sheep Conference Transactions and in the Wildlife Monograph series.

Rick continued his wildlife studies as a research assistant at Texas Tech University and the University of Washington from 1978-1980. Rick understood the importance of wildlife related experience to his overall education and maximized his opportunities by working for the Arizona Game and Fish Department as a hatchery assistant and wildlife specialist; Dames and Moore Environmental Consultants, as a botanist; the U.S. Forest Service as a wildlife contractor and range conservationist; and as a wildlife biologist for the U.S. Bureau of Land Management's California Desert Planning Staff, and the Yakima Indian Nation, Washington.

Rick returned to Arizona in 1981 to begin work on his Ph.D. degree in wildlife ecology at the University of Arizona. His studies encompassed mountain sheep, burros and deer. He had completed all required course work and successfully completed the written and oral examination for this degree in a superior manner. Rick was a true scholar and demonstrated knowledge of wildlife ecology to such a degree that he was welcomed as a professional and academic colleague. His reputation goes far beyond the University of Arizona; he is well known throughout the West as an accomplished wildlife ecologist. He was a member of The Wildlife Society, Society for Range Management, Ecological Society of America, American Society of Mammalogists and the American Society of Naturalists.

Rick was on the last leg of his field studies when he was killed. He died in a plane crash' 6 February 1983 while locating radio-collared bighorn in the rugged Harquahala Mountains of western Arizona. He died doing the thing he enjoyed so well: studying animals he dedicated his life to understand. Rick left this desert "where rainbows wait for water" way too soon but he left all who knew him with good memories, a model of high ideals and a richness we will miss. He is survived by his parents and loving family.

The Rick F. Seegmiller Scholarship has been established in the School of Renewable Natural Resources, University of Arizona to recognize the excellence in graduate studies that Rick exemplified.

Paul R. Krausman and John R. Morgart, Wildlife, Fisheries and Recreation Resources Division, School of Renewable Natural Resources, University of Arizona, Tucson, AZ 85721.

INTERMOUNTAIN MOVEMENTS BY A DESERT BIGHORN RAM IN WESTERN ARIZONA

Mark H. Cochran and E. Linwood Smith
E. Linwood Smith and Associates, Tucson, AZ

Abstract. From 26 July to 23 August 1982 a 6.5 year old desert bighorn ram (Ovis canadensis mexicana) traveled between the Little Horn, New Water, Eagle Tail, Gila Bend and Tank Mountains of western Arizona. He traveled a minimum of 154.1 km, averaging 5.5 km/day. His movements required crossing large tracts of level terrain of up to 17.5 km. These movements coincided with the breeding season and summer rains.

INTRODUCTION

In late summer 1982 a radio-collared desert bighorn ram (861) made an unusual series of intermountain movements, traveling between 5 mountain ranges in western Arizona. He was a 6.5 year old Class III ram (Geist 1971). The intermountain movements of 861 are presented here because they required crossing tracts of level terrain of a greater distance than those previously reported for desert bighorn (Welles and Welles 1961, Simmons 1980, Witham and Smith 1979). Also, this is the first documented movement of bighorn between the New Water, Eagle Tail, Gila Bend and Tank Mountains.

The movements of 861 were being monitored as part of a study on desert bighorn sheep being conducted on the Kofa National Wildlife Refuge. The study is being funded by the Southern California Edison and Arizona Public Service utility companies. The primary purpose of the study is to assess the effect of the Palo Verde to Devers transmission line on the desert bighorn in the area.

STUDY AREA AND METHODS

The major mountain masses encompassed by 861's movements are located in southern La Paz, northern Yuma, and eastern Maricopa counties of southwestern Arizona. The mountain ranges in this area support a large population of desert bighorn (Monson 1980). The mountain habitats are typified by precipitous and undulating terrain separated by flat valley bottoms. Vegetation of the study area consists of plant associations that are characteristic of Arizona Upland and Lower Colorado Valley Subdivisions of the Sonoran Desert (Turner and Brown 1982). The predominant plant associations are foothill paloverde-cacti *(Cercicium microphyllum-Opuntia* spp.), generally located on rocky slopes, and creosotebush-white bursage (Larrea tridentata-Ambrosiadumosa) which occurs in the valley bottoms and is broadly ecotonal with the paloverde-cacti associations on slopes.

We located ram 861 4 times from the air between 26 July and 23 August 1982. The aerial locations were made at one week intervals from a Cessna 150 aircraft. In addition, 861 was located and observed from the ground on 9 August. We then measured the minimum distance between locations as well as the minimum distance of level terrain crossed between locations.

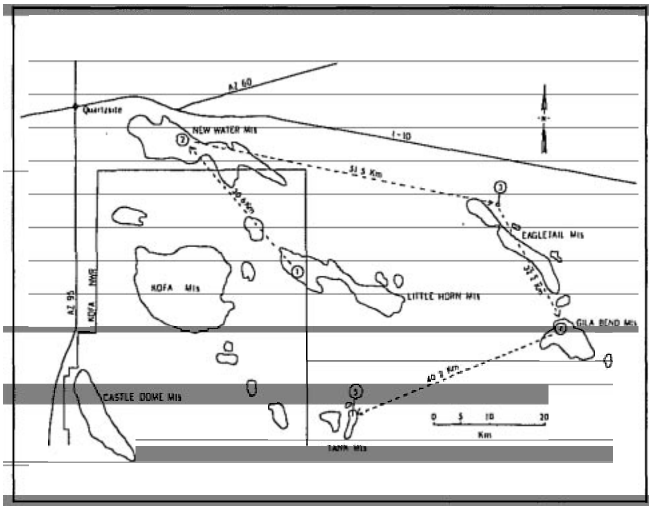


Figure 1. Movements by Ram #861 from 26 July to 23 August 1982. Circled numbers represent relocations on: (1) 26 July, (2) 2 August, (3) 9 August, (4) 16 August, and (5) 23 August. Dashed lines depict the direction of travel with airline distances between successive relocations show in kilometers.

RESULTS

The movements of 861 between 26 July and 23 August 1982 are depicted in Figure 1. During this 28 day period the ram traveled a minimum of 154.1 kilometers, averaging 5.5 kmlday. He is the first radio-collared sheep from this study to enter the Eagle Tail and Gila Bend Mountains.

Ram 861 had spent 11.5 months around Sheep Tank Mine in the western Little Horn Mountains prior to 2 August. On 2 August he was located near Arizona Game and Fish Catchment 518 in the eastern New Water Mountains. He had moved 30.6 km. On 9 August he was located off the northwest corner of the Eagle Tail Mountains 51.5 km to the east. This movement required crossing a minimum of 6.5 km of the Ranegras Plain. Crossing this small section of the plain would have required 861 to travel at least 74 km through the New Water and Little Horn Mountains. On 9 August Cochran observed 861 from the ground. The ram was approximately 7.6 meters above the base of a low hill (ca 38 m from base to top) on the Ranegras Plain, about 4 km north of the Eagle Tail Mountains.

On 16 August 861 was located at the base of the Gila Bend Mountains, approximately 4 km northeast of Columbus Peak. This movement of 32.2 km from the Eagle Tail to the Gila Bend Mountains required crossing a minimum of 8.5 km of open desert. On 23 August the ram was located in the Tank Mountains approximately 4 km northeast of Flat Top Butte. This movement of 40.2 km required crossing at least 17.5 km of the broad Palomas Plain.

Ram 861 was last located on 23 August 1982. We have concluded that his radio transmitter failed.

DISCUSSION

The timing of intermountain movements by 861 coincided with summer rains in July and August as well as the peak of the breeding season (Russo 1956). These two factors probably influenced 861's movements. Summer rainfall reduces desert bighorn dependence on perennial water sources and allows bighorn to expand their range (Simmons 1980). Since 861's movements occurred during the rut, he may have been seeking breeding opportunities.

Perhaps the most significant aspect of 861's movements are the long distances he had to travel across level terrain. Several authors have reported intermountain movements by desert bighorn (Russo 1956, Witham and Smith 1979, McQuivey 1978, and Simmons 1980). The longest reported movement across open terrain was 10 km as reported by Simmons (1980) on the Cabeza Prieta Wildlife Refuge. Movement by 861 between the Gila Bend and Tank Mountains is the longest (17.5 km) crossing of level terrain documented in the course of this study. At this time we feel crossings of this magnitude are uncommon.

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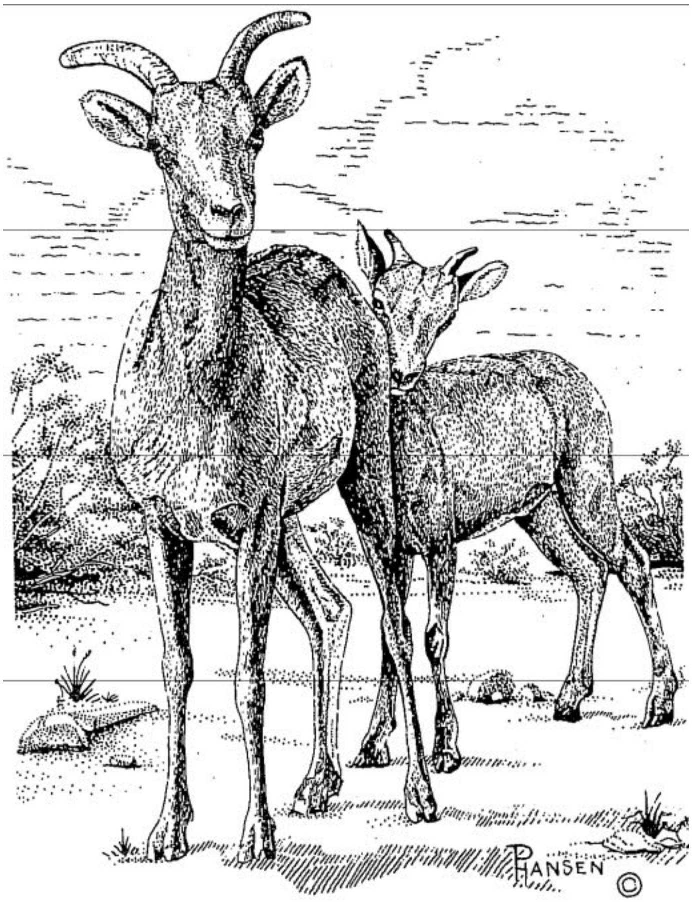

MOVEMENT AND HABITAT USE OF DESERT BIGHORN SHEEP 'IN SOUTHERN NEVADA - PRELIMINARY REPORT

William P. Burger
Humboldt State University
Arcata, CA 95521

Bruce L. Zeller
U.S. Fish and Wildlife Service
Las Vegas, NV 89108

Earl M. Kisler
U.S. Fish and Wildlife Service
Las Vegas, NV 89108

Abstract: Ten desert bighorn sheep Ovis canadensis *nelsoni)* were captured and released in the Las Vegas Mountains of Clark County, Nevada during July and August, 1982. Six adults were fitted with radio transmitters and three of four lambs were marked with highly visible Flock ear tags. Through November 1982, 79 relocations had been made on the radio collared sheep. This preliminary data indicated four ewe's home ranges to average 22.1 km². One ram had a home range of 99.6 km² over the four month period. Detailed habitat information is lacking at this time; however, there is extensive home range overlap, perhaps suggesting more preferable areas. The two sheep collared at Wamp Spring have shown a strong affinity for a burned area 8.8 km southeast of the spring.

INTRODUCTION

Desert National Wildlife Range (DNWR) contains about one-third of the desert bighorn sheep in Nevada (McQuivey 1978), yet information pertaining to bighorn movement and habitat utilization on DNWR is limited. Most available information is the result of studies conducted by Fish and Wildlife Service (FWS) biologists Demming and Hansen without the aid of radio telemetry or aircraft. The results of bighorn telemetry studies in the River Mountains (Leslie and Douglas 1979), are not entirely applicable to DNWR's populations because of dissimilarities in the habitat. Other desert bighorn telemetry studies in Nevada have dealt with transplanted populations. (McQuivey and Pulliam 1981); therefore, the findings are likely to differ from studies conducted on indigenous populations such as those at DNWR.

In 1978 the Nevada Department of Wildlife (NDOW) and the FWS entered into a cooperative agreement to trap desert bighorn sheep at DNWR. Prior to 1982 the primary purpose of trapping was to supply NDOW with desert bighorn for reintroduction into unoccupied, historical habitat. In 1982 trapping was conducted solely to mark and release sheep for later relocation and identification; operations were concentrated at Wamp Spring and Quail Spring in the Las Vegas Mountains. This study was initiated by the FWS in order to document the potential impacts of projects proposed for lands adjacent to DNWR.

The first author (W.P.B.) would like to thank the FWS for provision of housing, a vehicle, and equipment for use while in the field. The personnel at DNWR have been extremely helpful with advice, technical support, and field work. Special thanks goes to Carma Franz, a volunteer assisting in data collection. The roles of the U.S.

Air Force (USAF) and the NDOW are especially appreciated. Dr. Richard Golightly of Humboldt State University is thanked for his advice and support. Numerous others have assisted in various ways; thanks also goes to them.

METHODS

Three desert bighorn (an adult ewe, a lamb, and a three year old ram) were captured, marked, and released at Wamp Spring in July 1982. Captures were made using a drop gate panel trap. The lamb appeared to have a neck injury and was transported to the Black Mountain Animal Hospital in Henderson, Nevada for x-rays. The x-rays revealed no physical damage; consequently, the lamb was returned to Wamp Spring and released two days after capture.

Seven bighorn (4 adult ewes and 3 lambs) were captured at Quail Spring in August 1982. The adults and 2 of the 3 lambs were marked prior to release. Captures were made using a drop net trap belonging to NDOW; several earlier capture attempts using a rocket net trap were unsuccessful.

Radio transmitter collars supplied by Telonics (Mesa, Arizona) were placed on all 6 adults captured. Color-coded, numbered T-locks were attached to the ears of three lambs, and to the radio collars of adults captured at Wamp Spring. Aluminum strap ear tags were placed on all the marked sheep.

Plans for 1983 include capturing and radio collaring one ram on the Las Vegas Range and an additional six adults on the neighboring Sheep Range.

USAF HU-1 helicopters are used in aerial relocations of the collared bighorn. Although DNWR's requests for flight time are given lower priority than military missions, a minimum of one flight per month was flown during August through November 1982.

Efforts to relocate the radio collared bighorn from the ground were enhanced in October 1982 when W.P.B. adapted the original study proposal to fit his needs as a M.S. candidate. This author has voluntarily assumed the responsibility of gathering habitat information; expanding the duration and frequency of visual observations; and recording, analyzing, and compiling the data in a final report or master's thesis.

RESULTS

The findings presented in this report are based on data collected from August through November 1982. Field work is continuing and further results will be presented in a later report.

The lamb marked at Wamp Spring, for which release was postponed two days due to suspected injury, has been relocated twice. Both observations were made 11 plus km east of the capture site.

One of the ewes marked at Quail Spring died shortly after release. The carcass was located 0.8 km northwest of the capture site during the first follow-up flight nine days post release. Though a necropsy was not performed, this mortality is presumed to have resulted from stress associated with capture and marking operations.

Prior to October 1982, 12 relocations were obtained on the 5 radio collared sheep. Six of the relocations included visual observations and each of the sheep was located at least once.

During October and November the 5 sheep were relocated a total of 67 times. Three of the sheep were located on 12 different days, one on 14 days, and one on 17 days. Sixty-four percent of the location efforts included visual observations. Table 1 summarizes the relocation data.

Preliminary home ranges were established by connecting the outermost relocation points for each collared sheep. From the day of capture (which varied from 19 July to 10 August) until the end of November, the ewe's ranges averaged 21.1 km^2 (s.e. = 1.33) and the ram's range was 99.6 km^2. The maximum linear distance within the home ranges was 13.4 km for the ram and 4.0 for the ewes. Interestingly, both of these maximum distances correspond to the distance from the capture site to one of the other locations in the home range.

Table **1.** Summary of Relocation Data for Radio Collared Desert Bighorn Sheep in the Las Vegas Mountains, Aug. to Nov., **1982.**

Animal #	Sex	# of Days Relocated	Home Range Size **(km^2)**	Greatest Linear Distance Between **2** Relocations **(km)**
700	F	15	22.5	14.0
710	M	14	99.6	13.4
720	F	13	17.7	12.0
730	F	17	23.8	12.0
750	F	20	20.5	12.0

DISCUSSION

Although the habitat evaluation of the Las Vegas Range is not far enough along to attempt to relate habitat to sheep use, some interesting observations may be made by examining relocation distribution.

The three ewes marked at Quail Spring exhibit very similar home ranges; two of the ranges are almost entirely within the third. This cannot simply be attributed to group cohesion; only twice were all three ewes seen together, once being at the time of capture. However, groups including two collared ewes were fairly common. Ewe 720 was with at least one other collared ewe in 12 of 13 observations; ewe 750 was with another collared ewe in 10 of 13 observations; and ewe 730 was with another collared ewe in 4 of 13 observations. The area utilized extends to the north and west of Quail Spring along several major ridges. None of the sheep were located to the south or east of the spring.

The two sheep collared at Wamp Spring also exhibit largely overlapping ranges. Ewe 700's range was 91% within 710's, a three year old ram. Again, the capture site was on the periphery of the ranges; both sheep used an area southeast of the spring. Although spending much of their time in the same area, 700 and 710 have never been seen together. These sheep show a strong affinity to a recently burned area 8.8 km southeast of Wamp Spring. The ram's range encompassed 99.6 km^2, with 7 of 14 relocations within a .72 km^2 area by the burn. For the ewe, 11 of 15 relocations were within a 1.4 km^2 area in the burn, while her range totaled 22.5 km^2. An abundance of herbaceous growth and nearby steep terrain seemed to offer ideal bighorn habitat in the burned area.

Ground work on the collared sheep will intensify again in April 1983, and continue through March 1984. During this period all radio collared sheep, which should number 12 by late in the summer of 1983, will be monitored. Seasonal movements and ranges will be determined. Daily movements and habitat use will also be examined. Habitat evaluation will continue, using a grid system to break the area into "habitat blocks." The elevation, aspect, and slope for each block is being derived from topographical maps Vegetation analysis is also planned Scat will be collected in hopes that funding will become available for its analysis

It should be noted that the information presented in this report is based on preliminary data. Sample sizes are limited and results could change as research continues

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PRELIMINARY REPORT ON DESERT BIGHORN MOVEMENTS ON PUBLIC LANDS IN SOUTHEASTERN UTAH

Michael M. King
Gar W. Workman
Department of Fisheries and Wildlife
Utah State University, Logan, UT 84322

Abstract. Utah State University has been conducting a long term study of the ecology of desert bighorn sheep on public lands administered by the Bureau of Land Management in southeastern Utah since February 1981. Generalized trends with respect to home range size, movement patterns, and use of critical areas (lambing and breeding areas, movement corridors) over a 2 year period are reported.

INTRODUCTION

Desert bighorn sheep (Ovis canadensis *nelsoni)* inhabit the rugged desert and canyons of southeastern Utah. Historical conflicts that resulted from increased human activities in those remote areas include livestock competition and disease, mining, and illegal hunting (Wilson 1968, Follows 1969, Irvine 1969, Bates et al. 1975, Bates 1982). Recently the potential for increased interactions between man and sheep in southeastern Utah has grown. The development of Utah Highway 95 in 1976 increased human accessibility into bighorn habitat. In addition, the demand for livestock grazing, recreation, and mineral development continues to expand.

Because of these potential conflicts, the Bureau of Land Management (BLM) contracted Utah State University in 1980 to begin a long term study of the ecology of desert bighorn sheep on BLM administered lands in southeastern Utah. Study objectives include determination of home range size, movement patterns and critical use areas (lambing and breeding areas, movement corridors). The purpose of this paper is to present preliminary findings and to discuss their significance as they relate to potential conflicts with man. The study period covered extends from February 1981 to February 1983.

Special thanks go to BLM and Utah Division of Wildlife Resources (UDWR) personnel for their participation and financial support. Without their assistance, success of the project would not be possible.

STUDY AREA AND METHODS

The study area (approximately 1935 km²) is located immediately south of Canyonlands National Park and west of Natural Bridges National Monument, Utah (Fig. 1). The area is characterized by deep canyons, broken valley floors, precipitous talus slopes, and high mesas. Elevations range from 1100 m on the banks of the Colorado River and Lake Powell that border the study area on the west to 2130 m on the higher mesa tops.

Major vegetation types in the area include: 1) Blackbrush (Coleogyne *ramosissima)*-Galleta Grass *(Hilaria jamesii)* in valleys and on gentle slopes and benches, 2) Shadscale *(Atriplex confertifolia)*-Galleta Grass-Ephedra (Ephedra sp.) common on east and south facing slopes and benches, 3) Pinyon Pine *(Pinus edulis)*-Juniper *(Juniperous osteosperma)* primarily on mesa tops and rims, and 4) Salina Wild Rye *(Elymus salinus)*-Galleta Grass on north and west facing slopes and benches.

Twenty-four sheep were radio-collared (Telonics Inc., Mesa, AZ) over a 2 year period (February 1981-February 1983). Sheep (n = 12) were captured and collared in 1981 and 1982 by darting sheep with M-99 from a Hughes 500 D helicopter. In 1983 sheep (n = 12) were hazed into tangle nets by a helicopter, collared and released.

Sheep are located monthly from a UDWR fixed-wing aircraft and an average of once monthly from the ground at which time the sheep are observed directly. Home range sizes were calculated using the minimum area method (Mohr 1947). Peripheral locations of sheep were connected to form polygons that enclosed the area known to be used by radio-collared sheep.

RESULTS AND DISCUSSION

Two years' data have been collected on 6 sheep (4 young rams, 2 mature ewes). An additional year of data have been collected for 5 mature ewes and a 3½ year old ram (Table 1).

Average home range size is greater for rams (52.3 km², range: 23.2 km²-105.8 km², n = 5) than for ewes (23.6 km², range: 18.1 km²-38.7 km², n = 7). Figures 1 and 2 illustrate home range locations for radio-collared sheep on the study area. Bates et al. (1975) in Utah and Leslie (1977) in Nevada reported similar home range sizes for desert sheep.

Annual ewe movements were more restricted than ram movements. Ewes did not exhibit distinct migration routes nor occupy several distinct seasonal ranges as do Rocky Mountain bighorn *(O. c.* canadensis) described by Geist (1971:62). They do, however, exhibit seasonally directional movement across one large home range area. Directional movement generally occurs in April and May as ewes move towards lambing areas. Two collared ewes moved to the same canyon during 2 consecutive lambing seasons. Although neither ewe had a lamb the second year, other ewes from their groups did have lambs in those same areas. This indicates that those areas were still being used for lambing activity.

In addition, directional movement may occur when ewes move onto breeding areas. The same 2 collared ewes moved from different areas to the same general area for 2 consecutive breeding seasons. Movements at other times during the year did not appear to follow any distinguishable pattern.

Seasonal movements were only observed among rams (n = 10) during pre- and post-rut periods. Rams generally began movement to breeding areas in October. Throughout the breeding season, rams moved through various groups of sheep while searching for estrous ewes. In each of 2 consecutive years, 9 rams were known to return to exact locations and spend a majority of the breeding season with the same group of ewes. Breeding range fidelity of rams has been described for Rocky Mountain bighorn by Geist (1971:79).

Fidelity trends of ewes to lambing areas and rams to breeding areas are important to wildlife and land managers. Knowledge of consistent use of these "critical" areas by bighorn can allow managers to exclude critical areas from development or at least schedule potentially stressful activities during times when sheep are not using the areas.

Twelve major movement corridors have been located during the study (Fig. 3). Of particular interest is the movement of sheep between Found Mesa, Fry Point and Lone Butte. Within this 140 km² area (see Fig. 3) land use practices that are potentially conflicting with sheep movements including oil and gas exploration, mining activities, livestock operations and vehicular traffic on Utah Highway 95 exist.

Wilson (1968) and Bates et al. (1975) reported that sheep crossed Utah Highway 95 on several occasions. Prior to 1976, the highway was an unimproved dirt road that probably posed little threat to sheep movements. Wilson (1969) expressed concern that improvement of

Utah Highway 95 and subsequent increased traffic levels might restrict or prevent sheep movement across the highway.

In 1976 the highway was paved and now serves as an access route for thousands of vehicles through bighorn habitat annually. Between June 1982 and January 1983 a group of 10 (5 ewes and 5 lambs) crossed the highway a minimum of 6 times. This indicates that increased vehicular traffic has not been sufficient to prevent sheep from crossing the highway since it was paved. This is the first documentation of sheep movement across Utah Highway 95 since improved in 1976.

Sufficient data are not available to evaluate how livestock operations and mineral activities in the area affect sheep movements. However, data will be collected for an additional 2 years to determine how those human activities affect sheep movements in southeastern Utah.

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Table 1. Estimated home range sizes for radio-collared desert bighorn sheep on public lands in southeastern Utah (February 1981-February 1983).

Sex	Sheep Identification	Age (yes)	Number of Locations	Time Period	Home range Size (km²)
Males					
	A	3%	33	Feb 81-Feb 83	31.0
	B	3%	38	Feb 81-Feb 83	64.5
	C	2½	7	Feb 81-Sept 81	23.2
	D	2½	32	Feb 81-Dec 82	105.8
	E	2½	19	Feb 81-Feb 83	36.1
					Average 52.3
Females					
	F	Mature	15	Feb 82-Feb 83	23.2
	G	Mature	37	Feb 81-Feb 83	18 1
	H	Mature	49	Feb 81-Feb 83	25 8
	I	Mature	18	Feb 82-Feb 83	18.1
	J	Mature	26	Feb 82-Feb 83	38 7
	K	Mature	28	Feb 82-Feb 83	20.6
	L	Mature	28	Feb 82-Feb 83	20 6
					Average 23.6

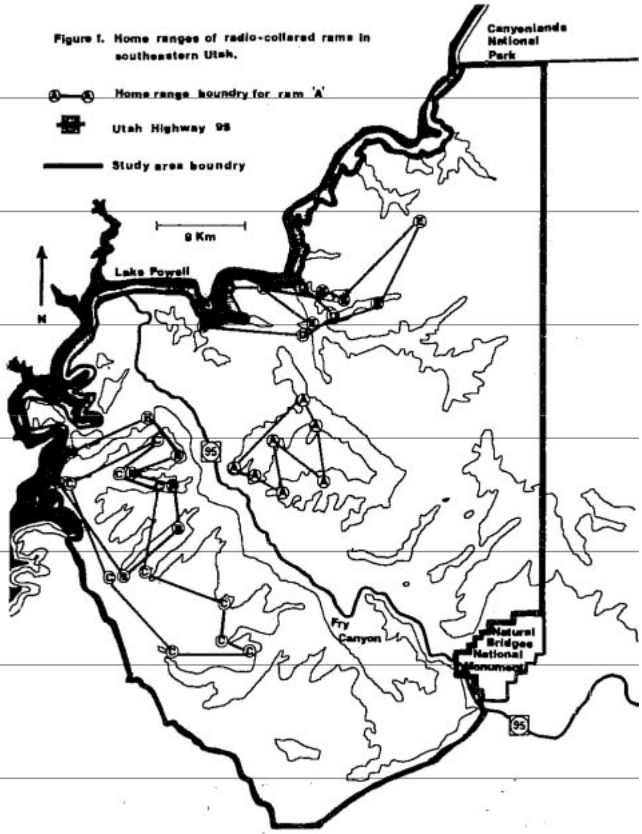


Figure 1. Home ranges of radio-collared rams in southeastern Utah.

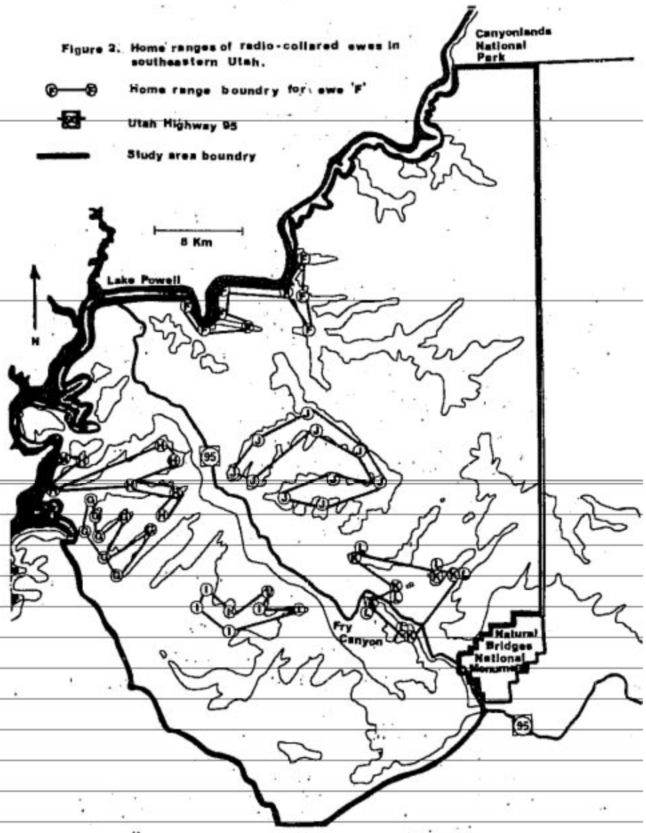


Figure 2. Home ranges of radio-collared ewes in southeastern Utah.

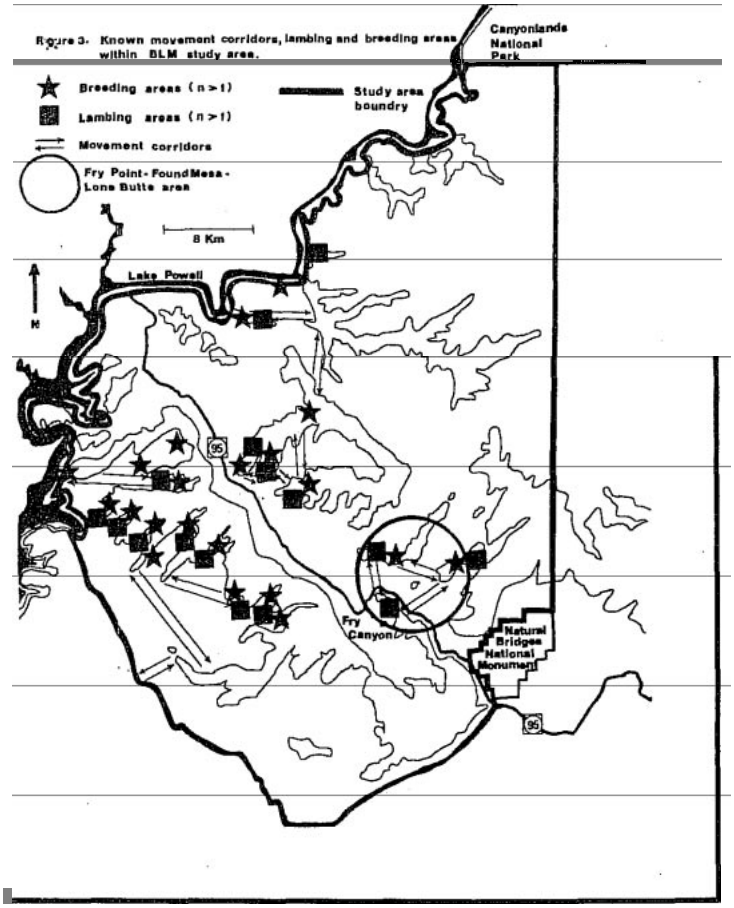
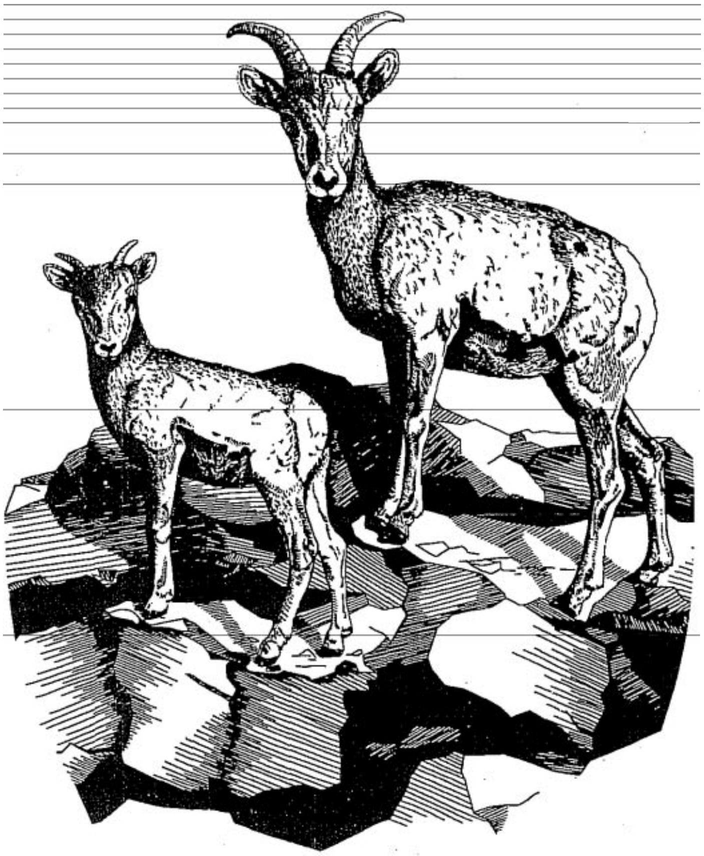


Figure 3. Known movement corridors, lambing and breeding areas within BLM study area.



PSOROPTES OVIS RESEARCH WITH BIGHORN SHEEP IN NEW MEXICO[1]

H.G. Kinzer, Woods E. Houghton, and J.M. Reeves
Department of Entomology and Plant Pathology
New Mexico State University, Las Cruces, NM 88003

Abstract. Studies at New Mexico State University showed that Psoroptes ovis collected from bighorn sheep (Ovis canadensis *mex-icana*) was not infective to domestic rabbit, mule deer (Odocoileus hemionus), audads (Ammotragus lervia) or oryx (Oryx gazella). They were successfully established on domestic cattle and sheep, but only with difficulty. On sheep they died out in a few generations; on cattle the progression of infestation was much slower than with *P. ovis* transferred from cattle to cattle. The investigations suggest that the mites from the bighorn are biologically distinct, that they do not easily adapt to cattle or sheep and, therefore would be unlikely to infest domestic cattle under natural conditions.

Ivermectin administered as a single injection was found to completely eliminate all mites on *P.* ovis infected animals at dosages of 500 and 1000 mglkg (Kinzer et al. 1983). Ivermectin administered by a ballistic implant system was not completely effective in eliminating mites at these dosages, but was 100% effective at the dosage of 1700 mglkg.

Opinions of the investigators on the management of *P.* ovis infected bighorn are included.

INTRODUCTION

During the 1978 fall hunt, all 5 of the desert bighorn rams harvested in the San Andres National Wildlife Refuge (SANWR), New Mexico, were infested with mites. Scabies lesions were present in the rams' ears and/or on their bodies. The causal organism was subsequently reported as Psoroptes ovis (Hering) by Lange et al. (1980). This was the first report of *P.* ovis from Mexican bighorn sheep in New Mexico.

Following the discovery of scabies in bighorn sheep, the animals were observed closely by New Mexico Game and Fish and U.S. Fish and Wildlife Service biologists. The first emaciated sheep were observed in January 1979. Aerial surveys in March and June of that year indicated the total number of sheep on the refuge was less than half that present the previous year and there was no lamb crop observed. A dead ewe with scabies lesions was found in September. Two ewes were tranquilized from a helicopter in October and both were heavily infected with psoroptic scabies. The ears of both ewes were completely plugged with hard, packed concentric rings of dry necrotic tissue and mite exuvia. Scabies lesions were present over much of their bodies.

Observers concluded a major scabies epizootic was underway, that scabies might have been a major contributing factor to the sheep mortality, and emergency control measures were imperative for survival of the San Andres bighorn.

"Operation Sheep Rescue" was initiated in November 1979. The remaining sheep on the refuge that could be located were tranquilized from helicopter, transported to a treatment facility and examined for scabies, blue tongue, contagious ectima, and other diseases, and

[1]Mention of a pesticide does not constitute a recommendation by the State of New Mexico nor does it imply registration under FIFRA as amended.

dipped in 0.5% Toxaphene. Following dip treatment, the sheep were released into a 4.05 ha. enclosure. Fourteen days later they were recaptured and redipped. After the second dip, all were transported to the Red Rock Wildlife area near Red Rock, New Mexico. The purpose of the relocation was to salvage a breeding population that would eventually serve to reintroduce desert bighorn back into the San Andres when that refuge could be made scabies free.

Many unanswered questions with implications for future bighorn sheep management in the San Andres and other scabies infected areas were evident. There was concern about the origin of the infestation, i.e., had these sheep historically co-existed with the mite, despite the fact that they had not been detected previously, or had they become infected from other wild or domestic animals as suggested by Lange et al. (1980). There was also a need to know if the mites from bighorn were transferable to domestic sheep and cattle. In addition, there was need to develop a one-time treatment method that would eliminate all mites from infected sheep. A treatment method, such as a remote delivery injection, would eliminate much of the trauma associated with a capture-treatment method used to salvage the San Andres herd. Injection of wild animals with various substances, particularly tranquilizers, by remote delivery systems has been widely practiced. The missing component in the delivery system for control of Psoroptes in free ranging bighorn was an effective, injectable acaracide. Ivermectin (22-23 dihydroavermectin B_1, an experimental acaracide and anthelminthic manufactured by Merck and Co., Rahway, New Jersey 07065) was known at that time to have efficacy as a single injection against *P.* ovis in domestic cattle (Barth and Sutherland 1980).

Since the 1978 outbreak, research on host specificity of *P.* ovis on bighorn has been conducted at three locations: Colorado State University; The Insects Affecting Animals Laboratory, Kerrville, Texas; and New Mexico State University (NMSU). In addition, new developments in Psoroptes control has been under study at NMSU.

INFECTIVITY OF PSOROPTES *OVIS* FROM BIGHORN SHEEP TO OTHER ANIMALS

Methods

Infectivity of Psoroptes from bighorn to domestic and wild species was studied, by challenging recipient animals with mites collected from infected bighorns maintained at NMSU.

Transfer of Psoroptes from bighorn sheep to domestic rabbits was accomplished by securing pieces of scab that contained viable mites in the ears with paper tape for 24-48 hours. Self-grooming was prevented by use of plastic collars.

Psoroptes transferred from bighorn to mule deer, aoudads and oryx were accomplished by securing pieces of mite infected scab in the ears and on the withers of recipient animals for at least 48 hours. Samples were secured in the ear location by paper tape and on the wither location by forming a tent of hair, held in place by a rubber band, over the mites. Infestations were repeated at least 3 times with each species.

Psoroptes infestations from bighorn to domestic cattle were accomplished as with the wild game species. The cattle were prevented from self grooming for several weeks post-infection by placing them in stanchions. Ability of mites to transfer among these hosts was evaluated at NMSU and at the USDA Laboratory [redacted] Kerrville (Wright et al. 1981).

Transfer of Psoroptes from bighorn to domestic sheep was accomplished by securing mite infested scab in the ears and on the withers of recipient animals. Both stanchioned and unstanchioned animals were used.

RESULTS

Successful establishment of breeding populations of Psoroptes transferred from bighorn to domestic rabbits was easily accomplished at both the USDA Kerrville Laboratory (Wright et al. 1981), at Colorado State University, and at NMSU. Populations in rabbits at NMSU regressed rapidly when the collars were removed, presumably the result of grooming by the rabbits. Thus the domestic rabbit appeared to be an acceptable physiological host for the bighorn Psoroptes, but the rabbit's natural grooming activity makes mite establishment unlikely on uncollared animals.

Routine post-infection examinations failed to reveal reproducing colonies of mites on either mule deer, audads or oryx, indicating that these species are unsuitable physiological hosts for *P.* ovis from bighorn sheep.

Studies at both the USDA Kerrville laboratory and at NMSU showed that Psoroptes from bighorn could be established with difficulty on domestic cattle. Compared with the normal progression seen when *P.* ovis were transferred from cattle to cattle, the infestations from bighorn to cattle progressed at a slow rate. The total mite population was much lower and percentage of adults was low. Both investigations suggested that *P.* ovis from bighorn do not easily adapt to cattle and therefore, would not be likely to transfer to domestic cattle under natural conditions.

Scabies lesions were formed in the ear of one sheep at the Kerrville Laboratory (Wright et al. 1981) following challenges with bighorn scabies; however, the infestation disappeared by 4 weeks post-treatment. NMSU efforts were successful in establishing breeding populations of Psoroptes on domestic sheep, but the populations disappeared during the hot summer months. It was concluded that *P.* ovis from bighorn are unlikely to transfer to domestic sheep under natural conditions.

EVALUATION OF NEW METHODS OF MITE CONTROL

Methods

Control of *P.* ovis in desert bighorn with single injections of ivermectin was evaluated. Six desert bighorn ewes, naturally infected with *P.* ovis, were treated experimentally in December 1979 with intramuscularly injected ivermectin. Two were injected at 500 mglkg, 2 were injected at 1000 ug/kg and 2 remained untreated. Evaluations of effectiveness were made at 7, 14 and 35 days post-treatment,

Control of *P.* ovis with ivermectin injected by remote delivery systems by (3M Company, St. Paul, Minnesota 55165) was also evaluated.

The system utilizes a compressed air-powered gun that fires .22 caliber drug laden "bullets" designed to be absorbed and when injected into the animal. Merck and Co., Inc. furnished ivermectin for loading the "bullets" or implants. Nine bighorn rams were experimentally infected with *P.* ovis from naturally infected bighorn sheep. Two each of the rams were treated at the rate of 500 and 1,000 mglkg, respectively. Routine post-treatment determination of the number of live mites on the treated and untreated sheep were used to establish effectiveness of the treatments.

RESULTS

The laboratory trial with intramuscular injected ivermectim indicated that both the 500 and the 1000 mglkg were completely effective in eliminating *P. ovis* from the treated animals (Kinzer et al. 1983).

Both the 500 and the 1000 mg/kg dosages administered by the ballistic implant system failed to eliminate the mite population from infected sheep. Subsequent tests showed a dosage of 1700 mglkg is required to eliminate all mites from infected sheep by the ballistic implant system. Follow up investigations (unpublished) have indicated absorption of ivermectin from the ballistic implant system was much slower compared with animals treated with an intramuscular injection.

The ballistic implant system has considerable potential for treatment of free ranging bighorn, .as well as other wildlife'species. However, it must be improved befoce it is more'advantageous than injection by conventional impact activated darts. The problem with the ballistic implant system is that the powder formulation of ivermectin presently used to load implants is not concentrated enough to permit a single implant to achieve effective treatment. Also, it is possible that the powder form is not as readily absorbed as the liquid formulation used for injection. We are continuing our efforts to develop technology to adapt the ballistic implant system for efficient treatment of free ranging wildlife species.

IMPLICATIONS OF PSOROPTES INFECTION IN SANWR

Scabies is one of many important factors, (e.g. environmental stress, diet, disease, and predation) that can influence bighorn sheep populations. There is little doubt that scabies has been a primary cause in many of the recent San Andres sheep deaths. In other cases it may have been a factor that predisposed the sheep to predation and disease.

The finding that *P.* ovis from desert bighorn sheep are physiologically distinct from those *P.* ovis from domestic cattle provides strong circumstantial evidence that the *P. ovis* infestation on San Andres bighorn is a historical infestation. The reason for its sudden virulence is unknown. Perhaps a prior stress or rigorous environmental conditions played a part. Nonetheless, the emergence of a particularly virulent strain is suspected.

The *P.* ovis infection continues in the SANWR in 1983. Older sheep that were heavily infected with *P.* ovis, but successfully treated, do not show the severe effects seen at the height of the epizootic in 1979. Offspring from these sheep are likely to be severely affected. For this and other reasons, we suspect treatment of infected sheep provides the relief necessary for the treated animals to survive while they develop an acquired immunity to the virulent strain of *P.* ovis. If this is a correct assumption, it follows that attempts to eradicate all Psoroptes in an infected herd are contraindicated. Most likely Psoroptes mites have co-existed with bighorn for thousands of years. Survival of both has always hinged on a tenuous balance. Sheep in a herd where all mites are eliminated for a long period may lose the resistance mechanisms and upon reinfectation may be devastated. Today's herds are isolated or semi-isolated from other herds, and immigration from healthy herds may not occur as in the past. The bighorn thus must maintain a level of resistance to mites by supporting low level, endemic populations. When virulent strains emerge they must develop resistance to the new strain.

Therefore, treatment should have as its objective the management of the mite population during critical periods rather than eradication which is probably not a realistic goal. Remote treatment of free-ranging bighorn sheep with ivermectin allows sheep the time necessary to build resistance and thus is a potential tool for management of scabies.

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CENSUS OF PSOROPTIC SCABIES IN DESERT BIGHORN SHEEP *(Ovis canadensis nelsoni)* FROM NORTHWESTERN ARIZONA DURING 1979-1982

George W. Welsh
Arizona Game and Fish Department
1420 West Beal Street
Kingman, AZ 86401

Thomas D. Bunch
Dept. of Animal, Dairy and Veterinary Sciences
Utah State University
Logan, UT 84322

Abstract: Psoroptic scabies was monitored in Nelson's desert bighorn (Ovis canadensis nelsoni) sheep in northwestern Arizona from 1979 to 1982. Diagnosis of scabies was based on visual examination of the ear and the detection of Psoroptes ovis in scrapings taken from the ventral surface of the ear. The occurrence of scabies in live-captured sheep was 25%, 25% and 0% for the years 1979, 1980 and 1981, respectively. No sheep were captured in 1982. The occurrence in hunter-harvested rams was 23%, 44%, 7% and 0% for the years 1979, 1980, 1981 and 1982, respectively. Although there were no deaths directly attributed to scabies, there was a population decline in the Black Mountains most likely brought on by a combination of population density, drought and competition from domestic livestock. The scabies outbreak that reached its highest level of occurrence in 1980, apparently has run its course and was not detected in the 1982 survey.

INTRODUCTION

Scabies outbreaks have been documented in bighorn sheep for more than a century (Hansen 1967, Carter 1968, Decker 1970, Lange et al. 1980). However, the effects of psoroptic scabies on populations of bighorn sheep have been obscure. As a consequence, reports vary from scabies causing rapid population declines to no apparent affects at all (Hornaday 1901, Hones and Frost 1941, Packard 1946, Lange et al. 1980). Potential deleterious effects of scabies on a population of desert bighorn sheep was reported in New Mexico (Lange et al. 1980), where an epizootic in the San Andres National Wildlife Refuge occurred concomittantly with a population decline of more than 50 percent.

Psoroptic scabies was observed in the desert bighorn of northwestern Arizona in 1979. The occurrence of scabies in the Arizona population of sheep has been monitored for the last 4 years, with no attempt to minimize its effects by treating the disease or altering management policies. The purpose of this report is to present data on annual prevalence of scabies in this population from 1979-1982 and to compare these rates to census data.

Table 1. Occurrence of psoroptic scabies in Nelson's desert bighorn sheep in the Black Mountains and Lake Mead area of northwestern Arizona.

		Method of surveillance					
		Live-capture		Hunter-harvested		Total	
Area	Year	No. of Sheep	Occurrence (%)	No. of Sheep	Occurrence (%)	No. of Sheep	Occurrence (%)
Black Mtns.	1979	12	25	8	25	20	25
	1980	8	25	10	50	18	39
	1981	22	0	8	12	30	3
	1982	--	--	9	0	9	0
Lake Mead*	1979	--	--	5	20	5	20
	1980	--	--	8	37	8	3
	1981	31	0	6	0	37	0
	1982	2	0	5	0	7	0

-- No sheep sampled.

MATERIALS AND METHODS

Populations of Nelson's desert bighorn were sampled from the Black Mountains and Lake Mead area of northwestern Arizona. Sheep were surveyed by live-capture methods using chemical immobilization with M99 (Etorphine-DM Pharmaceuticals) and from hunter harvested animals. Sheep were physically examined for psoroptic lesions and ear scrapings were taken from the external auditory meatus to the distal end on both ears. Scrapings were examined for mites by staff at either the USDA Livestock Insects Laboratory, U.S. Department of Agriculture, Kerrville, Texas or the Department of Entomology, University of Arizona, Tucson.

An aerial census was taken of the sheep in the two study areas from 1979-1982. Because of policy changes, the routine annual surveillance of sheep populations in May was changed to October in 1981 in the Black Mountains, with the May census still being taken in 1981. The May surveillance was maintained during all 4 years in the Lake Mead area.

RESULTS

The occurrence of psoroptic scabies in live-captured sheep from the Black Mountains was 25% (12), 25% (8), and 0% (22) for the years 1979, 1980 and 1981, respectively, whereas in hunter-harvested animals during 1979, 1980, 1981 and 1982 it was 25% (8), 50% (10), 12% (8) and 0% (9), respectively (Table 1). The occurrence in hunter-harvested sheep from the Lake Mead area was 20% (5), 37% (8), 0% (6) and 0% (5), respectively, for the same time period. There were no incidences of scabies in live-captured sheep from the Lake Mead area in 1981 and 1982.

Total numbers of sheep censused ranged from 222 to 511 in the Black Mountains and ranged from 263 to 568 in the Lake Mead area between 1979-1981 (Table 2).

DISCUSSION

It is impossible to define a cause and effect relationship between occurrence of psoroptic scabies and trends in population numbers, however, there appears to be a correlation between population size and the prevalence of scabies. Aerial census in the Black Mountain showed a 38% decline in total sheep numbers during 1981, which was preceded by a high of 38% of the sheep having scabies the previous year. The time at which the aerial surveys were taken in this area shifted from May to October during 1981. The total sheep numbers during the October 1982 survey were down slightly from the May 1981 survey which further supports the possibility of a die-off in the Black Mountains. A similar decline in the Lake Mead area could not be interpreted from the census data. Upon comparing the 1980 to the 1981 survey, there was a 33% difference in total sheep numbers, although the total numbers in 1980 are exceptionally high and are most likely an inherent bias in the sampling method. The same holds true for the 1982 census.

The occurrence of psoroptic scabies peaked during 1980 in the Black Mountains and Lake Mead area and then declined in 1981. Reasons for the decline in numbers of infected sheep are not fully understood. In the Black Mountains, sheep more seriously infected with scabies in the fall of 1980, may have died prior to the 1981 survey. Even if scabies may have entered into a latent period following the 1980 survey, sheep exhibiting severe encrustations of the ear would more than likely still exhibit some epidermal exfoliation in the 1981 survey. This was not the case, however, and only 1 in 96 sheep examined in 1981 and 1982 had scabies, and that was only a minor infestation.

Another factor that may have contributed to the increased prevalence of scabies was the nutritional status of the sheep. A drought occurred in northwestern Arizona from April 1979 to March 1981. We noticed that the sheep live-captured in 1980 were in much poorer body condition than in either 1979 or 1981. An animals' nutritional condition is directly related to its susceptability to and the expression of virulence of parasites (Imes 1918, Cottereau 1976, Liebisch et al. 1978, National Research Council 1979). Therefore, in addition to the possible die-off of sheep severely infected with scabies, the decline in occurrence of scabies may also have been a response to the sheeps' increased immunocompetence.

Another puzzling issue deals with the origin of the infestation. Were the mites transmitted by domestic livestock coinhabiting ranges with these sheep, or are other reservoir hosts involved, or did the mites enter prolonged periods of latency that were breached only when host or environmental conditions became optimal for their reproduction and survival? It is probable that bighorn sheep initially acquired *P. ovis* from domestic sheep when livestock were introduced to the ranges of western U.S. (National Research Council 1979). At present, several Psoroptes species have been shown to infect animals, but the only probable host for *P. ovis* is domestic and wild sheep (National Research Council 1979). Probably what was observed in the Arizona bighorn involved a situation in which latent or asymptomatic scabies developed into symptomatic scabies, with the initial source of infestation being domestic sheep. High population numbers, compounded by effects of drought, were the most likely factors contributing to the increase of psoroptic scabies and the decline in numbers of sheep. Once these adverse factors became moderated, the prevalence of patent scabies reverted to a near zero level as observed in 1981 and 1982.

Table 2. Population census of Nelson's bighorn sheep in the Black Mountains and Lake Mead areas of northwestern Arizona from 1979-1982.

Area	Month	Year	Rams	Ewes	Lambs	Ewe/Lamb ratio	Total number
Black Mtns.	May	1979	92	211	87	0.41	390
	May	1980	117	260	134	0.52	511
	May	1981	79	182	52	0.29	313
	October*	1981	102	126	44	0.35	272
	October	1982	74	97	51	0.53	222
Lake Mead	May	1979	32	151	80	0.53	263
	May	1980	87	235	109	0.46	431
	May	1982	120	314	134	0.43	568

*Time of survey changed to October in the Black Mountains.

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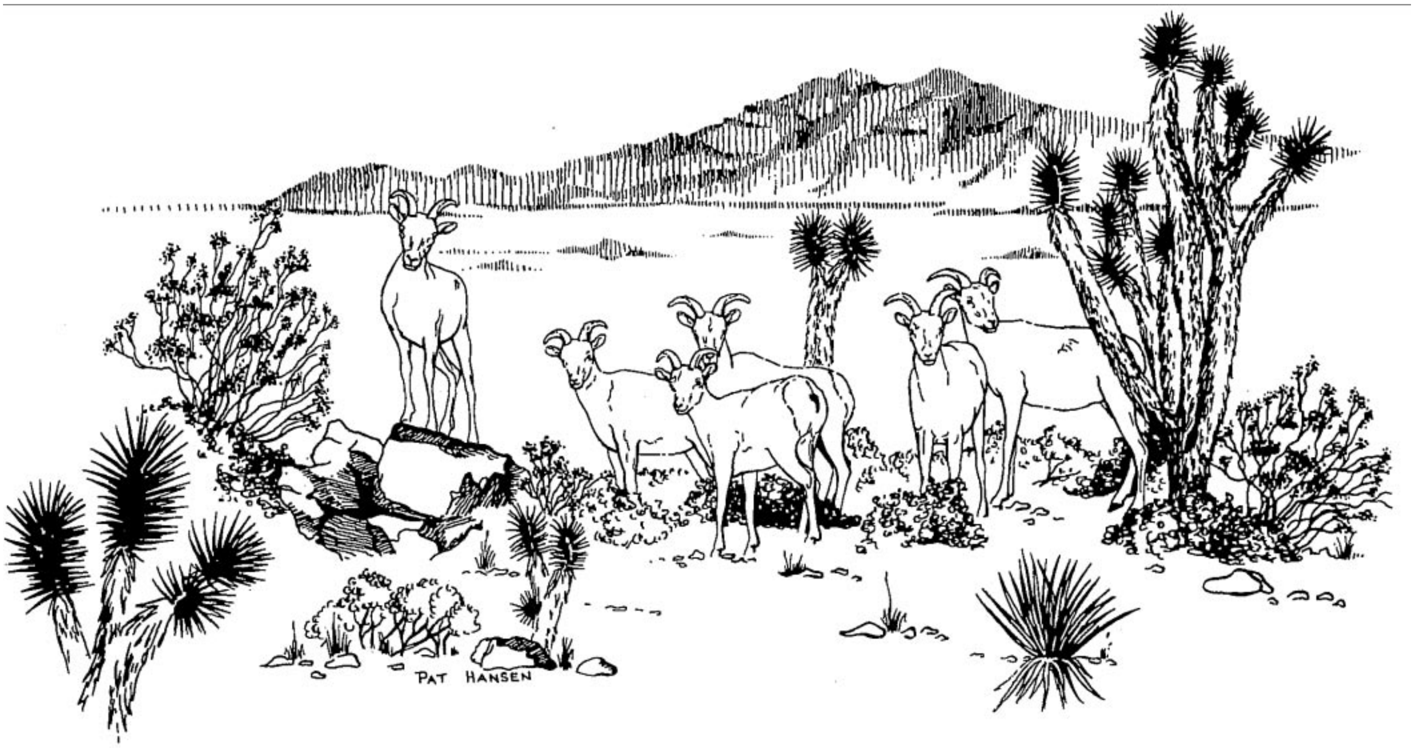

OCCURRENCEOF CONTAGIOUS ECTHYMA IN DESERT BIGHORN SHEEP IN SOUTHEASTERN UTAH

Michael M. King
Gar W. Workman
Department of Fisheries and Wildlife
Utah State University, Logan, UT 84322

Abstract. Bighorn sheep in Utah have been affected by infectious diseases including sinusitis, pneumonia and scabies mites. Disease and physiological information was collected from bighorn sheep *(Ovis* canadensis *nelsoni)* on Bureau of Land Management administered land in southeastern Utah and in Canyonlands National Park, Utah from February 1981-February 1983. Sheep were infected with sinusitis and scabies ear mites. Approximately 30 percent of sheep sampled had positive titers for blue tongue disease. In September 1982 several sheep were infected with contagious ecthyma.

INTRODUCTION

In February 1981, Utah State University began a study on the ecology of desert bighorn sheep on Bureau of Land Management (BLM) administered lands in southeastern Utah. A major objective of the study is collection of disease and physiological data from sheep populations within the study area.

Bighorn sheep have been exposed to and negatively affected by several infectious diseases. In the early 1900's, an outbreak of scabies decimated populations of bighorn in Canyonlands National Park, Utah (Follows 1969). Wilson (1968) reported seeing several lambs coughing which he thought to be a result of pneumonia. He also reported a mature ewe with lung deterioration attributed to pneumonia. Bunch et al. (1978) described chronic desert bighorn sinusitis and the deleterious effects it had on bighorn sheep in Zion National Park, Utah. Bates (pers. comm.) observed several cases of sinusitis during his study in Canyonlands National Park, Utah (Bates 1982).

Because sheep in Utah have been susceptible to potentially dangerous diseases, herd vigor and incidence of disease in sheep populations have been monitored. This paper is a summary of disease information collected from desert bighorn populations in southeastern Utah from February 1981-February 1983

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STUDY AREA AND METHODS

The study is being conducted on BLM administered lands in southeastern Utah and in Canyonlands National Park, Utah.

In February 1981, 1982 and 1983 sheep were captured, collared, and blood samples were collected for laboratory analysis. Whole blood was collected from each sheep by jugular puncture and transferred to sterile tubes for serology. Serum was separated and sent to U.S. Dept. of Agriculture Veterinary Services Laboratories, Salt Lake City, Utah to determine if sheep had been exposed to anaplasmosis (card agglutination), blue tongue (compliment fixation), brucellosis (plate agglutination), and leptospirosis (card agglutination). In February 1983 serum was also sent to National Veterinary Services, Ames, Iowa to determine if sheep had been exposed to contagious ecthyma (compliment fixation) or vescular stomatis (compliment fixation).

RESULTS

Seventy-nine sheep have been bled and tested for anaplasmosis, blue tongue, brucellosis, and leptospirosis (18 in 1981, 31 in 1982, 30 in 1983). No titers for anaplasmosis, brucellosis, or leptospirosis have been detected in any of the 79 samples. However, positive blue tongue titers were found in 24 of 79 samples (30.4%) since 1981 (4 of 18 in 1981, 10 of 31 in 1982, 10 of 30 in 1983). The rate of appearance of positive blue tongue titers in bighorn sheep in Utah is approximately equal to the percentage of domestic livestock (particularly cattle) in Utah that also exhibit blue tongue titers. Although many sheep showed positive blue tongue titers, no clinical cases (cases in which exposure to the virus caused expression of external symptoms) of the disease have ever been observed in Utah, nor have any clinical cases of the disease been reported in cattle herds in Utah (Hedelius, pers. comm.). This suggests that a majority of cattle and bighorn sheep develop immunity after one infection (Blood 1971).

Since 1981, 6 cases of sinusitis have been reported in Canyonlands National Park, Utah. Two of the infected sheep were captured and sent to Glaze Veterinary Clinic, Kerrville, Texas for further study. Also in 1981, 2 minor cases of ear mites were observed in sheep on BLM administered land in southeastern Utah. Ear mites were also reported by a successful hunter in September 1982. None of the cases of ear mites appeared severe enough to be detrimental to the health of the sheep.

In September 1982, researchers observed several sheep in the Blue Notch-Scourp Canyon area of southeastern Utah infected with some form of mouth disease. In a group of 12 sheep observed, 8 sheep (3 mature ewes, 1 yearling ewe, 4 yearling rams) were observed with varying degrees of the following symptoms: 1) swelling of lips and chin, 2) scabs and draining lesions on chin, lip, and nasal regions, 3) blisters or pustules on lips, 4) difficulty in eating, and 5) lethargy. There was no apparent swelling of coronary bands, pasterns, or shanks, nor were there any signs of lameness in any infected sheep. These symptoms are common to several viral diseases including blue tongue, contagious ecthyma, and vesicular stomatitis (Robinson et al. 1967, Blood 1971, Samuel et al. 1974, Scott 1981:116).

The sheep were observed from 20 September - 19 October, 1982 to monitor progression of the disease. The infection ran a rather benign course and no external symptoms were observed by 19 October, 1982.

In February 1983, blood samples were collected from 30 sheep and analyzed at National Veterinary Services, Ames, Iowa to determine the disease that affected the sheep. Two of the blood samples came from the group of sheep that was visibly affected by the disease in September 1982, though at the time of capture did not exhibit any external symptoms.

It was suspected because of the nature of the disease that it was probably 1 of 3 viral diseases: 1) blue tongue, 2) contagious ecthyma, or 3) vesicular stomatitis. However, results of 30 blood tests showed that none of the sheep in the area where external symptoms were observed showed any titer levels for vesicular stomatitis. Ten of 30 blood samples were positive for blue tongue but none of the 10 cases came from the area where the external symptoms were observed. Twenty-eight of 30 did show positive titer levels for contagious ecthyma, including 5 sheep from the immediate vicinity where the external symptoms were observed, leading us to suspect that contagious ecthyma was responsible for the problems experienced by the sheep the previous September.

DISCUSSION

Contagious ecthyma is a highly contagious viral disease of cosmopolitan occurrence in domestic sheep and goats (Blood 1971). The virus responsible for the disease is a dermatotrophic pox virus, composed of at least 6 immunological strains (Blood and Henderson 1968:356). The disease oflen occurs among domestic lambs and less often in mature animals. In domestic sheep the disease primarily occurs in feed lots or other areas of high concentration such as salt licks. In Rocky Mountain bighorn *(O. c.* canadensis) most occurrences have been in areas where many individuals have frequent and lengthy contact with salt blocks (Blood 1971). In southeastern Utah where contagious ecthyma was observed, there are no such salt licks used by wild sheep. However, there are but few watering areas and continued use of these sites by infected individuals may allow the disease to spread to uninfected sheep.

The disease, though generally not fatal, poses potential problems to wild sheep populations in North America. Due to the nature of the disease, the mouth region of the animal is affected which can prevent infected animals from eating properly. This leads to poor condition and increased susceptibility to other diseases. This is particularly significant in wild sheep populations because a majority of reported infections have occurred between June and October — a time that potentially overlaps both lambing and breeding seasons. If reproductively mature ewes or rams are severely infected by the disease and reduced to poor condition, chances of successful fertilization and parturition could be significantly reduced. Among ewes, other possible results are caked udder and mastitis. These may be brought on if the virus attacks udders making them so sore that ewes will not permit lambs to nurse. In such cases young could suffer from lack of milk (Stamm 1975:255).

Contagious ecthyma appears to have little negative effect on desert bighorn sheep populations in Utah. However, because the potential for problems exists, the disease should be carefully monitored if future outbreaks are discovered.

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IDEAS AND RECOMMENDATIONS FOR MAXIMIZING DESERT BIGHORN TRANSPLANT EFFORTS

Norris L. Dodd
Arizona Game and Fish Department
Phoenix, AZ 85023

Abstract. Follow-up research on desert bighorn *(Ovis* canadensis mexicana) reintroductions at 2 areas in Arizona has been ongoing since 1980. Post release movements, mortality and population trends were studied and are reported in detail. Recommendations based on these findings were proposed that may maximize future reintroduction efforts. These recommendations address post release follow-up, mountain lion control, and refinements in transplant procedures that reflect bighorn biology and behavior. Proposed refinements include utilizing direct releases of 2-3 groups of 8-10 sheep, spaced 6-10 km apart, in an attempt to induce dispersed lambing areas. These procedures may increase distribution of transplanted bighorn and allow for increased population growth.

INTRODUCTION

Active transplant and reintroduction programs are ongoing in every western state that supports desert bighorn sheep. Results of past efforts to re-establish desert bighorn to historical habitats have met with varying degrees of success, ranging from disappointing failures to dramatic successes. Since initial efforts in the late 1950s, biologists have been improving transplant procedures based on current knowledge and striving to increase chances for success.

Guidelines for re-establishing bighorn developed by Wilson et al. (1973) represented the first attempt to assimilate current knowledge for making transplants. These guidelines were recently revised by Wilson and Douglas (1982) to reflect knowledge gained from 10 years of transplant experience. An excellent review of 17 desert bighorn reintroductions was made by Rowland and Schmidt (1981) providing insights into the relative effectiveness of various procedures employed to re-establish bighorn.

Arizona initiated its desert bighorn reintroduction program in 1957 at Aravaipa Canyon, and those efforts have greatly accelerated in the past 3 years. To date, sheep have been re-established in 5 areas through 8 releases. Since 1980, the Arizona Game and Fish Department has conducted follow-up research at 2 of those sites: Aravaipa Canyon and Goat Mountain.

Aravaipa Canyon provided an excellent opportunity to study long term movements, dispersal and ecology of an enclosure-established herd that has been free-ranging for 10 years. Goat Mountain, on the other hand, allowed for the study of short term movements of a herd established through direct releases in 1980 and 1981. An important goal of these follow-up studies was to assess and refine transplant procedures to maximize transplant efforts.

The goal of this paper is to present data, ideas, and recommendations that may significantly improve effectiveness of desert bighorn transplant efforts. My work concerns the use of direct *vs.* enclosure releases, season and design of releases, follow-up of these efforts, and control of mountain lion *(Felis* concolor) during bighorn reintroductions.

STUDY AREAS

Aravaipa Canyon lies on the northern slopes of the Galiuro Mountains, approximately 100 km southeast of Phoenix. The physiography of the area is dominated by an impressive steep walled canyon with vertical cliffs exceeding 250 m in height. The canyon, through which Aravaipa Creek flows year-round, contains numerous rugged side canyons. The terrain adjacent to the canyon is characterized by a mosaic of mesa tops, buttes and broken canyon rims. Elevation ranges from 790 m at canyon bottom to 1220 m. Temperatures range from winter lows of -5°C to summer highs in excess of 38°C. Precipitation averages 35 cm annually.

Aravaipa lies within the Lower and Upper Sonoran Life-zones. Vegetation in interior canyons is characterized by productive desert scrub communities. Areas adjacent to Aravaipa Canyon are vegetated with desert grassland communities. Riparian vegetation is prevalent in canyon bottoms.

Weaver (1973) detailed the efforts involved in re-establishing desert bighorn at Aravaipa. In 1957, a 0.45 km^2 enclosure was constructed, and between 1958-1972, a total of 16 sheep were relocated in western Arizona. In 1973, 22 bighorn were released from the enclosure to disperse into the surrounding habitat. Following release, the herd increased dramatically and currently numbers about 100.

Goat Mountain lies on the southern extent of the Mazatzal Mountains, approximately 70 km northeast of Phoenix, and lies on the north shore of Apache Lake. Rugged terrain of the area is typified by vertical cliffs up to 250 m in height, canyons and sparsely vegetated mesas. Elevations range from 655 m at lake shore to 1130 m at the top of Goat Mountain. Temperatures range from -5°C in winter to summer highs nearing 40°C. Annual precipitation averages 35 cm.

Like Aravaipa, Goat Mountain vegetation encompasses both desert scrub and desert grassland communities; however, chaparral influences on mesic sites are more apparent.

Desert bighorn were reintroduced to Goat Mountain during 2 direct releases in 1980 and 1981. In November 1980, 20 sheep from western Arizona were released from an overnight holding pen constructed of woven wire and burlap. The purpose of the pen was to calm the sheep and allow the formation of loose social ties prior to their early morning release. In November 1981, a supplemental release of 12 sheep was made in a similar fashion at Painted Cliffs, 5 km west of the initial release site. Reproduction has been excellent following release, and the herd now numbers 50-60.

METHODS

To facilitate the post release study of bighorn at both study areas, sheep were fitted with radio collars. At Aravaipa Canyon, a total of 14 sheep were captured by darting from a helicopter; 10 in December 1980 (2 rams, 8 ewes), 2 rams in October 1981, and 2 ewes in May 1982. At Goat Mountain, 10 sheep (2 rams, 8 ewes) were fitted with radios prior to the initial release and 6 (3 rams, 3 ewes) in the second. In addition, all sheep were ear tagged and most other sheep at Goat Mountain were marked with colored visibility collars.

Movements of radio collared sheep were determined by aerial tracking using fixed wing aircrafl equipped with antennae (LeCount and Carrel 1979). Flights were conducted bimonthly at Aravaipa Canyon. Goat Mountain flights were made weekly the first year and bimonthly thereafter. Movements information was also collected at Aravaipa during the course of ground tracking in association with an intensive bighorn-cattle interaction study. Movements data were analyzed by computer and seasonal and yearly home ranges were calculated using the convex polygon technique (Stickle 1954). Seasons considered were spring (Feb.-May), summer (June-Sept.) and fall (Oct.-Jan.).

To assess the degree and causes of mortality in both herds, radio collars were utilized incorporating mortality sensing circuitry. A change in pulse rate from 75 to 150 beats/min. occurred when a sheep remained immobile for 3-4 hours, indicating a possible mortality. Of particular relevance to this paper were those mortalities attributable to mountain lions. To further understand the relationship between lions and bighorn at Aravaipa Canyon, an approximation of the lion diet was determined from the analysis of prey remains in scats that were collected randomly throughout the study area.

Information on population parameters including size, trend, lamb production and survival were obtained from intensive helicopter surveys flown at both areas in May and October of each year.

Table 1. Mean home range sizes (km^2) of radio collared bighorn sheep at Arvaipa Canyon, determined from aerial tracking flights, **1980-1983.**

Sex (n)	Yearlong	Spring	Summer	Fall
Ewes (10)	56.2	12.9	32.6	18.0
Rams (4)	402.0	236.9	84.4	127.5

RESULTS

Movements and Home Ranges. At Aravaipa Canyon, 54 tracking flights yielded 450 bighorn locations, while 72 flights at Goat Mountain provided 750 locations. Ground tracking at Aravaipa resulted in approximately 1600 bighorn sightings.

Aravaipa Canyon. Annual home ranges for ewes averaged 56.2 km^2 compared to 402.0 km^2 for rams (Table 1). Home ranges of ewes were largest in summer (32.6 km^2) while spring ranges were smallest (12.9 km^2). Large summer ranges may have resulted from breeding activities and the abundance of water. Rams had the largest home ranges in spring following segregation from ewes; they spent considerable time on the San Carlos Indian Reservation north of Aravaipa Canyon.

Table **2.** Mean distances (km) traveled by radio collared desert bighorn sheep between bimonthly aerial tracking flights at Aravaipa Canyon, **1980-1983.**

Sex (n)	Spring	Summer	Fall
Ewes (10)	6.1	9.7	9.2
Rams (4)	13.5	10.9	10.8

Mean distance traveled between tracking flights (Table 2) shows a trend similar to home ranges. Spring movements of ewes were shortest (6.1 km between locations) while summer (9.7 km) and fall (9.2 km) were considerably greater. Rams moved furthest between locations in spring (13.5 km) and least in fall (10.8 km).

Summer distribution of sheep in Aravaipa, based on ground sightings, were quite widespread. Approximately 75% of observations for that period were made in excess of 5 km of the enclosure. In fall, sheep were not as widely distributed; 75% of the sightings made within 5 km of the enclosure. Sheep were concentrated each spring in the vicinity of the enclosure; 75% of the sightings occurred less than 3 km from the enclosure.

Very little use of the south side of Aravaipa Canyon was observed, which was surprising as it appears to be suitable bighorn habitat.

During 1982, tracking flights at Aravaipa were made at considerably lower altitudes (below 100 m) than those prior to 1982. Low level flights appeared to have a noticeable impact on sheep. Sheep often moved considerable distances subsequent to location from aircraft. Similar observations were made by Krausman and Hervert (in press).

Goat Mountain. Whereas movements of the Aravaipa herd represent those of a well established population, those of the Goat Mountain herd were indicative of a newly established one. Changes in patterns of movement over time following release, as well as the development of these patterns, were documented.

Table **3.** Mean home range sizes **(km^2)** of radio collared bighorn sheep at Goat Mountain, determined from aerial tracking flights, **1980-1983.**

Sex (n)	Yearlong	Spring	Summer	Fall
Ewes (11)	151.3	16.2	14.5	112.4
Rams (5)	150.4	118.0	37.9	44.9

Even though year-long home ranges of all radio collared ewes and rams were nearly equal (151.3 km^2 and 150.4 km^2, respectively), marked seasonal differences were apparent (Table 3). Summer ranges of ewes (14.5 km^2) and rams (39.7 km^2) were the smallest. Fall ranges of ewes increased greatly, to 112.4 km^2, while ram ranges changed little. In spring, ewe home ranges became concentrated about Goat Mountain and averaged only 16.6 km^2. Ram ranges were their largest at this time, as at Aravaipa, averaging 118.0 km^2.

During the first year following release, home ranges of all collared sheep averaged 196.4 km^2, with ewes averaging 183.6 km^2 (Table 4). Home ranges during the second year dropped to 42.3 km^2, and ewe ranges averaged only 51.4 km^2. First year movements appeared to be exploratory in nature, prior to "settling in" in the vicinity of Goat Mountain.

Table **4.** Mean home range sizes **(km^2)** for radio collared bighorn sheep from each release at Goat Mountain, determined by aerial tracking, **1980-82.**

	1980-81	1981-82
First Release (Nov. 1980)		
Ewes (n = 6)	183.6	51.4
Rams (n = 2)	249.1	15.1
Second Release (Nov. 1981)		
Ewes (n = 3)		11.8
Rams (n = 3)	----	71.1
All Sheep	196.4	31.6

The second release of 12 sheep did not increase the overall area of use by bighorn. Due to the extreme fall dispersal of sheep already present, most of the sheep from the second release had joined the others within days. The exploratory movements of fhese sheep were greatly buffered by the presence of sheep already there (Table 4). Home ranges of ewes from the second release were actually smaller (11.8 km^2) than those from the first, while rams were considerably larger.

Table **5.** Mean distances (km) traveled by radio collared desert bighorn sheep between aerial tracking flights at Goat Mountain, **1980-1983.**

Sex (n)	Spring	Summer	Fall
Ewes (11)	6.5	7.7	6.7
Rams (5)	10.6	11.9	9.6

Mean distance traveled between tracking flights at Goat Mountain did not fluctuate seasonally as they did at Aravaipa Canyon (Table 5). Spring movements of ewes were smallest (6.5 km) but differed little from summer (7.7 km) or fall 6.7 km). Even though distances traveled did not change considerably, localization of movements near Goat Mountain in spring and summer was apparent.

As in transplants in other areas (Elenowitz 1982, McQuivey and Pulliam 1980), some rams from Goat Mountain dispersed widely following release. One radio collared ram traveled about 45 km before his return to Goat Mountain during the breeding season. His dispersal may have been influenced by hazing by a helicopter prior to its trek. Two other rams with ear tags were followed to Goat Mountain, although with some difficulty; colored collars would have made identification easier. One ram traveled 45 km soon after release and has not been seen since, while the other has been sighted on several occasions, as recently as fall 1982, about 75 km from Goat Mountain.

Sources of Mortality. Four mortalities of ewes have been recorded at Aravaipa Canyon. Causes of the mortalities included a fall from a cliff, lymphosarcomic chest tumor, undetermined besides predation, and a mountain lion kill. The relatively insignificant loss to lion predation is surprising in light of their high densities in the area. Only 1 sheep was lost to lions in 275 radio-sheep months of tracking.

Of 13 lion scats collected during the study at Aravaipa, 11 (84.6%) were comprised of javelina *(Pecari tajacu),* 1 (7.7%) of deer *(Odocoileus* spp.) and 1 of bighorn remains.

At Goat Mountain, 5 radio collared sheep mortalities have occurred. Two ewes (one radioed) were lost shortly after release due to injuries incurred during transport. Other mortalities included a young ram from undetermined causes, other than predation, a ewe with chronic sinusitis, and 3 ewes killed by lions. The loss to lions at Goat Mountain, one every 120 radio-sheep months, has sparked interest in lion control, despite an increasing sheep population.

Population Trends. Surveys at Aravaipa have been conducted since release and include spring and fall helicopter surveys. The population at Aravaipa doubled every 3-4 years since release from the enclosure to its current level of about 100. This rate of growth appears to have slowed last year following a drop from 61 lambs:100 ewes in May 1982 to 23 lambs:100 ewes in October, an atypical (for Aravaipa) loss of 62% of the lamb crop. It is unknown whether this slowing of the growth rate will continue but is being monitored closely.

The first intensive helicopter survey was made at Goat Mountain in October 1981 and yielded 70 lambs:100 ewes, excellent lamb survival for a newly transplanted herd. Surveys in May 1982 showed 81 lambs:100 ewes which dropped to 41 lambs:100 ewes by October. The Goat Mountain herd appears to be reproducing very well and has shown an increase to 50-60 sheep.

DISCUSSION

The Aravaipa Canyon herd represents the most successful reintroduction undertaken in Arizona, but there are strong indications that the full potential of the area to support bighorn may not be realized. Since release from the enclosure, the herd has increased its area of use to include the entire length of Aravaipa Canyon's north side, particularly in summer. However, the concentration which persists, and is in fact worsening, may ultimately limit both dispersal and potential for population increase. The spring concentration in the vicinity of the enclosure suggests that dispersal has been seriously limited by the apparent ties which ewes have developed to this area for lambing and post-lambing activities. The return of 3 of 4 radio collared ewes, all descendents of the original relocated sheep, to lamb inside the enclosure in 1982 strongly supports the notion that fidelity to lambing areas is passed on from generation to generation (Geist 1967, 1971) and has been intensified by use of an enclosure (Dodd 1982). Return of ewes to enclosures following release has also been documented in Utah (McCutchen 1980) and New Mexico (Bavin 1980). Geist (1967, 1971, 1975) has long stressed the management implications of this trait of ewes to form strong ties to lambing areas, as well as their relative inability to exploit new habitat. The latter notion is supported at Aravaipa, as well. Rams continue to exploit new areas, not used by ewes, such as the San Carlos Indian Reservation and the south side of Aravaipa Canyon.

Not only have the ties that ewes have developed to the lambing areas limited further dispersal, but there is evidence to suggest that the potential for growth may be limited as well. The slowing of the growth rate following the loss of lambs in 1982 may indicate that the herd is approaching saturation, even though habitat exists to support many more sheep if yearlong distribution were improved. Other indications that social stress may be present among sheep includes the discovery of 3 sheep (2 ewes, 1 ram) in the last 9 months which have succumbed to causes other than predation, as well as the first signs of scabies (Psorptes *ovis)* in the herd. An 85% incidence of one or more disease titers was detected in the blood of sheep captured for radio collaring (n = 7) (Dodd 1981). This, in conjunction with continued spring concentration, may indicate that the potential exists for additional sheep losses due to social stress, as described by Hansen (1971).

The apparent early success of the Goat Mountain reintroduction supports the continued use of direct releases in making reintroductions. Rowland and Schmidt (1981) and Wilson and Douglas (1982) discussed the pros and cons of using enclosures to re-establish desert bighorn. Based on successes achieved from direct releases, lower costs, wider applicability and reduced lambing site imprinting by ewes, it appears that the advantages of a direct release far outweigh those of using an enclosure.

Though the short post release period of establishment of the Goat Mountain herd precludes making strong conclusions, it appears that distinct patterns in movements are becoming established. Following the initial release in 1980, sheep moved about widely. Ewes interacted tightly and eventually centered their activities in the vicinity of Goat Mountain. These ewes lambed there in 1981 and returned in both 1982 and 1983 for lambing and post lambing activities. The release of an additional 12 sheep had minimal affect in establishing additional lambing sites. Though the degree of fidelity to Goat Mountain for lambing has not yet approached that seen at Aravaipa, the fact that one major lambing area has been established may indicate that a similar seasonal overcrowding may potentially occur. The phenomenon of self regulation through overcrowding in endemic populations was described by Hansen (1971) and appears to also be operating in reintroduced populations.

Efforts to control mountain lions in conjunction with bighorn reintroductions has been met with varying degrees of success, usually failure, and remains a controversial topic. In New Mexico, for example, intense efforts to control lions have met with minimal success (Munoz 1982). Rowland and Schmidt (1981) seriously questioned the use of lion control in association with bighorn transplants, except in some extreme instances.

The negligible losses of bighorn due to lion predation at Aravaipa despite high lion densities are probably related to the great abundance of javelina in the area. Javelina, the most prevalent item in lion scats (84.6%), might be acting to reduce the impact of lions on bighorn. Although the take by lions at Goat Mountain has been somewhat worse, the presence of javelina and deer may also be buffering lion predation on sheep, allowing the herd to show steady Increases following reintroduction.

Some post release losses of bighorn to lion are expected, but lion control should be considered an extreme measure. In fact, removal of adult resident lions may actually increase the lion population by vacating territories for which several transient lions may vie (Russell 1978, Shaw 1981). Efforts to control mountain lions might be better utilized searching for a more suitable reintroduction site or making attempts to increase alternative prey densities. If lion control is undertaken, long term commitments will probably be necessary for these efforts to become effective.

MANAGEMENT IMPLICATIONS

The strong fidelity to lambing areas that desert bighorn ewes exhibit at Aravaipa Canyon may also be developing at Goat Mountain. This represents the single most important factor limiting bighorn distribution, dispersal and numbers. But this anomaly of desert bighorn may also be the key to refining and maxipizing reintroduction efforts.

The optimal bighorn reintroduction would be one that resulted in the greatest overall distribution of sheep and lambing sites, thus reducing the potential for spring overcrowding. The basic thrust of proposed refinements to current transplant procedures includes: 1) transplanting sheep in the early spring prior to lambing, when movements are the smallest *vs* the fall when movements are greater, and 2) transplanting bighorn in 2-3 small groups of 8-10 sheep, spaced 6-10 km apart vs 1 single release of 20-30 bighorn.

The rationale behind these refinements is to create a situation where several lambing areas are "induced" throughout a range utilizing 2-3 direct "mini-releases" of sheep at a time when ewes are most sedentary. The sedentary nature of ewes at that time would theoretically keep each "mini-release" segregated through lambing and thereby allow the creation of several lambing sites. This would have the net effect of evening out spring distribution of sheep and preventing a situation such as the one at Aravaipa Canyon. This condition could not be achieved through fall releases due to the extreme movements exhibited at this time (e.g., Goat Mountain). Once several dispersed lambing areas were established throughout a range, bighorn would integrate in summer and fall, as movements increase. In subsequent springs, ewes and their offspring would hopefully show fidelity to their respective lambing areas spreading potential concentrations between several areas. This would achieve greater overall distribution and allow for greater population growth, thus maximizing transplant effort.

The following factors were considered before proposing these refinements: possible impacts of early spring capture and transport on lamb survival, the ability of biologists to select suitable lambing habitat for making "mini-releases", and how representative movement patterns of bighorn at Aravaipa and Goat Mountain are compared to other populations.

The capture literature (Young 1975, Harthoorn 1976) and several veterinarians that were consulted indicated that early spring capture and transport of pregnant ewes (up to early third trimester) would probably be no more stressful to ewes and their fetal lambs than fall operations. This could be tested by using portable ultrasound equipment to detect pregnancy (Smith and Lindzey 1982) and by monitoring lambing success following release.'

Sheep must be placed in proximity of suitable lambing habitat. With various habitat rating guidelines for bighorn (Hansen 1980, Ferrier and Bradley 1970, Holl 1982), managers should be able to select sites that possess attributes of lambing habitat.

A multitude of factors influence movements and home range size of desert bighorn. The patterns observed at Aravaipa Canyon and Goat Mountain are indeed unique in certain regards, but they do show general patterns which are evident in other populations. Small spring ranges and movements, a key factor in proposing spring releases, were reported in other areas by Seegmiller and Ohmart (1981) and Leslie and Douglas (1979).

In conclusion, to quote Geist (1975): "Reintroductions are crucial to sheep management since we cannot expect sheep to disperse readily, but they should be tailored to sheep biology. . ." Refinements in sheep transplant procedures proposed in this paper reflect bighorn biology and behavior and may increase the effectiveness of our efforts to return desert bighorn to former distribution and numbers.

SUMMARY OF RECOMMENDATIONS AND IDEAS

Post Release Follow-up.

1. All bighorn should be clearly marked prior to release with ear tags and colored collars which readily identify each sheep. This will facilitate follow-up study, identification of dispersing sheep, and allow for future population estimation using Lincoln-Peterson estimators.
2. A minimum of 3 ewes should be fitted with radio collars from each reintroduction, regardless of follow-up intensity, to allow for post release location and assessment.

3. Aerial tracking of reintroduced bighorn should be conducted in a manner to reduce impacts to sheep, biases in data, and maintain safety to researchers. Use of a directional belly antenna (LeCount and Carrel 1979) allows maintenance of accuracy and safety while tracking above 100 m.

4. Use of helicopters in newly established herds should be deferred for a period of up to 6 months to avoid possible adverse impacts.

Mountain Lion Control.

1. Except where a specific need exists, mountain lion control in association with bighorn reintroductions should be considered an extreme measure. If undertaken, long term commitments will be necessary.

2. Mountain lion status (e.g., density) should be considered in determining the suitability of areas for reintroduction of bighorn prior to release.

3. Measures to increase densities of alternative prey species should be undertaken to reduce impacts of lion on bighorn.

Design of Reintroductions.

1. Except where a specific need exists, reintroductions should employ direct release techniques; overnight holding pens may be necessary under some circumstances.

2. "Mini-releases" of 2-3 groups of 8-10 sheep each, spaced 6-10 km apart, should be tried and assessed.

3. Early spring releases of sheep prior to lambing should be tried and assessed as to the effectiveness in creating dispersed lambing areas.

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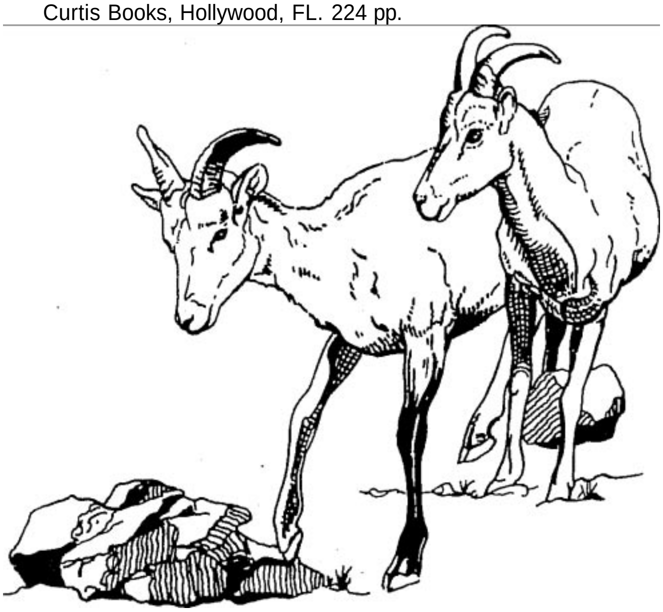

BURRO-SMALL VERTEBRATE INTERACTIONS IN DEATH VALLEY NATIONAL MONUMENT, CALIFORNIA

Myrna J. Yancey
Charles L. Douglas
N.P.S. Cooperative Studies Unit
University of Nevada, Las Vegas, NV 89154

Abstract. Study sites were established in Death Valley in Wildrose and Nemo canyons, which have histories of high and low *Equus asinus* populations. Climate and soils were equivalent between sites. An increase in threatened shrubs in Nemo has been paralleled by a decrease in Wildrose, indicating that more burros are using Nemo than in the past. Plant diversity was similar in both canyons, but plant composition was subtly different. Nemo had more heavily browsed species, whereas Wildrose has experienced selective removal of preferred species. Total plant volume was greater in Wildrose than in Nemo. Rodent diversity and reproduction were equivalent between sites. Mean species weights were greater in Wildrose, but Nemo had more large species, more rodent mass, and more recaptures. There were no statistical differences in lizard diversity or numbers between Nemo and Wildrose.

INTRODUCTION

The burro, *Equus asinus,* is a native of northeastern Africa. Because of its value as a draft animal, many were introduced into America during the last three centuries. Specifically, burros probably were brought into Death Valley National Monument by miners throughout the 1800's (Woodward and Ohmart 1976). During this time, burros escaped and/or were released when mining claims became unprofitable. These burros continued to thrive in Death Valley, and have since developed into large herds.

These herds have become a major concern because any exotic plant or animal could destroy delicate environmental balances. Fisher (1974), Moehlman (1974), Norment and Douglas (1977), White (1980), and Ginnett (1982) studied interactions of burros with vegetation and native bighorn sheep; however, little has been done concerning burro-small vertebrate interactions (Norment and Douglas 1977). Small vertebrates may be used as range indicators. If burros affect small vertebrate populations, they probably would also impact vegetation and large mammals such as bighorn sheep.

DESCRIPTION OF SITE

Location and Physiography. The study area was located in the northern Panamint Range of Death Valley National Monument, California. Sites were in Nemo and Wildrose canyons (Fig. 1), within the 15 minute series for Telescope Peak Quadrangle and Emigrant Canyon Quadrangle. The study site in Nemo Canyon was approximately 5.217 km², and ranged in elevation from 1493 m to 1646 m. The Wildrose Canyon site was 7.823 km², and ranged from 1372 m to 1524 m. Vegetation studies also were conducted in the Wildrose Canyon burro enclosure that was established in February 1972 at 1463 m (Fisher 1974). Slopes were 3% with a northwestern aspect at the enclosure, 4% with a northern aspect in Wildrose, and 4% with a western aspect in Nemo.

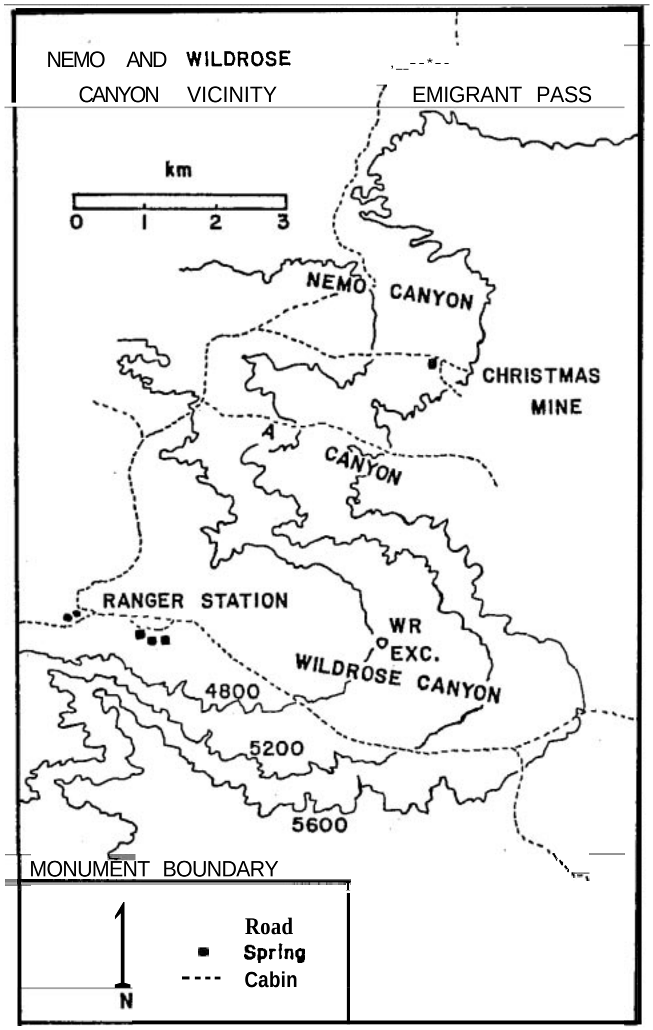

Figure 1. Map of the study area showing permanent water sources, major landmarks, and the Wildrose Canyon burro enclosure. The contour interval equals 136 meters (400 ft.).

Both Nemo and Wildrose are broad basin canyons surrounded by rugged terrain (USDI/NPS 1981). Bedrock within the area is more than 15,000 ft. (ca. 4572 m) thick (Lanphere 1962). The principle rocks are Precambrian and Paleozoic carbonates, quartzites, and shales with Mesozoic and Tertiary granitic intrusions (USDIINPS 1981, Clements 1977). Quaternary alluvium is also present (Lanphere 1962).

Climate. Climatic conditions within Death Valley National Monument are extremely variable on an annual and Spatial basis. This study was begun after a relatively dry year, but conditions became more favorable as it progressed. From June 1981 to August 1982, Nemo Canyon had a mean precipitation of 17.31 ml, while Wildrose received 23.26 ml. Heavy rainfall could occur in one canyon, with little or none in the other. There are no permanent water sources in Nemo. Wildrose. has several, including tanks within a burro capture corral. These springs are important point sources for wildlife.

From September 1981 through August 1982, the average minimum temperature in Nemo was 7.2°C and the average maximum was 20.8°C.

METHODS

Rodents. From June 1981 through August 1982, rodents were live-trapped to compare Nemo and Wildrose Canyon populations. The trapline configuration (Fig. 2) was modified from O'Farrell et al (1977) after personal communication with O'Farrell in 1981. The 185 m parallel lines were placed 53 m apart and consisted of 20 stations each. Four 255 m assessment lines had 18 stations each and intersected the parallel lines at 45° angles. There were 15 stations outside the parallel line configuration. All stations were 15 m apart.

Each station had two aluminum foldable Sherman traps baited with either Omaline (horse sweet feed) or oatmeal. Parallel lines usually were run for three consecutive nights, and assessment lines for two consecutive nights per month for 15 months. In January and February 1982, one assessment line and one parallel line were not run due to weather conditions. Trap nights were consecutive from June to August 1981, January 1982, and April through August 1982. The remaining data were collected on sequential weekends.

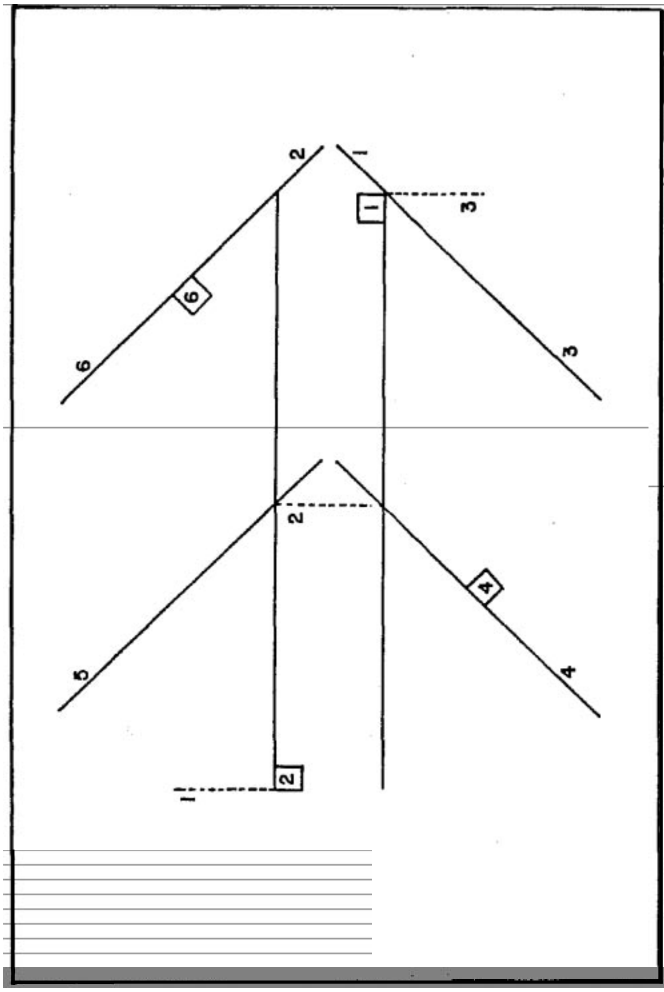

Figure **2.** Rodent **trapline** and lizard transect configuration with burro browse transects and vegetation quadrats. Solid lines represent rodent and lizard traps. Dotted lines are the burro browse transects. The squares are vegetation quadrats.

From December 1981 to July 1982, traps were left open and checked twice a day. Otherwise, traps were closed in the morning and reopened before nightfall. This method increased diurnal rodent captures and decreased hyperthermia of captured individuals. Cotton was placed in the traps from December to March to reduce hypothermia.

All rodents were identified, sexed, and weighed with a 100- or 300-gram Pesola scale. New captures were toe clipped.

Lizards. Pitfalls and transects were combined to compare lizard populations between Nemo and Wildrose Canyon (Parker 1972a, 1972b, 1974; Parker and Pianka 1975; Creusere and Whitford 1982). Twenty-eight one-gallon (4.21) cans were buried up to their rims at the same stations in each site. Rocks were propped over the cans when trapping, and the cans were covered with aluminum foil when not in use. Pitfalls were checked daily during the monthly rodent trapping periods from June 1981 through August 1982. All captured lizards were toe clipped and systematically marked with Pactra enamel, using a modified No. 1 Delta 1127 brush (Medica et al. 1971).

Parallel line transects for lizards (Fig. 2) were run immediately after checking rodent traps in the morning, and again when traps were rebaited in the afternoon (no transects were run in March). Four assessment lines (Fig. 2) were run 1 to 4 times per month (excluding January). All transects were considered to be 4 m wide. Marked and unmarked individuals were recorded.

Burros. Burro usage within each canyon was evaluated by using browsing transects and vegetation quadrats; burros were counted monthly along a 2-mi. (3.2 km) jeep road centering on each site.

Road transects generally were run twice daily during monthly rodent trapping periods from June 1981 through August 1982. Recognizable animals were noted, but no further attempt was made to distinguish individuals. Ages and sexes also were recorded whenever possible. Topographical maps were used to estimate the total area that was censused during each road transect, and average burro densities were calculated.

Vegetation. Perennial species diversities, volumes, and compositions were compared by using four 5 x 5 m quadrats (White 1980) located at the same trapping stations in each canyon (Fig. 2). Two control quadrats also were established in a small Wildrose Canyon burro exclosure. Perennials were considered to be within a quadrat if at least ½ of their bases were inside. One height and two 90° oriented width measurements were taken per plant. Annual species were noted.

In February 1982, three 2 x 50 m transects were run in each site (Fig. 2). Individual plants were examined for evidence of browsing, and categorized according to the Vesey-Fitzgerald (1973) browse impact method:

(1) 0 = no evidence of browsing
(2) 1 = light impact; impact replaceable by new growth
(3) 2 = moderate impact; broken branches present, shrubs often modified from natural growth form; i.e., cratered
(4) 3 = severe impact; survival probabilities greatly reduced

This method has been used in Death Valley by Norment and Douglas (1977), White (1980), and Ginnett (1982). Transect lines also were used to estimate species diversity and composition between sites.

Soil. In September 1982, 26 standardized core samples of soil were taken at the same stations in both study sites. No samples were taken over rodent trapping pathways, or near lizard pitfalls. Field weights were recorded by means of a 300-gram Pesola scale.

All samples were oven-dried for 48 hours at approximately 60°C, reweighed with a triple beam balance, and moisture content calculated. Separate weights were recorded for sieve sizes of .420 mm, .706 mm, and 1.00 mm (Rosenzweig and Winokur 1969). This provided a basis for comparison of particle sizes between the Wildrose and Nemo sites, and are not intended to describe soil types beyond the aridisol level (Fuller 1975).

Weather. One maximum-minimum thermometer and rain gauge were centrally placed in each canyon site. Readings were taken twice daily, excepting single recordings for arrival and departure dates. The rain gauges consisted of buried one-pound (ca .45 k) cans, topped by glass funnels. Thin layers of mineral oil helped prevent evaporation. Rain gauge data were collected from June 1981 through August 1982, and temperature recordings from December 1981 through August 1982, with supplemental readings from the Wildrose Canyon Ranger Station (September to November 1981) when a single thermometer was in Nemo Canyon.

Statistical Analyses. All statistical tests were run at the 5% significance level. Tests used were analysis of variance, chi-square with contingency tables and Yate's correction for continuity, Fisher's exact test with contingency tables, Kolmogorov-Smirnov goodness of fit, Mann-Whitney U test, Shannon's index of diversity, T test, and the variance ratio test (Zar, 1974). Nemo and Wildrose rodent, lizard, burro, temperature, and precipitation data were compared each month. Vegetation quadrat, vegetation transect, and soil data were collected only once during the study period, and could not be tested on a continuous basis for either canyon or for the Wildrose exclosure. Rodents, lizards, and shrubs were compared on both the species and community levels.

RESULTS AND DISCUSSION

Burro Use of Study Sites. Burros were more abundant in Wildrose Canyon during June, July, and August 1981, and March, April, and June 1982 than in Nemo Canyon (Mann-Whitney U-Test at $\alpha = 0.05$; Zar 1974). Nemo Canyon had more burros in December 1981 and January 1982 than Wildrose; all other months were similar. This agrees with Norment and Douglas (1977), Moehlman (1974), and National Park Service helicopter surveys. Temperature and precipitation measurements from these canyons were not significantly different. Therefore, variations in burro numbers may be related to seasonal stress and distance from water. Wildrose Canyon has permanent water sources; Nemo does not (Norment and Douglas 1977, Moehlman 1974).

TABLE 1
BROWSE IMPACT SURVEY, NEMO CANYON
Browse Impact is given as Number/Percent Total Individuals of Species

Species	No. Indi-viduals	Browse Impact Categories 0	1	2	3
Acamptopappus shockleyi	136	90166.2	32123.5	1017.4	412.9
Ambrosia dumosa	0	--	–		
Artemisia spinescens	15	3120.	116.8	3120.	8153.3
Coleogyne ramosissima	14	9164.3	2114.3	3121.4	010
Psorothamnus fremontii	17	7141.2	8147.1	115.9	115.9
Ephedra nevadensis	54	38/70.4	16129.6	010	010
Erigonum fasciculatum	0	--		–	
Eurotia lanata	10	2120.	7170.	1/10.	010
Grayia spinosa	52	19136.5	31159.6	111.9	111.9
Haplopappus cooperi	2	21100	010	010	010
Hymenoclea salsola	13	4130.8	8161.5	010	117.7
Lycium andersonii	66	19128.8	40160.6	7110.6	010
Machaeranthera tortifolia	13	4/30.8	4/30.8	3123.1	2115.4
Salazaria mexicana	3	2166.7	1133.3	010	010
Sphaeralcea ambigua	0	--	–		
Tetradymia axillaris	1	010	11100	010	010
Total	396	199150.2	151138.1	2917.3	1714.3

Burro activities also were affected by the National Park Service management program — at least 61 burros were removed from the monument during February 1982 (Wildrose Park Ranger, pers. comrn.). Wildrose Canyon served as an operational base for the cowboys, helicopter, and burro holding pens. This increase in human activity probably decreased the number of free-roaming burros in the area. Some burros also were removed from Wildrose on a continuous basis from a one-way capture corral. These factors, combined with a relatively wet, stress free year, may have increased the numbers of burros using Nemo Canyon. Norment and Douglas (1977), Moehlman (1974), and the NPS helicopter surveys indicated greater monthly and yearly variations between Nemo and Wildrose. This study probably underestimates the number of burros normally using Wildrose Canyon.

TABLE 2
BROWSE IMPACT SURVEY, WILDROSE CANYON
Browse Impact is given as Number/Percent Total Individuals of Species

Species	No. Indi-viduals	Browse Impact Categories 0	1	2	3
Acamptopappus shockleyi	120	98/81.7	66/13.3	5/4.2	1/.83
Ambrosia dumosa	5	4/80	0/0	0/0	1/20
Artemisia spinescens	5	1/20	2/40	2/40	0/0
Coleogyne ramosissima	73	42/57.5	27/37.0	3/4.1	1/1.4
Psorothamnus fremontii	1	1/100	0/0	0/0	0/0
Ephedra nevadensis	46	25/54.4	21/45.7	0/0	0/0
Erigonum fasciculatum	1	0/0	1/100	0/0	0/0
Eurotia lanata	0	--	--	--	--
Grayia spinosa	104	47/45.2	53/51.0	2/1.9	2/1.9
Haplopappus cooperi	26	26/100	0/0	0/0	0/0
Hymenoclea salsola	10	5/50	3/30	0/0	2/20
Lycium andersonii	42	13/31.0	27/64.3	2/4.8	0/0
Machaeranthera tortifolia	20	6/30	4/20	2/10	8/40
Salazaria mexicana	0	--	--	--	--
Sphaeralcea ambigua	15	8/53.3	7/46.7	0/0	0/0
Tetradymia axillaris	3	30/0	3/100	0/0	0/0
Total	**471**	**276/58.6**	**164/34.8**	**16/3.4**	**15/3.2**

Vegetation transects run in February 1982 did not show a significant difference in total browse impact between Nemo and Wildrose canyons (Kolmogorov-Smirnov Test, Zar 1974). There were also no significant differences in browse impact between any of the perennial species occurring in both sites (Kolrnogorov-Smirnov Test; Zar 1974) (Table 1, 2). Thus, browse impact was the same at both the community and species levels. This does not agree with Norment and Douglas (1977) who founda comparable browsing impact in Wildrose, but only 21% total browsing in Nerno. There also were 12.2% threatened species in Wildrose (Browse Cat. 3) compared with approximately 1% in Nemo. There has been a fourfold decrease in the threatened shrubs in Wildrose, with a concurrent fourfold increase in Nemo. This indicates that burros have probably removed many of the threatened plants in Wildrose, and are presently removing more from Nemo. This would coincide with the increased number of burros observed in Nemo Canyon.

Among major species in the study areas, *Acamptopappus* shockleyi, Ambrosia dumosa, Arternisia *spinescens,* Psorothamnus *fremontii,* Eurotia lanata, *Hilaria jamesii,* Hyrnenoclea salsola, *Lycium* andersonii, Sphaeralcea ambigua, and Stipa speciosa have been impacted by burros in other locations (Browning 1960; Koehler 1974; Hanley and Brady 1977; O'Farrell 1978; White 1980; Reddick 1981; and Ginnett 1982). Coleogyne rarnosissima, Ephedra *nevadensis,* Grayia *spinosa,* and Haplopappus cooperi have not been heavily used. There were no adequate records for *Erigonum fasciculatum,* Machaeranthera *tortifolia,* Salazaria mexicana or *Tetradymia* axillaris.

Coleogyne *ramosissima,* Ephedra nevadensis, and Grayia spinosa were browsed more in Nemo and Wildrose than other locations, although the populations were not heavily impacted. This agrees with Moehlman (1974) and Norment and Douglas (1977). Ephedra *nevadensis* was greatly impacted by burros on the China Lake Naval Weapons Center (Reddick 1981). In Wildrose, Hansen (1973), Fisher (1974), and Norment and Douglas (1977) observed heavy use of *Artemisia* spinescens, Psotharnnus fremontii, *Hilaria jamesii,* Hymenoclea salsola, and Stipa speciosa. The moderate use of *Sphaeralcea ambigua* agrees with these Panamint studies, but not with studies in other locations. Eriogonum fasciculatum, Eurotia lanata, Lycium andersonii, Machaeranthera tortifolia, Salazaria mexicana, and Tetradymia axillaris were heavily used.

TABLE 3
VEGETATION SURVEY, NEMO CANYON QUADRATS
Percent Composition of N of **Species/Total** N X **100**
Mean Volume is given as **M³** per Species

Species	N	Percent Composition	Mean Volume (M^3)
Acamptopappus shockleyi	82	27.52	.16
Astragalus sp.	1	.34	
Coleogyne ramosissima	2	.67	.73
Psorothamnus fremontii	4	1.34	.40
Ephedra nevadensis	21	7.05	1.70
Erioneuron pulchellum	19	6.38	00
Eurotia lanata	2	.67	.30
Grayia spinosa	28	9.40	.46
Hackelia floribunda	1	.34	--
Hilaria jamesii	36	12.08	--
Hymenoclea salsola var. *salsola*	1	.34	--
Lycium andersonii	24	8.05	.81
Machaeranthera tortifolia	6	2.01	.08
Oryzopsis hymenoides	5	1.68	.01
Poa nevadensis	3	1.01	.00
Salazaria mexicana	1	.34	--
Sphaeralcea ambigua	5	1.68	.00
Stipa speciosa	55	18.46	.11
Tetradymia axillaris	2	.67	1.58

Total N: **298**

These heavily used perennials appear to be browsed in Nemo and Wildrose when they are readily accessible. Many are small volume plants that may occur within larger shrubs (Tables 3-5). Thus, Ambrosia dumosa was either exploited or left alone. This was also true of *Stipa* speciosa, which was more abundant between shrubs in Nemo than in Wildrose. Such accessible plants may not appear in browse impact data if entire individuals were removed. This is probably also the case in other moderately to heavily browsed areas. The local increased use of Coleogyne *ramosissima,* Ephedra nevadensis, and Grayia spinosa could be related to the steady decrease in availability of heavily used species, such as Artemisia spinescens. Reddick (1981) also noted this possibility. A decline in the usage of *Acamptopappus* shockleyi, the dominant shrub in both sites, cannot be explained without further studies.

TABLE **4**
VEGETATION SURVEY, **WILDROSE** CANYON QUADRATS
Percent Composition is N of **Species/Total** N X **100**
Mean Volume is given as M3 **per Species**

Species	N	Percent Composition	Mean Volume (M^3)
Acamptopappus shockleyi	82	23.03	.13
Arabis sp.	4	1.12	--
Artemisia spinescens	2	.56	--
Astragalus sp.	1	.28	--
Coleogyne ramosissima	11	3.09	.67
Ephedra nevadensis	49	13.76	.65
Grayia spinosa	60	16.85	.40
Haplopappus cooperi	26	7.30	.23
Haplopappus linearifolius	1	.28	--
Lycium andersonii	30	8.43	.84
Machaeranthera tortifolia	26	7.30	.04
Opuntia basilaris	1 *(Dead)*	--	--
Oryzopsis hymenoides	2	.56	--
Sitanion jubatum	26	7.30	.00
Sphaeralcea ambigua	10	2.81	.00
Stipa speciosa	22	6.18	.03
Tetradymia axillaris	4	1.12	.49

Total N: 356

Psorothamnus fremontii, Hilaria jamesii, Hymenoclea salsola, and Stipa speciosa are heavily browsed species that occurred in larger proportions in Nemo. Less impacted dominant species such as *Col*eogyne ramosissima, Ephedra nevadensis, and Grayia spinosa were more prevalent in Wildrose (Tables 3-7). Plant diversity in Nemo and Wildrose was not significantly different. Both sites differed from the Wildrose exclosure, which was less diverse (Zar 1974). This does not agree with Brown and Schuster (1969) or Waser and Price (1981) who reported that cattle grazing reduced plant diversities. The results agree with Laycock (1967), Vesey-Fitzgerald (1973), and Pitt and Heady (1979) who found that sheep, elephant, and/or antelope seemed to enhance or maintain plant diversities, depending upon seasonal impact and annual weather patterns. Nemo and Wildrose probably were similar in diversity because both have inaccessible plant species growing within other shrubs, and have been continuously impacted by burros, to some extent, for some time.

TABLE *5*
VEGETATION SURVEY, **WILDROSE** EXCLOSURE QUADRATS
Percent **Composition** is N of **Species/Total N** x **100**
Mean Volume is **given** as **M³** per Species

Species	N	Percent Composition	Mean Volume (M^3)
Acamptopappus shockleyi	68	45.03	.11
Ambrosia dumosa	2	1.33	.03
Coleogyne ramosissima	3	1.99	--
Ephedra nevadensis	9	5.96	.10
Grayia spinosa	6	3.97	.39
Haplopappus cooperi	2	1.33	.39
Lycium andersonii	9	5.96	.58
Oryzopsis hymenoides	15	9.93	.03
Poa nevadensis	1	.66	--
Sphaeralcea ambigua	27	17.88	.00
Stipa saeciosa	9	5.96	--

Total N: 151

Burro impact also may be assessed by examining plant volumes. Sheep reduced Ambrosia and Acamptopappus volumes between lightly and heavily grazed plots (Webb and Stillstra 1979). Fisher (1974) found significantly higher volume in Acamptopappus, Ambrosia, *Col*eogyne, Psorothamnus, and Grayia located inside the Wildrose exclbsure than in those species outside. His results do not concur with analysis of variance tests of data in Tables 3-5.

Wildrose and Nemo also had a significant site-species interaction, indicating that there was a positive correlation between species and site in affecting plant volume (Anova Test; a = 0.05; Zar 1974). This correlation may be attributed to burro impact.

By heavily browsing some shrubs, burros may have increased the proportion of less used species in Wildrose Canyon (Tables 3-7). Some

TABLE **6**
VEGETATION SURVEY, NEMO CANYON TRANSECTS
Percent Composition is N of **Species/Total** N X **100**

Species	N	Percent Composition
Acamptopappus shockleyi	136	34.34
Artemisia spinescens	15	3.79
Coleogyne ramosissima	14	3.54
Psorothamnus fremontii	17	4.29
Ephedra nevadensis	54	13.64
Eurotia lanata	10	2.53
Grayia spinosa	52	13.13
Haplopappus cooperi	2	.51
Hymenoclea salsola	13	3.28
Lycium andersonii	66	16.67
Machaeranthera tortifolia	13	3.28
Salazaria mexicana	3	.76
Tetradymia axillaris	1	.25

Total N: 396

of these shrubs, such as Ephedra nevadensis, are large volume plants compared to species such as *Hilaria jamesii* and Stipa speciosa. Yoder et al. (1983) found that Ambrosia dumosa and Lycium cooperi were depressed by grazing, while Ephedra nevadensis, Haplopappus cooperi, and Hymenoclea salsola were stimulated. However, few shrubs showed a volumetric difference between moderately to heavily grazed plots and lightly to non-grazed plots. This suggests that plant composition affects total plant volume more than variations in individual species. Therefore, although individual species were on the average smaller in Wildrose than Nemo (Tables 3-5), Wildrose still had a greater overall volume. The robust Shannon Diversity Index did not reflect proportional variations between the two sites.

The Wildrose exclosure appears to be recovering from past burro impact. Its diversity was comparatively low, but its plant volume was statistically equal to both study sites. With further recovery, the exclosure could have a total volume statistically lower than Wildrose, and perhaps Nemo. Fisher's study (1974) took place only two years after the exclosure was established, and probably reflected little or no vegetative recovery. However, the Wildrose exclosure may not be representative of the Wildrose area, thereby limiting its comparative value.

TABLE 7
VEGETATION SURVEY, **WILDROSE** CANYON TRANSECTS
Percent **Composition** is N of **Species/Total** N X 100

Species	N	Percent Composition
Acamptopappus shockleyi	120	25.48
Ambrosia dumosa	5	1.06
Artemisia spinescens	5	1.06
Coleogyne *ramosissima*	73	15.50
Psorothamnus *fremontii*	1	.21
Ephedra nevadensis	46	9.77
Erogonum fascicula*tum*	1	.21
Grayia *spinosa*	104	22.08
Haplopappus cooperi	26	5.52
Hymenoclea salsola	10	2.12
Lycium andersonii	42	8.92
Machaeranthera *tortifolia*	20	4.25
Sphaeralcea *ambigua*	15	3.19
Tetradymia *axillaris*	3	.64

Total N: 471

Rodents. Rodents were active throughout the year except Perognathus formosus, Perognathus longimembris, Peromyscus crinitus, and Peromyscus maniculatus. Peromyscus maniculatus was not captured in February 1982, probably due to small sample sizes. Perognathus formosus was inactive from November through February, while *P.* longimembris wasn't found from October through January. These inactive periods agree with past reports (Chew and Butterworth 1974; Bradley and Deacon 1971; Bradley and Mauer 1973; Kenagy 1973; Ruffner and Tomko 1976; Lawhon and Hafner 1981). Bradley and Deacon (1971) captured fewer Peromyscus crinitus in the fall. *P.* crinitus was inactive in Nerno from April through July 1982. It did not occur in Wildrose. Ammospermophilus *leucurus*, Dipodomys microps, and Neotoma lepida were less active in winter (Bradley 1967; Bradley and Mauer 1973; Kenagy 1973; Lawhon and Hafner 1981). One Dipodomys merriami was captured several times in Wildrose during July and August, 1982, but when present in larger numbers, this species would probably be trapped throughout the year (Chew and Butterworth 1964; Bradley and Mauer 1973). Two hundred and forty-seven rodents were captured in Nerno, and 232 in Wildrose (Table 9). Numbers of Ammospermophilus *leucurus*, Dipodomys microps, and Perognathus longimembris differed between areas. Hanley and Page (1981) found that Perognathus longimembris, Peromyscus maniculatus, and Neotoma *lepida* were adversely affected by grazing. Dipodomys *microps* did better in ungrazed areas. Csuti (1979) did not find *D. microps* in areas of grazing disturbance. Carothers (1976) had an average mammal density almost four times greater in his controlled versus impacted study areas. Reddick (1981) also recorded significant differences in density between heavily and moderately impacted burro areas. Beatley (1976a) found that Dipodomys merriami replaced *D. microps* following blading, fire, or nuclear disturbances.

This study did not agree with those results, probably due in part to the unique climate associated with Death Valley. Van DeGraaff and Balda (1973), Reichman and Van DeGraaff (1975), and Beatley (1976a, 1976b) hypothesized that small mammals are greatly affected by the presence or absence of annuals and forbs, which is related to seasonal rain patterns. If rodents are indirectly affected by precipitation, the extreme spatial and annual variation in Death Valley could influence rodent populations. The removal of green vegetation through grazing may only be a secondary factor that increases in importance during dry years. This study took place during a relatively wet year.

Monthly rodent reproduction was compared using new parallel line captures, new assessment line captures, all new captures, and total captures. There were no significant differences in numbers of males or females for any species (Contingency Tables at $\alpha = 0.05$, $v = 1$; Fisher's Exact Test; Gar 1974). Males were considered reproductive if they had enlarged testes, while females were reproductive if they had copulatory plugs, extended bellies, and/or nipples. Temperature and precipitation were similar for Nemo and Wildrose. The variation in burro usage did not seem to impact rodent reproduction.

Brown and Lieberman (1973) found that individual species require differing amounts of shrub cover. Dipodomys seem to forage primarily in open areas, while Perognathus species have been associated with denser vegetation (Rosenzweig and Winokur 1969; Lawhon and Hafner 1981). Wildrose Canyon had an overall plant volume and plant volume diversity that was greater than Nemo. Perognathus *longimembris* was more prominent in Wildrose, while Dipodomys *microps* occurred more often in Nerno.

There was no significant difference in rodent diversity between the sites (Shannon's Index of Diversity at $\alpha = .05$; Zar 1974). Carothers (1976) found different diversities in the Grand Canyon between impacted and control sites. Again, this disagreement with the present study may be related to climatic and vegetative variations between the study areas. Hanley and Page (1981) indicated that rodent species diversities are greatly affected by plant form diversities. Mammal diversities and densities do not seem to be affected by soil depths or particle sizes (Rosenzweig and Winokur 1969). Soil particle sizes were similar for Nemo and Wildrose (Table 8).

TABLE 8
AVERAGE **SOIL** PARTICLE WEIGHTS,
NEMO AND **WILDROSE** CANYONS
Weight is given as grams

	Nemo	**Wildrose**
FIELD	100.65	107.35
DRY	92.25	98.04
PAN	44.26	41.20
.420 MM SIEVE	37.81	46.65
.706 MM SIEVE	2.56	3.86
1.000 MM SIEVE	6.42	6.05

AVERAGE MOISTURE CONTENT:
NEMO: **8.40G** WILDROSE: **9.31G**

Most researchers, such as Stickell (1960), have used densities and/or biomasses to study rodent populations. Hanley and Page (1981) used the term "abundance," but did not define it. Biomass is useful as an expression of population density (Steen 1971), but it assumes constant density over a given area. O'Farrell et al. (1977) and O'Farrell and Austin (1978) eliminated this assumption by calculating areas of effect for their basic trapping configurations. The present study used rodent mass to compare Nerno and Wildrose. Mass has been defined as weight. New captures on parallel and assessment lines and total rodent captures were tested separately (Analysis of Variahce Test; $\alpha = 0.05$; Zar 1974). Total captures included individuals caught more than once per month.

TABLE 9
RODENT SURVEY, NEMO AND WILDROSE CANYON FIRST CAPTURES
Percent Composition is N of Species per canyon/
Total N per Canyon X 100

Species	Nemo	Number of Individuals	Wildrose	Number of Individuals
Ammospermophilus leucurus	12.55	31	5.47	II
Dipodomys merriami	0	0	.50	1
Dipodomys *microps*	48.99	121	34.33	69
Neotoma lepida	2.83	7	1.00	2
Perognathus *formosus*	7.29	18	11.94	24
Perognathus longimembris	18.62	46	44.28	89
Peromyscus crinitus	6.07	15	0	0
Peromyscus maniculatus	3.64	9	2.49	5
Total N		247		201

There were significant differences in rodent mass between sites for every month except December 1981. Of the other 85 testable cases, Nemo masses were significantly less than Wildrose only 14.12% of the time (Tables 10, 11). This indicates that Nemo usually had more trapable rodents, or that the animals weighed more. Population sizes were comparable (assessment and parallel line captures), but Nerno had more' total captures. Two of the heavier species, *Ammospermophilus leucurus* and Dipodomys *microps* were more numerous in Nerno. Only Peromyscus maniculatus had a greater overall weight average in Nerno than Wildrose. Very few juveniles were caught in either site. Weight differences could not be attributed to age or reproduction, but could be caused by variations in diet and food availability. However, the weight differences were not extreme enough to support this possibility without further work.

TABLE 10
AVERAGE RODENT MASS BY MONTH, NEMO CANYON
Mass is given as grams per parallel line first captures, assessment line first captures, and total captures

		Parallel Line (New Captures)		Assessment Line (New Captures)		Total Captures	
Year	Month	Mass	N	Mass	N	Mass	N
1981	June	44.94	27	45.11	43	50.19	109
	July	42.81	8	43.82	11	46.81	96
	Aug.	35.63	4	7.50	1	36.78	39
	Sept.	60.50	2	24.75	4	42.02	32
	Oct.	46.00	1	23.00	4	47.59	34
	Nov.	35.63	4	47.79	7	51.36	28
	Dec.	82.00	2	47.00	3	57.87	34
1982	Jan.	78.13	4	--	--	67.00	25
	Feb.	65.50	2	48.75	4	49.12	17
	Mar.	--	--	50.88	4	54.12	13
	Apr.	71.50	1	0	0	36.92	13
	May	52.36	11	42.70	20	35.17	51
	June	41.67	12	35.56	17	36.30	79
	July	14.00	4	27.50	5	36.43	36
	Aug.	43.92	6	35.95	10	41.70	51
Total N:			88		133		657

The same statistical tests showed significant site-species interactions for assessment line captures in July 1982, and for total captures in June and July 1981 and July and August 1982. During these months, there was a positive correlation between species and site in affecting rodent mass. These correlations do not seem to be related .to reproduction, temperature, precipitation, or burro density. They probably result from burro impact upon plant composition and volume in the past.

These results support the idea that rodents may be used as indicators of environmental conditions. Burros can directly and/or indirectly affect small mammals and plants on the species and community levels.

TABLE 11
AVERAGE RODENT MASS BY MONTH, WILDROSE CANYON
Mass is given as grams per parallel line first captures, assessment line first captures, and total captures

		Parallel Line (New Captures)		Assessment Line (New Captures)		Total Captures	
Year	Month	Mass	N	Mass	N	Mass	N
1981	June	38.21	22	41.77	37	39.56	78
	July	8.42	6	18.00	16	26.61	87
	Aug.	8.50	1	20.50	4	23.33	32
	Sept.	26.75	4	12.50	1	35.60	25
	Oct.	60.50	2	70.75	2	57.73	26
	Nov.	64.00	1	65.90	5	62.22	18
	Dec.	0	0	65.75	2	69.50	8
1982	Jan.	0	0	--	--	35.75	2
	Feb.	70.50	1	0	0	65.83	3
	Mar.	--	--	63.64	7	46.57	14
	Apr.	8.50	1	9.63	4	16.25	8
	May	35.54	12	28.59	11	28.05	32
	June	33.60	5	22.09	16	27.62	48
	July	26.25	4	34.50	18	32.31	58
	Aug.	10.50	7	30.56	8	28.53	46
Total N:			66		131		485

Lizards. Lizard populations were estimated in Nemo and Wildrose using transects and pitfalls. The transects were run twice daily; the pitfalls once. All pitfalls were left open until the last day of collection. There was no significant difference between the Nerno and Wildrose parallel line transects (Mann-Whitney U Test at $\alpha = 0.05$; Zar 1974) (Table 12). Numbers of Cnemidophorus *tigris* and Uta stansburlana were tested separately between sites. Data from Coleonyx variegatus, Crotaphytus *collaris,* C. *wislizenii,* Phrynosoma *platyrhinos,* and *Sceloporous graciosus* were combined. The assessment lines were not run often enough to provide reliable statistical results. The raw data are similar for both sites (Table 13). There was also no significant difference in numbers of captured Uta stansburiana between sites (Mann-Whitney U Test; Zar 1974). Other trapped species were rare and not testable. None of the data showed a significant difference in diversity (Shannon's Index of Diversity; Zar 1974).

TABLE 12
AVERAGE LIZARD DENSITY BY MONTH
NEMO AND WILDROSE CANYON PARALLEL LINE TRANSECTS
Density is per 1000 m^2

YEAR	MONTH	NEMO	WILDROSE
1981	June	1.065	.564
	July	.702	.351
	Aug.	1.750	1.316
	Sept.	2.467	2.083
	Oct.	1.170	.804
	Nov.	.219	0
	Dec.	0	0
1982	Jan.	.146	.073
	Feb.	.146	.110
	Mar.	--	--
	Apr.	.804	.877
	May	1.243	.877
	June	1.023	.804
	July	.950	.292
	Aug.	1.228	.731

These results agree with Jones (1981) who found no difference in abundance or diversity between grazed and lightly grazed areas in Sonoran Desert scrub. He found differences in other vegetative sites less comparable to Nerno and Wildrosk. Jones thought this exception was due to similarities in vegetative structure. Nemo and Wildrose both have similar (Analysis of Variance Test; Zar 1974) shadscale-scrub communities (Munz 1974). Using vegetative volumes and diversities, the presence of 6 to 7 lizard species per site would be predicted (Pianka 1966).

Precipitation may also greatly influence lizard populations. Ballinger (1977) indicated that *Urosaurus* ornatus reproduction varied with precipitation levels and food availability. As with rodents, burro impact may be only a secondary influence increasing with importance during dry periods.

These results must be considered as building blocks for further research. The methods employed provided tangible data for a simplified approach to burro impact upon lizard populations where no previous work had been done. A larger work force, drift fences, pitfalls, and noosing would be necessary to provide complete data for each species. These methods would probably show that there are statistically more *U.* stansburiana in Nerno than Wildrose, but the methods could not be employed in areas concurrently being used for rodent research.

TABLE 13
AVERAGE LIZARD DENSITY BY MONTH, NEMO AND WILDROSE CANYONS ASSESSMENT LINE TRANSECTS
Density is per 1000 m²

YEAR	MONTH	NEMO	WILDROSE
1981	June	.735	.654
	July	.674	.919
	Aug.	.429	1.164
	Sept.	1.961	1.716
	Oct.	.245	.163
	Nov.	.123	0
	Dec.	0	0
1982	Jan.	--	--
	Feb.	1.471	1.961
	Mar.	1.471	1.716
	Apr.	.735	.735
	May	.245	.245
	June	.245	.245
	July	.245	.245
	Aug.	1.961	.735

CONCLUSION

Temperature, precipitation, soil moisture, and soil particle size were similar in Nerno and Wildrose canyons. More burros used Wildrose throughout the study period. This agrees with past work, but to a lesser degree than expected. Browse impacts were the same for both sites, which does not concur with past studies. An increase in threatened plant species in Nemo has been paralleled by a decrease in Wildrose. This suggests that burros have removed many plants from Wildrose, and are currently doing the same in Nemo. This was reflected in subtle changes in plant composition between sites. More burros may be using Nerno than in the past because of human activity and/or less water stress associated with a relatively wet year. Both sites had greater vegetational diversities than the Wildrose exclosure. Burro tramplings and droppings may enhance the growth of seedlings, or the enclosure may never have been representative of the Wildrose shadscale-scrub community.

Wildrose had a greater total plant volume than Nemo. Nemo had many small volume species that were heavily browsed, where less used, larger volume shrubs were more prominent in Wildrose. Both canyons had significant site-species interactions, indicating a positive correlation between species and site in affecting plant volume. The basis for this correlation was burro impact.

Because the only differences between Wildrose and Nemo were directly related to burro activity, any variations in small vertebrate populations would also be caused by burros. Nemo Canyon had larger populations of Ammospermophilus *leucurus* and *Dipodomys microps*, while Perognathus longimembris was more prominent in Wildrose. P. longimembris often occurs in dense vegetation, whereas, *D. microps* is found in sparser vegetation.

There were no differences in rodent diversity or reproduction between Nemo and Wildrose. Plant diversity and climatic conditions were the same in both sites. Variances in plant composition were subtle. Rodents may require certain plant forms and volumes rather than specific species to provide shelter and aid foraging strategies. Rodents and burros have overlapping diets; however, rodents depend more upon seeds than leaves, and burros probably have not depleted the seed reservoirs in either study area. Only threatened plant species are not likely to produce seeds. Dormant seeds may also persist long after the original vegetative sources has died or been reduced through browsing. Burro impacts upon annuals would be more pronounced during droughts.

Nerno had a larger rodent mass than Wildrose. More animals were captured in Nerno than Wildrose throughout the study period. The predominance of heavier species, such as Ammospermophilus *leucurus* and Dipodomys microps, in Nemo also affected the results. Both study areas had site-species interactions, where there was a positive correlation between species and site in affecting rodent mass. These correlations occurred during summer and early fall and cannot be explained at this time.

There were no significant differences in numbers or diversity of lizard species found in each site, although more Uta stansburiana were seen and captured in Nemo than Wildrose. Further intensive research might provide statistical evidence that habitat or food supplies of *U.* stansburiana have been adversely affected by burros.

Lizards were not significantly affected by burro activity; whereas, at least some rodent species were. If burros continue to use Nemo more than in the past, the study sites will become increasingly similar. There would be no variations in any of the small vertebrate species. Neither site has had irreparable range damage caused by the burros. Threatened plants have been removed, but many individuals remain undamaged while growing in shrubs. These provide a continuous seed source. Plant diversity has also been enhanced by trampling and droppings. These results cannot be compared with data collected before burros were introduced. The Wildrose burro exclosure has not existed long enough to recover from past impact, nor is the enclosed area typical of Wildrose Canyon. Any major changes in plant or small vertebrate populations have probably already occurred. Unless burro use greatly increases throughout the study area, no comparable changes seem imminent.

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DESERT BIGHORN SHEEP HABITAT UTILIZATION IN CANYONLANDS NATIONAL PARK

J. William Bates, Jr.
Gar W. Workman
Department of Fisheries and Wildlife
Utah State University, Logan, UT 84322

Abstract. Habitat utilization of desert bighorn sheep *(Ovis canadensis nelsoni)* was determined by observing 6 rams and 10 ewes marked with radio-collars. Distance to escape cover and the cover value of the area were variables most strongly correlated with bighorn use. Bighorn used steep slopes for resting and as escape terrain, and to a lesser degree for feeding. Blackbrush flats were used mainly as feeding areas. Bighorn diets consisted of 43% shrubs, 38% grasses, and 19% forbs; however, forbs were used to a greater degree and shrubs to a lesser degree than their availability in the habitat. Livestock grazing and human disturbance also affected habitat utilization.

INTRODUCTION

Habitat selection by an ungulate is a behavioral response to environmental variables that allow it to feed, reproduce, and avoid being fed upon (Morgantini 1979). These variables must provide food, water, cover from weather and enemies, and the requirements for social needs (Scotter 1980). Desert bighorn sheep behavior and environmental variables were recorded while observing radio-collared sheep and their associated groups in Canyonlands National Park. This project was funded by the National Park Service, the Utah Division of Wildlife Resources, Utah State University, and the Eastern Utah Natural History Survey. Objectives of this study were:

1. to study the habitat used by desert bighorn sheep throughout the year; and
2. to analyze vegetation in feeding areas used by desert bighorn sheep.

DESCRIPTION OF STUDY AREA

Canyonlands National Park is located in southeastern Utah, 22 km southwest of Moab. The Park is divided into 3 districts by the confluence of the Green and Colorado Rivers. This study focused on desert bighorn sheep in the Island in the Sky District. Elevations vary from 1219 m at the river level, to 1830 m on the hlgh mesas. Erosion by the rivers has created a 3 level environment: the mesa top, talus slopes and White Rim flats, and broken lower canyons. Precipitation averages 18 cm annually. Loope (1977) analyzed vegetation in the Park and described 7 habitat types which include: grasslands, pinyon-juniper, talus slopes with sparse vegetation, blackbrush, saltbrush, broken Cutler slopes with variable shrubland, and riverbank vegetation. Areas used by bighorn in the Island in the Sky also are used by about 1500 backpackers, 1800 back country vehicles, and 8000 river runners annually.

METHODS

Habitat utilization was determined by observing 6 rams and 10 ewes marked with radio-collars. Collared sheep were located 370 times during telemetry flights, and 142 times on the ground on a rotating basis, for a total of 512 observations. The total number of sheep observed during the study was 1319, which included 465 rams, 509 ewes, 302 lambs, and 43 unclassified. Field work was initiated in July 1980 and completed in September 1981.

Habitat utilization was compared between 2 study areas that were divided on the basis of differences in bighorn use patterns and topography. In the Island-north area, there were over 30 known access points for bighorn up and down the White Rim within 0.8 km of escape cover. In the Island-south area there were only 9 known access points, which ranged from 1.2-2.8 km from escape terrain. Chi-squared analysis and a test comparing habitat availability with use of that habitat type were used to determine which habitat types were being selected (Neu et al. 1974).

A scan-sampling technique (Altmann 1974) was used to record behavior every 10 min while observing groups of bighorn sheep. Environmental variables that were recorded included water availability, band size, habitat type, distance to escape terrain, and reactions to human disturbance. These were analyzed with a covariate factorial (Ostle and Mensing 1975) to determine significant variables of habitat utilization. Forage utilization was also recorded using a scan-sampling technique every 2 min. Observations were made through 10x50 binoculars or a 15-60x variable power spotting scope. Data were recorded only when close enough to determine which plants were being used. If a plant species could not be identified it was recorded as unidentified grass, shrub, or forb.

Vegetation was analyzed using a 9.6 ft² wire hoop. Annual production, basal cover, canopy cover, and percent rock were recorded in 10 plots in each transect (U.S. Forest Service Manual 1978). Twenty transects were completed in the talus slope, blackbrush flat, and Cutler slope habitat types, while 10 transects were completed in the grassland, saltbrush and pinyon-juniper areas, because they comprised a much smaller area. Vegetation was analyzed in the spring when plants could be more easily identified.

RESULTS

Vegetation Analysis. Analysis of variance showed a significant difference in the annual production in each habitat type ($F = 6.96$, $P = 0.98$). Habitat types on flat terrain were more productive than the sloped areas. Grassland flats averaged 72.6 kglha, blackbrush flats 64.4 kglha, and saltbrush flats 56.4 kglha. Talus slopes averaged 57.1 kglha, Cutler slopes 39.2 kglha, and pinyon-juniper areas 32.7 kglha.

Forage Utilization. Major forages used by desert bighorn sheep were galleta grass *(Hilaria* jamesii), blackbrush (Coleogyne ramosissima), single leaf ash (Fraxinus anomalaj, Mojave aster (Machaeranthera tortifoliaj, and Indian rice grass (Orzyopsis hymenoides) (Table 1). Single leaf ash and Mojave aster were used seasonally, while galleta grass, blackbrush, and Indian rice grass were used year-round.

Table 1. Average annual diet of desert bighorn sheep in Canyonlands National Park, July 1980 to September 1981 (n = 2140).

Species	% of diet
Hilaria jamesii	21.8
Coleogyne ramosissima	17.5
Fraxinus anomala	6.9
Macheranthera tortifolia	5.3
Orzyopsis hymenoides	4.9
Ephedra torreyana	3.9
Bromus tectorum	3.4
Atriplex *confertifolia*	3.3
Stanleya pinnata	3.2
Sphaeralcea leptophylla	3.0
Cowania mexicana	3.0
other shrubs	8.6
other grasses	8.2
other forbs	7.2

Annual diets consisted of 43% shrubs, 38% grasses, and 19% forbs. However, when compared to the availability of each forage class in the habitat (Neu et al. 1974), forbs were used significantly more than expected, based on their availability ($X^2 = 70.8$, 6 df, $P = 0.001$), grasses the same as expected, and shrubs significantly less than expected (Table 2, Figure 1).

Habitat Utilization. Chi-squared analysis showed a significant difference between habitat utilization by rams and ewes, and between rams in the 2 study areas ($P = 0.01$). Habitat use was also significantly different by season ($P = 0.01$). These differences were attributed to seasonal movements by rams and shifts in areas used by ewe groups.

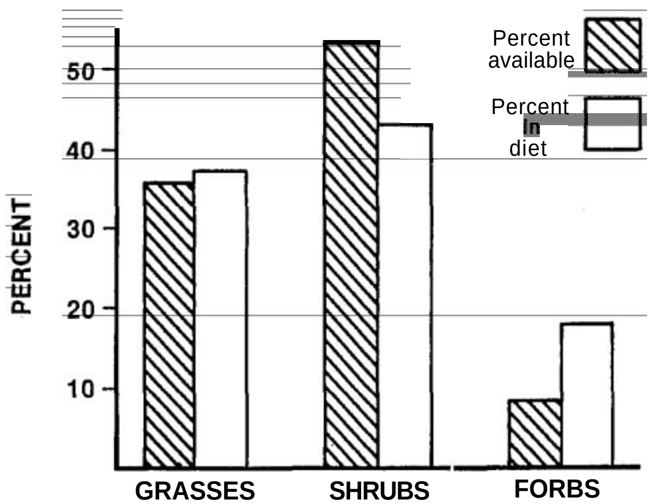

Figure 1. Comparison of forage used versus available forage by desert bighorn sheep in Canyonlands National Park, 1980-1981.

Table 2. Use of shrubs, grasses, and forbs by desert bighorn sheep in comparison to their occurrence in the Island in the Sky District of Canyonlands National Park.

Forage type	Incidents of use observed	Incidents of use expected	Total kilograms of forage type*	Proportion of total kilograms	Proportion of diet (Pi)	90% confidence interval on (Pi)
Shrubs	932	1151	4,884,158	0.538	0.435	.412◄P1◄.458c
Grasses	813	794	3,369,836	0.371	0.380	.358◄P2◄.402b
Forbs	395	197	831,445	0.092	0.185	.167◄P3◄.203a
Total	2140	2142	9,085,439			

a = used more than expected, b = used the same as expected, c = used less than expected.
'determined by multiplying forage production by the number of hectares in each habitat type.

Table 3. Habitat type utilization by desert bighorn sheep in 2 study areas in Canyonlands National Park, 1980-81 (n = 512).

Study Area	Sex	Habitat type (% of observations in habitat type)					
		Talus Slopes	Blackbrush Flats	Grassland Flats	Saltbrush Flats	Pinyon-Juniper	Cutler Slopes
North	Rams	63a	20b	4b	1b	7b	4c
South	Rams	24b	15c	0c	2b	0c	60a
North	Ewes	8c	24b	2b	1b	0c	65a
South	Ewes	9c	14c	0c	0c	2b	75a

aUsed more than expected
bUsed the same as expected
cUsed less than expected

Four of the 6 radio-collared rams moved to different areas in fall, winter, spring and summer. Ewes were found in the same general areas in each season, except prior to lambing when they retreated to rugged, isolated canyons below the White Rim.

On a yearly basis, rams in the north study area used upper talus slopes more than expected, based on the availability of that habitat type in comparison to the number of radio-collared rams found there (Neu et al. 1974) (Table 3). Ewes in both study areas and rams in the south area used the Cutler slopes more than expected. Use of blackbrush flats was the same as expected in the north area by rams and ewes, and less than expected by bighorn in the south area. However, it has apparently increased since 1975. Dean (1977) did not observe ewes west of the White Rim Road in blackbrush areas in 1975. In 1980 and 1981 over 75 ewe groups were seen west of this road.

Behavioral and environmental variables were analyzed by sex, season, habitat type and study area using covariate factorial analysis. The distance to escape cover, defined as steep, broken terrain, and the cover value of the area (Hansen 1980) were the variables most strongly correlated with habitat utilization. Of 1319 desert bighorn sheep observed during the study, only 1 was farther than 0.6 km from escape cover.

By season, bighorn spent more time feeding in the summer than in the winter (Table 4). Blackbrush flats were more productive than the sloped areas and were selected for feeding. Grassland and saltbrush flats were used in a similar manner to blackbrush flats; however, some grassland areas that did not have shrubs dispersed through them were not used by the sheep. The more rugged talus and Cutler slopes were selected for resting and escape cover, and used to a lesser degree for feeding (Table 5).

Disturbance caused by humans may have also affected habitat utilization. Over 41% of 337 bighorn groups observed to come in contact with humans moved to a new habitat type. However, 78% of those on flat areas moved to escape terrain, either the talus or Cutler slopes.

Circumstantial evidence suggested that livestock may have also affected habitat utilization. Livestock grazing was terminated in most of the Island in the Sky District in 1975. Since then, the population has apparently increased. In 1975, Dean (1977) estimated a maximum population of 80 sheep, while in 1981 the Utah Division of Wildlife Resources estimated a minimum of 400 (Bates 1981, pers. comm.). The ewe/lamb ratio in 1980-81 was 60 lambs/100 ewes, and lamb mortality was not significantly different from ewe mortality ($X^2 = 1.4$, 4 df, $P = 0.18$). The range of the bighorn has increased to include areas formerly used by domestic livestock. In 1981, 40 cattle were allowed to graze in Shafer's Canyon, and although ewes could be found on both sides of the canyon, no resident ewes were observed in areas heavily used by the cattle.

DISCUSSION

Desert bighorn sheep fulfilled their basic requirements for survival through the use of several habitat types. They were apparently dependent on escape cover (broken, rocky, precipitious terrain) that allowed avoidance from human disturbance or predators. Of 1319 sheep sighted, only 1 was farther than 0.6 km from escape cover. Those areas also provided cover from sun and wind. While sloped areas were also used for some foraging, bighorn moved onto blackbrush, saltbrush and grassland flats for feeding as well. Flat areas produced more forage, and less energy may have been required for forag-

Table 4. Statistically significant relationships (P = 0.05) between desert bighorn sheep behavior and environmental variables and season, in Canyonlands National Park.

Season	Variable			
	% time feeding	% time courting	Cover value at bighorn locations	Distance to cover (mi)
Summer	54.2	0.0	3.78	.041
Fall	43.2	5.0	3.45	.089
Winter	30.8	0.0	4.28	.020
Spring	47.8	0.0	3.95	.055

Table 5. Statistically significant relationships (P = 0.05) between behavioral and environmental variables and habitat types used by desert bighorn sheep in Canyonlands National Park.

Habitat type	Variable				
	% time feeding	% time resting	% time courting (fall only)	Cover value	Distance to cover (mi)
Talus slopes	39.2	52.0	2.2	3.95	.040
Blackbrush flats	70.0	6.9	5.3	1.97	.103
Cutler slopes	36.4	47.5	5.8	4.93	.032

ing (Moen 1973). Flat areas in the Island-north area were used to a greater extent than those in the south area because they were all within 0.5 km of escape terrain. Use of the flat areas increased after livestock were removed from the area in 1975.

Water availability was not a statistically significant factor (P = 0.94) affecting habitat utilization, probably because of the relative abundance of water during the study period. However, movement by ewes did appear to be restricted during a dry period early in the summer of 1981 when 94% of radio-collared ewe locations were within 0.8 km of a permanent water source. Summer and fall rains during most of the study period kept potholes on the White Rim full and seeps and springs flowing. Bighorn also had access to the Colorado River in many areas, and'at a few areas along the Green River.

Human disturbance also may affect habitat utilization. This appeared to cause a temporary displacement of sheep on the White Rim. The population has continued to increase in spite of the use of bighorn areas by visitors, Increased human use, however, may have a detrimental effect on the bighorn population (Bates 1982).

Historically, livestock grazing may have had an effect on use of areas by desert bighorn sheep and population size. Circumstantial evidence indicates that there were many bighorn sheep in the Island in the Sky prior to the introduction of livestock in 1920 (Follows 1969). A few years later, the bighorn population crashed, possibly from a scabies outbreak. Another population decline occurred in the 1950s when uranium mining began (Dean 1977). After Canyonlands National Park was created in 1975, mining and most livestock grazing was terminated. Since then, the range of the bighorn has increased to include areas formerly used by livestock and the population has increased. Areas still used by cattle and sheep are not used. extensively by desert bighorn sheep. Long term studies should be instigated to determine the effects of livestock on desert bighorn sheep.

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STATUS OF DESERT BIGHORN SHEEP IN NEVADA - 1982

Daniel E. Delaney
Nevada Department of Wildlife
Las Vegas, NV 89158

Abstract. Intensive aerial surveys resulted in the observation of 1,466 bighorn with a ratio of 63 rams and 40 lambs per 100 ewes. Generally, populations in the state are at high levels with some populations stable and others slightly increasing. The Mormon Mountain herd has begun recovery following an estimated 50% to 60% die-off in 1980. Trappings and transplant activities resulted in the reintroduction of desert bighorn sheep into both the Hot Creek and Toquima Mountain Ranges in Nevada.

HELICOPTER SURVEY RESULTS

A total of 1,466 desert bighorn sheep were observed during 65.9 hours of intensive helicopter surveys on 13 different mountain ranges within Nevada between September 22 and October 22, 1982. This year's surveys resulted in the highest observation rate (22.2 sheep observed per hour) and the second highest total number of sheep observed since surveys were initiated in 1969.

The 1,466 bighorns were comprised of 725 ewes, 454 rams and 287 iambs for an average ratio of 63 rams and 40 lambs per 100 ewes, as compared with the previous five-year average of 1,372 observed with an average of 58 rams and 29 lambs per 100 ewes. A summary of the 1982 survey results are presented in Table 1.

The age class structure of Nevada's bighorn population based on the estimated ages of rams observed during the current years' surveys is within the statewide long term norm and suggests that 37.9% of the sheep are between one and three years of age, 35.5% between four and six years of age and 26.6% seven years of age or older.

POPULATION TRENDS

Generally desert bighorn populations within the state are currently at high levels. Due to favorable precipitation patterns, which resulted in excellent range conditions, lamb production and survival, as documented in 1982 aerial surveys, increased dramatically from 1981 levels. The current year's surveys show the second highest lamb per 100 ewe ratio on record (401100) and follows the 1981 ratio of 16 lamb per 100 ewes which was the poorest ratio documented since surveys were initiated in 1969.

Record high counts and observation rates from some mountain ranges, coupled with relatively stable ram to ewe ratios and high lamb production and survival rates, indicate Nevada's bighorn populations are continuing to expand. The 1982 statewide desert bighorn sheep population is estimated at 4,969 animals comprised of 1,471 rams, 2,628 ewes and 870 lambs, which represent a 6.8% increase over the 1980 population estimate of 4,654 animals.

THE MORMON MOUNTAIN HERD

The catastrophic die-off in the Mormon Mountains which occurred during the fall months of 1980 reduced the herd by an estimated 50 to 60 percent. The outlook for recovery of the herd, with over 100 ewes estimated to have survived the die-off, was very optimistic. However, due to poor range conditions during the spring and critical summer months, lamb production and survival in the Mormon Mountains (8 lambs per 100 ewes), and throughout most of the state (statewide average 16 lambs per 100 ewes), was extremely low in 1981. Aerial surveys conducted during the fall of 1981 and 1982 on the Mormon resulted in the same total number of sheep observed, with both comparable observation rates and ram to ewe ratios.

These data indicate that 1981 recruitment to the population was neither sufficient to initiate recovery nor sufficient to offset natural mortality to the adult segment of the population, and as a result no expansion of the herd occurred in 1981. The observation of 37 lambs per 100 ewes (1982 recruitment) indicates an expanding population and is the first sign that population recovery is underway. The continued monitoring of population parameters over the next few years should provide some much needed information on the recovery rate for such a population.

HUNTING AND HARVEST TRENDS

A total of 90 desert bighorn sheep tags were available in Nevada during the 1982 season including: 80 resident, 9 nonresident and one special bid tag that was auctioned for the sum of $21,000.

Interest for hunting bighorns remains high as indicated by the number of applications received for available tags. A total of 1,139 (average 14.2 applicants per tag) were received for the 80 resident tags, while 565 applications (average 62.7 applicants per tag) were received for the nine nonresident tags. The number of resident applications

Table 1. Record of bighorn sheep observed during Fall 1982 helicopter surveys.

Mountain Range	Survey Time	Total Observations	Number of Ewes	Number of Lambs	Number of Rams	Ratio Ram/Ewe/Lamb
Mormon Range	9.8	111	59	22	30	511100137
Muddy Mountains	4.7	93	47	14	32	681100130
Black Mountains	6.5	321	153	89	79	521100/58
River Mountains	3.7	233	92	39	102	1111100142
Las Vegas Range	3.3	27	14	6	7	501100143
Sheep Range	7.9	146	88	27	31	351100131
Newberry Range	2.3	35	17	10	8	471100159
S. Eldorado Range	2.8	47	26	6	15	581100123
N. Eldorado Range	7.3	178	90	30	58	641100133
Spring Range	5.3	22	13	5	4	31/100/38
Cone Mountain	4.6	199	97	34	68	701100135
Monte Cristo Range	3.1	28	17	1	10	59110016
Silver Peak Range	4.6	26	12	4	10	831100133
Totals	65.9	1,466	725	287	454	631100/40

represents a 3.2 percent decrease from last year, while demand for nonresident tags remained virtually unchanged.

A total of 58 bighorn rams were harvested during the 1982 season for a success rate of 62.5 percent for residents and 80 percent for nonresidents, with an overall success at 64.4 percent. The 1982 harvest represents a 10.7 percent decrease over last year's near record harvest and brings the total number of rams harvested in the state, since hunting was initiated in 1952, to 988 animals.

The average age of rams harvested was 8.1 years which is above the previous five-year average of 7.3 years. Ages ranged between five and 13 with only 10.3 percent of the rams under the age of seven. A total of five animals scored ("green") sufficient points to be considered for the Boone and Crockett Record Book, with the highest score, a new state record of 187 4/8 points.

Hunters reported expending 681 days in the field (8.4 days per hunter) while observing 3,322 sheep or 41.0 sheep per hunter and 4.9 sheep per hunter day. Hunter observation statistics continue to support aerial survey data in showing populations are at high levels.

TRAPPING AND TRANSPLANTING ACTIVITIES

Since the favorable climate conditions which currently exist on bighorn ranges cannot be expected to continue indefinitely and declines in relatively high density populations are anticipated in poor years, the Nevada Department of Wildlife is utilizing sheep from these high density populations to provide animals for an intensified reintroduction program.

As part of a continuing program for the reintroduction of bighorn sheep into areas of historic distribution, the Nevada Department of Wildlife in cooperation with the National Park Service conducted trapping operations in the River Mountains of Clark County during the summer of 1982. A total of 88 desert bighorn sheep comprised of eight rams, 50 ewes and 30 lambs (13 males and 17 females) were trapped from the area between June 16 and June 28, 1982. A total of 19 mortalities occurred during trapping and transplant operations. Three sheep (one ewe and two lambs) were lost as a result of the actual trapping portion of the operation. A total of 16 bighorns (one ram, nine ewes and six lambs) were lost when a fire, apparently caused by an electrical short in the truck's wiring system, consumed the transport vehicle and all sheep aboard.

Sheep trapped from the River Mountains were utilized to accomplish reintroduction in both the Toquima Range (22 sheep released) and Hot Creek Range (18 sheep released) of Nye County. Additionally 25 sheep were released into the Stillwater Range of Churchill County to augment the initial reintroduction of 20 sheep accomplished last year. The last transport of 1982 was that of one ram and three ewes into the Jett Canyon area of the Toiyabe Range in Nye County for the purpose of providing some genetic variability into a historic population which has remained somewhat stagnate at low population levels. Data on composition and transport locations is provided in Table 2.

Table 2. Record of Desert Bighorn Sheep Trapped and Transplanted within Nevada during 1982.

Location	Ram	Ewe	Lambs Male	Lambs Female	Total
Hot Creek Range	3	10	1	4	18
Toquima Range	2	12	4	4	22
Stillwater Range	1	15	5	4	25
Toiyabe Range	1	3			4
Totals	7	40	10	12	69

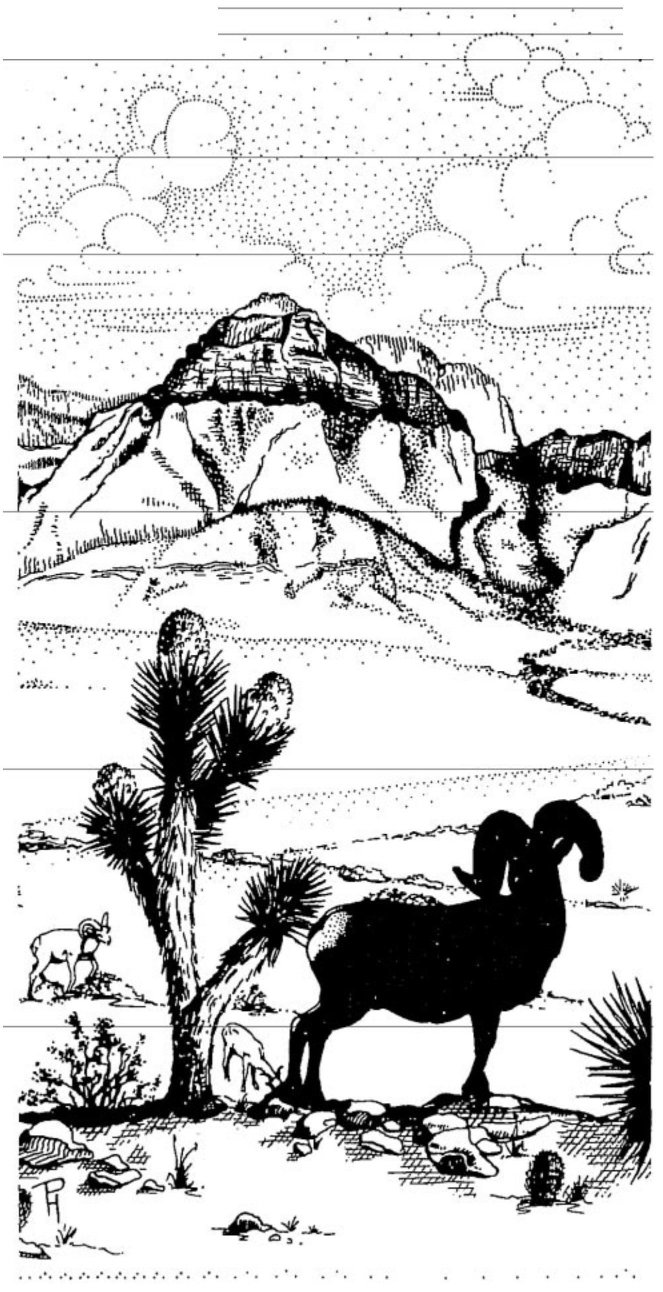
WATER DEVELOPMENT

The development of waters for the purpose of extending seasonal utilization and distribution of bighorn is a continuing program within the state. This past year budgetary constraints restricted the department's development activities to the maintenance of existing facilities.

However, the Bureau of Land Management, Las Vegas District, constructed a number of water catchment devices ("guzzlers") aimed at providing additional waters for bighorns.

Bureau of Land Management wildlife projects included the construction of three large guzzlers in the Mormon Mountains, a new guzzler in the Highland Range, and the reconstruction of two guzzlers in the Silver Peak Range.

Both the Nevada Department of Wildlife and the Bureau of Land Management have plans for additional developments in the near future.



STATUS REPORT UTAH'S DESERT BIGHORN

James W. Bates
Utah Division of Wildlife
Price, UT

Historical. The history of desert bighorn (Ovis canadensis *nelsoni)*, prior to 1957 in Utah as recorded in prehistoric and historic records has been reviewed by Dalton (1971). Skeletal remains of bighorn have been found in many parts of the state. Bighorn dung and remains have been found in cave excavations indicating possible use by prehistoric man as a source of food and clothing.

The earliest records of bighorn are the petroglyphs and pictographs created by early human inhabitants of Utah. Early records depicting bighorn are prevalent throughout the southern part of the state. Father Escalante in 1776 was the first white man to record bighorn in Utah (Briggs 1976). Early trappers and explorers in Utah also recorded bighorn in their journals (Haines 1955).

Bighorn were widespread throughout Utah prior to 1920, but with the advance of western civilization bighorn numbers began to decline (Buechner, 1960). Remnant populations still persisted in parts of the state in the 1940s when uranium was discovered in bighorn country. Prospecting and development of mines brought large numbers of prospectors and miners into the area eroding the habitat base and contributing to the demise of the bighorn.

BIGHORN INVESTIGATIONS

Initial Research. Interest in Utah's desert bighorn developed steadily through the late 1950s and early 1960s. The first bighorn hunt was proposed in 1964; however, the director needed information that a huntable herd existed. This resulted in the initiation of the first bighorn study in Utah which began in 1965 (Wilson 1968). A second study (Irvine 1969), a follow up, began in 1967. A third study (Dean 1977) soon followed in Canyonlands National Park. Since 1965 desert bighorn have been studied throughout southeastern Utah.

The first research project was centered in the rugged White Canyon-Red Canyon area of San Juan County, Utah (Wilson 1968). Wilson concluded that the bighorn population was static as a result of the following limiting factors: 1) lack of water, 2) competition with cattle and deer, 3) internal parasites and 4) high lamb mortality resulting from predation. Irvine (1969) followed Wilson's (1968) study and concluded contrary to what Wilson found that the bighorn population was growing as a result of low lamb mortality. Increased lamb survival may have been a result of increased water availability. Dean (1977) conducted the first study on the ecology of desert bighorn in Canyonlands National Park, Utah. His objectives were to determine distribution and abundance of bighorn in Canyonlands, effects of human encroachment and factors affecting bighorn movements. He concluded there were between 80 to 130 bighorn within Canyonlands National Park and that human activity and livestock grazing were limiting bighorn distribution. He found no migration of bighorn but observed seasonal movements of rams before and after the rut as they moved to and from areas of ewe concentration.

The first bighorn telemetry study (Bates et al. 1975) was conducted in the White Canyon-Red Canyon and extended north into the Cataract Canyon-Dark Canyon areas. The objectives were to study bighorn seasonal movement and distribution. They concluded rams occupied generally larger home ranges and moved greater distances each season than did ewes. Relocation distances of bighorn were the shortest during winter and summer, longer in spring, and longest during autumn. There was an overlap of home ranges and several animals occupied the same range, but not necessarily at the same time; rams utilized more major drainages than did ewes and ranged at higher elevations.

Two early bighorn studies (Wilson 1968; Irvine 1969) provided baseline bighorn data. As a result, in 1969 an aggressive bighorn management program was initiated by the Utah Division of Wildlife Resources. Since little was known about the general distribution of sheep throughout the southeastern region of Utah, winter aerial surveys were initiated and continued through 1979 when they were discontinued due to budgetary constraints. In 1977 the National Park Service and the Division signed a cooperative agreement to also conduct aerial surveys within Canyonlands National Park. The aerial surveys provided information on distribution, productivity, and bighorn population trends. They demonstrated a steady increase in numbers of bighorn throughout the area and a stable ewe lamb ratio of 48 lambs per 100 ewes.

The largest present day bighorn population in Utah occurs between Interstate 70 south to the San Juan River on the east side of the Colorado and Green Rivers. For management purposes the area has been divided into four units which include; 1) South San Juan, 2) North San Juan, 3) Canyonlands and 4) Potash (1982 hunting proclamation).

Aerial surveys and observations indicated populations in the South San Juan unit were stable or slightly increasing. Populations in North San Juan and Canyonlands (Needles District) were declining, indicated by fewer observations and the lack of sign on traditional trails. Bighorn within Canyonlands (Island District) and the Potash unit continued to increase and expand their range northward along the Colorado and Green Rivers.

Hunting. Prior to 1876 there were no regulations in Utah regarding the harvest of bighorn. When Utah became a state the legislature set a July through December season on big game. Bighorn were protected from hunting in 1899.

The initial research in Utah indicated that bighorn populations east of the Colorado River in San Juan County, Utah, could support a limited hunt. As a result between 1967 and 1981 the Division issued 178 trophy ram permits — had 174 hunters in the field, harvested 64 rams and achieved a 36 percent hunter success.

In Utah, a trophy ram is defined as a male sheep with horns scoring 144 points (modified Boone and Crockett scoring) or at least seven years old. A mandatory hunter training and orientation program is required of all successful applicants where scoring and aging techniques are taught by Division biologists.

Reintroduction. In 1967, the National Park Service investigated the possibility of reintroducing bighorn into Zion National Park. Bighorn had once been abundant in the area, but like other populations in the west, the numbers declined and eventually all bighorn in the area were extirpated (McCutchen 1977).

In 1972, twelve bighorn from Nevada were released into an 80 acre enclosure in Zion National Park to propagate animals for release into the park and into other areas in Utah where they had once occurred. By 1976 the population had increased to 22 animals. In 1977, 13 bighorn were trapped from the enclosure, transported by helicopter to a smaller 10 acre release enclosure and eventually released into the wild.

During this period bighorn populations increased and expanded in other parts of the state and the Division established a goal to reintroduce bighorn into suitable historic habitats. An aggressive reintroduction program was developed that evolved through experience gained from various capture and transplant operations over many years. A combination of techniques were used to assure the success of any particular project.

Earlier project success depended on the use of drugs. Capture myopathy was identified as a source of mortality in captures utilizing M-99 as an immobilizer. When drugs were used, capture myopathy was eliminated by holding the sheep in a horse trailer or truck where they could be held together and not isolated from other sheep. Capture mortality was eliminated by going from capture gun and drugs to drive nets. Transportation problems were reduced to a minimum by transporting groups of sheep in trailers or trucks. When using the helicopter 3 to 5 sheep were confined in body bags and transported in the backseat. Stress apparently was greatly reduced by not using drugs.

The aerial surveys resulted in one of the highlights of the bighorn transplanting program in Utah when an agreement was made between the Utah Division of Wildlife Resources and the National Park Service, Canyonlands National Park on December 31, 1981. The bighorn population in the park was increasing so a cooperative agreement was signed that allowed bighorn to be captured and transplanted within and without the National Park dependent upon available surplus sheep. Since the agreement was made, one transplant project from the park has been completed. This completed five areas where bighorn were reintroduced in Utah over the past five years (Table 3).

Table 1. Desert Bighorn **Transplants** in Utah.

Location	Rams	Ewes	Lambs
Moody Canyon (1977)	6	17	
Kaiparowits (1982)	7	25	2
West Water (1979)	2	5	
San Rafael Swell (1982)	5	18	1
Maze (1982)	5	10	8
Total	**25**	**75**	**11**

Disease. The Division is concerned with the health and welfare of bighorn and emphasizes control of all mortality factors including disease.

Sinusitis, a chronic disease that infects bighorn, is a potential decimating factor posing a serious threat (Bunch et al., 1978). Sinusitis has been observed in native populations from Red Canyon, San Juan County, north to Moab, Grand County, Utah. Several have been captured, some observed on aerial surveys, and others captured after being observed by persons on the range. The exact cause of the disease is still unknown. To assure the health and welfare of our herds, this problem must be solved through clinical research; therefore, the Division will continue to pursue and contribute to research until the causative agent is determined and perhaps a cure effected.

To aid in clinical research bighorn disease, the Division captured 2 desert bighorn rams in September 1979 to hybridize with ewes (*Ovis musimon x O. ammon*) at Utah State University. These ewes have been selectively developed for research under confinement and represent one of the best groups as such in the United States. The rams were kept at their isolation facilities at the University Veterinarian Farm and used for breeding from the middle of September to the first of November when they were returned to the place of capture.

The objectives of the study were: 1) develop a nearly pure desert bighorn (3/4 to 7/8) for research under strict confinement, 2) inoculate hybrid rams with bat fly larvae to determine if the larvae initiates sinusitis and 3) develop methods of treating disease under field conditions. Results of the study were not achieved. Only three lambs were born — all dead. This first attempt didn't work.

A ewe, exhibiting clinical symptoms of sinusitis, was captured in the spring of 1980 and delivered to Utah State University for examination and treatment. She responded to treatment briefly but expired to the disease within 3 months.

In 1981 a cooperative agreement between the Division of Wildlife Resources and the Glaze Veterinarian Clinic, Kerrville, Texas was completed to allow continued research on bighorn sinusitis. The Division has agreed to provide animals exhibiting clinical symptoms to Glaze Clinic where Dr. Glaze will perform the clinical research. Hopefully this will provide needed information to develop a cure or preventative agent for desert bighorn sinusitis.

A radio collared ewe with sinusitis was captured in 1981 in Canyonlands National Park and shipped to the Glaze Clinic. She was successfully operated on at the clinic and continues to progress. Two rams with sinusitis were captured in Canyonlands National Park, Utah in 1982. One ram was sent to the Glaze Clinic where he expired due to a dislocated hip. The other ram died at the capture site.

Habitat Improvement. The Division in cooperation with the Bureau of Land Management and the Utah Chapter of the Desert Bighorn Society have developed springs and seeps for bighorn use in the South San Juan unit. Twenty-one projects have been completed to date.

Public Education. The Division is actively engaged in all aspects of public education to promote better bighorn management. The Division has provided skulls, capes, and hides to major universities for their mammalogy museums to further knowledge of university personnel and students regarding desert bighorn. Utah State Parks at Blanding has been provided with bighorn skulls and horns for display to enlarge the public's understanding of bighorn and their habitat.

To promote better relationships with all concerned with bighorn, the Division has worked cooperatively with the U.S. Department of Agriculture veterinarian to assure the health and stability of the herds. Samples of blood chemistry have also been provided to several universities and the crime lab at Weber State College in Ogden, Utah.

Continued Research. Recently, several cooperative bighorn research projects were entered into between the Bureau of Land Management, U.S. Forest Service, National Park Service, Utah State University and the Utah Division of Wildlife Resources.

Bates (1982) studied habitat used by bighorn and evaluated forage utilization. He found distance to escape cover and cover value of the area to be variables most strongly correlated with location of bighorns throughout the year. He concluded that bighorn used 43.2 percent shrubs, 38.4 percent grass and 18.4 percent forbs; however, when compared to availability, shrubs were used less than expected and forbs more than expected. He observed removal of domestic livestock from the park appears to have contributed to increase and expansion of bighorn within the park.

King (1981) completed a review of literature on bighorn. Historical material and information on bighorn life history, movements, foraging habits, etc. was summarized. Field work began in 1981 to determine bighorn movements, foraging habits, habitat utilization, influence of mining, recreation, livestock use, and disease on bighorns.

An interpersonnel agreement was entered into between the Division of Wildlife Resources, U.S. Forest Service and the Bureau of Land Management in 1981. The first annual report on this project is due July 1, 1982.

The employee will identify new springs, seeps, streams, tanks and other waters and determine their seasonal status. He will identify water development opportunities and will identify and prioritize project maintenance needs. He will conduct periodic bighorn surveys and document seasonal bighorn movements, distribution and map critical areas. He will also provide assistance in bighorn sheep capture and transplanting programs.

A follow up to the Bates Canyonlands bighorn study (1982) has been initiated. Bill Hull, graduate student Utah State University, will continue research within Canyonlands National Park.

These cooperative research studies in southeastern Utah will update and enhance bighorn habitat development and management practices.

CURRENT PROBLEMS

Financial. Financial problems within the State of Utah and budgetary constraints within the Division of Wildlife Resources have severely limited and curtailed bighorn management programs. These financial limitations are serious concerns to the UDWR. These problems are being alleviated by alternate financing such as: 1) auctioning a bighorn hunting permit to the highest bidder, and 2) solicitation of research funds from foundations and conservation organizations. These funds, coupled with sound management practices, particularly comprehensive trapping and transplanting programs, will help insure the perpetuity of desert bighorn in Utah.

Livestock Competition. Throughout the desert bighorn range in Utah, livestock compete with bighorn for space, forage, and water (Bates 1982). Livestock in the arid desert must use the same resources that the bighorn do. Any of these areas of competition can become limiting and affect numbers and distribution of bighorn.

Historically the southeastern bighorn range of the state has been grazed by a few large livestock companies such as Scourp's and Redd's. These large livestock companies have sold out and livestock permits have changed hands in recent years. The new permittees generally are younger, more aggressive managers and use all the water and land resource available to them. Permits are being reactivated and cattle are being put back onto desert ranges where they haven't grazed for a number of years. Livestock numbers are being increased from the current demand to the permittee's preferential right. Cattle in canyons such as Red Canyon, San Juan County, compete with bighorn from the valley floor to the base of the Wingate (Wilson 1968, 1969; Irvine 1969).

Livestock trespass on bighorn range is a problem. Operators trespass livestock and in many instances damage to range used by bighorn has occurred before livestock have been or can be removed.

The Division is steadily receiving requests from livestock operators to revegetate native range or to improve springs and seeps for livestock management in areas that have been historically unavailable to livestock. Future range or water development must be carefully selected to avoid expanding use of the range within bighorn habitat by domestic livestock thereby canceling or deteriorating the effect of any wildlife improvements.

The Division works closely with public land management agencies to maintain and improve conditions on the desert ranges for bighorn. To guarantee survival and restoration of bighorn populations, public interest groups and conservation groups must actively participate in habitat restoration projects and in the political process.

Mineral Development. During the last 30 years man has exploited the earth's mineral resources to meet the needs of modern day life styles. In this unrelentless quest the wilderness required for bighorn survival has been widely penetrated, made more accessible to man, developed for industrial use and in general degraded. Laws regulating "locatable minerals" such as uranium were developed under principles and concepts popular during the late 1800s and are antiquated. Regulations relative to "leasable minerals" such as potash are of modern day origin but interpretation and the resultant policies are influenced by changes of federal or state administrations. The environmental regulation of "saleable minerals" such as sand, gravel or rock has great flexibility and is seldom manipulated by the political process.

The mineral industry is a source of disturbance to bighorn and a serious competitor with bighorn for limited water resources (McQuivey 1978). Mining camps, exploration operations and industrial development require water. Seeps and springs are frequently enclosed and piped away and slick rock tanks are pumped. All of these activities are or can be accomplished without legal consequences, since water laws apply only to uses by man or his livestock — wildlife are not considered a beneficial use of water.

Growth of Utah's human population is directly related to growth in the mineral industry. Existing settlements have grown to become cities. Some new towns have appeared. During the "off duty" periods Utahns become recreationists. They invade the bighorn's wilderness due to its great aesthetic appeal; they cause exploration roads to remain open; they frequently extend or create roads with ORV equipment; they camp at water holes and regularly explore once remote canyons and mesas; and some become involved with poaching.

Bighorn managers must strive to understand the complex laws regulating mineral exploration and development. Knowledge of water laws is also a must as well as a basic up to date understanding of reclamation techniques. This background coupled with experience in traditional bighorn management techniques may allow for perpetuation of the bighorn resource into future generations. Possibly our greatest challenge will be management of dispersed recreators. In Utah these challenges are being met through development of a resource analysis section (RAS) within the Division of Wildlife Resources.

FUTURE OUTLOOK

The Division's management objectives are firm and in the future they intend to continue to: 1) increase the knowledge of the life history, distribution, behavior and habitat requirements of bighorn as well as effects of human intrusion and activity, 2) to maintain the current population of bighorn by reducing human impact on present sheep habitat and populations, 3) to expand present distribution of bighorn into suitable and historic habitats through natural expansion and selected transplants, and 4) to provide increased opportunity for consumptive and non-consumptive use of bighorns through expansion of bighorn populations and through an aggressive I & E program. These objectives will be accomplished through the resources and funds available for continuing bighorn management and research.

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THE COLORADO DESERT BIGHORN INTRODUCTION PROJECT A STATUS REPORT

Paul J. Creeden
John L. Schmidt
Dept. of Fishery & Wildlife Biology
Colorado State University, Ft. Collins, CO 80523

Abstract. Three transplants involving a total of 36 desert bighorn have been made in western Colorado since 1979. Twenty five sheep have been radio collared and all 3 releases have been closely monitored. Reproduction resulted in 1 lamb in 1980, 7 in 1981 and 10 lambs in 1982. All 10 lambs produced in 1982 were believed to be alive through August when intensive research ceased. Five of 8 lambs born in 1980 and 1981 were recruited into the 1+ age class. Sixteen mortalities have been recorded since the initial release. The known active lamb:ewe:ram ratio is currently 10:14:10. Early interaction with established sheep and formation of groups soon afler release were important in limiting individual exploration of the 1981 transplant group. The herd presently occupies approximately 125 km² of the canyonlands of the Colorado River in and' around Colorado National Monument. Water availability does not appear to be a critical problem for the herd.

INTRODUCTION

The question of historical presence of bighorn sheep *(Ovis canadensis)* in extreme western Colorado is subject to debate. Buechner (1960) included this area as historic range and Monson (1980) believed desert bighorn once extended from Utah into Colorado along the Colorado River. The study area was not considered historic range by Cowan (1940) or Bear and Jones (1973) however. Dalton and Spillett (1971) found skeletal remains of bighorn less than 80 km from the Colorado National Monument area and Kasper (1977) found bighorn bone fragments in adjacent Montrose County. Petroglyphs (Stroh and Ewing 1964) and pictographs (Denny 1976) of bighorn have been found in and around Colorado National Monument. A study by Bauer (1977) indicated desert bighorn could be successfully transplanted into the canyon country of the Colorado River.

In an attempt to establish desert bighorn in areas of suitable habitat and probable historic range, the Colorado Division of Wildlife, U.S. National Park Service and Bureau of Land Management, in cooperation with the states of Arizona and Nevada, initiated efforts to introduce the desert bighorn. Three transplants involving a total of 36 sheep have occurred. Eleven sheep *(O. c. mexicana)* captured on the Kofa Game Range in Arizona were released on 8 November 1979. Sixteen sheep *(O. c. nelsoni)* from the Lake Mead National Recreation Area in Nevada were transplanted on 17 June 1980. The third transplant involved 9 ewes *(O.* c. nelsoni) captured in the Black Mountains of Arizona and occurred on 19 November 1981.

We would like to acknowledge the following organizations for their participation in this project. Funding has been provided by the National Rifle Assocation, the Pope & Young Club, the Rocky Mountain Bighorn Society and the Colorado Bowhunters Association. The Colorado Division of Wildlife has provided assistance in many ways including supplying a vehicle, fixed-wing air time and a helicopter flight. The National Park Service and Bureau of Land Management have provided tactical support. Our special thanks to Dr. R.S. Cook and Mr. J.H. Ellenberger for their help.

STUDY AREA

The study area is located in Mesa County, Colorado and comprises approximately 670 km² of the canyonlands of the Colorado River. It extends westward from Colorado National Monument into Utah and is bounded on the north by the Colorado River and on the south by Glade Park (Ravey and Schmidt 1981). Situated on the northeast edge of the Uncompahgre Plateau the area is characterized by numerous mesas and deep sandstone canyons having steep talus slopes. Elevation rises in abrupt steps from 1370 m at the Colorado River to over 2150 m on Black Ridge. The area is considered semi-arid desert with cool winters and hot summers. Annual precipitation averages 28 cm.

MATERIALS AND METHODS

The 1979 transplant involved 11 sheep (8 ewes and 3 rams) captured as individuals with the aid of a helicopter. The sheep were trucked to the mouth of Devils Canyon and directly released. The second release included 16 sheep (7 ewes, 4 rams, 3 male lambs and 2 female lambs) captured in 2 groups and airlifled to a 1 ha enclosure within Colorado National Monument and held overnight (Ravey and Schmidt 1981). The latest release involved 9 ewes captured as individuals with the aid of a helicopter. A direct release was again employed using the Devils Canyon site. All sheep received eartags and adults were collared prior to release. Six, 10 and 9 sheep from the 1979, 1980 and 1981 transplants were radio collared. Radio telemetry equipment was purchased from Telonics, Inc. of Mesa, Arizona.

Monitoring involves radio tracking from the ground and air as well as analysis of animal sign. When possible aerial positions are followed up by observation. Ground positions are determined by obtaining 2 or more line of sight signals separated by at least 1 km each. Location, habitat and behavior data are recorded during each observation. All positions are plotted on USGS 7.5 min. topographic maps using the U.T.M. coordinate system.

RESULTS

Field research in 1982 resulted in a known active population of 34 sheep. The observed lamb:ewe:ram ratio was 10:14:10 in August when intensive monitoring ceased for the year (Fig. 1). Four marked sheep were not observed during the study. The Colorado desert bighorn herd presently occupies approximately 125 km² of the canyonlands of the Colorado River in and around Colorado National Monument. Activities in 1982 were centered 2.5, 3.0, 5.0, 7.5 and 10 km from the site of the 1979 and 1981 releases.

Movements. Ravey and Schmidt (1981) compared the exploratory behavior of the 1979 and 1980 transplant groups. They reported that sheep captured as individuals and directly released scattered and initially explored as individuals while sheep captured in groups with existing social structures and held in an enclosure prior to release explored primarily in groups. The desert bighorn released in 1981 showed characteristics of both types of behavior. Radio tracking the day of the release followed by an aerial survey 20 November revealed that 6 of 9 ewes remained within 2 km of the release site. A seventh explored 4 km south along the west rim of Devils Canyon. Of the 2 remaining, 1 traveled 7 km west to Rattlesnake Canyon while the other explored 5 km southeast into Colorado National Monument.

Four ewes grouped together shortly after being released, exploring 1 km east of the release site initially then the east rim of Devils Canyon. One of these ewes was found dead shortly after intensive research began. Another ewe from the 1981 release joined this group in late February. The group remained intact throughout the 1982 study and has made extensive use of the Kodels Canyon area, 2.5 km east of the release site.

Two other ewes remained in lower Devils Canyon following release and joined a group composed of rams and ewes from the earlier transplants. One of these ewes continued to associate with individuals from previous releases throughout the spring and summer months and has explored Devils Canyon extensively. The other ewe left this group and joined the previously mentioned group.

The 3 ewes exploring farthest apparently did so as individuals and had no known interactions with other sheep immediately following release. The ewe traveling to Rattlesnake Canyon entered the canyon and remained there throughout August. Her first documented association with other sheep occurred on 6 June. The ewe exploring the west rim of Devils Canyon remained in that area throughout the 1982 study and was first observed with other sheep on 24 May. The ewe traveling into the Monument continued to move southeast to Bangs Canyon, 29 km distant. She made a trip back to the release area then returned to Bangs Canyon where her carcass was later found.

Movements of radio collared sheep from the previous releases were primarily confined to activity centers established in 1980 and 1981. These sheep exist in 3 fairly stable groups occupying the mesas and canyons from Devils Canyon to Mee Canyon, 10 km west of the release site.

Lamb Production. Reproduction has resulted in a minimum of 18 lambs since the initial transplant in 1979. One lamb was produced in 1980 and 7 more were documented in 1981 (Ravey and Schmidt, unpbl. rep., Dept. of Fishery and Wildlife Biol., Colo. State Univ. October 1981. 5pp.). Ten lambs were observed in 1982 resulting in a lamb:ewe ratio of 10:14 or 71%. Of the 4 ewes not lambing 2 were yearlings and 1 was a 1981 lamb.

Five of 7 ewes surviving from the 1981 release and bred in Arizona lambed in Colorado. In addition, 1 ewe which died was carrying a fetus. This results in a production ratio of 6 lambs:8 ewes or 75% for this sample of Black Mountain ewes. Five of 7 or 71% of ewes from the previous transplants and breeding in Colorado produced lambs in 1982.

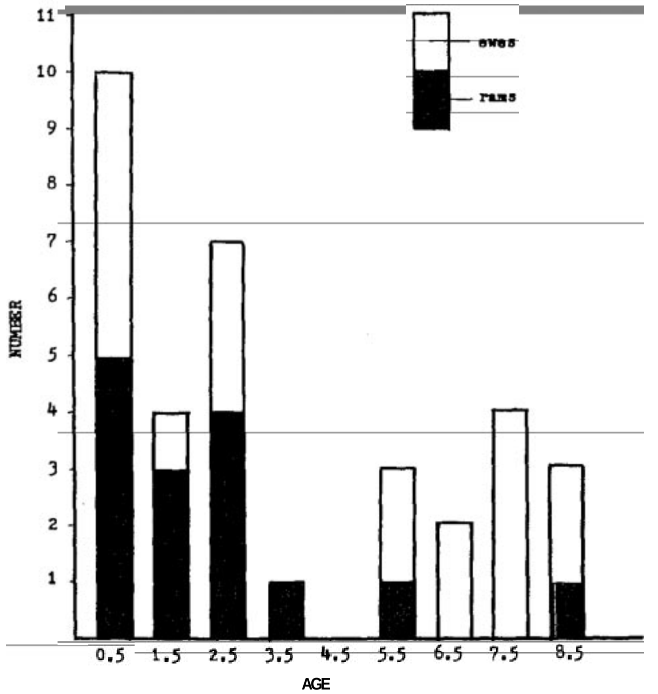

Fig. **1.** Sex and age structure of the Colorado desert bighorn herd in August **1982.**

Nine of 10 ewes lambing did so inside major canyons. Ewes typically selected ledges and rock outcrops at or very near the vertical canyon walls and atop steep talus slopes. Wilson (1968) reported lambing occurring in similar habitats in southeast Utah and use of such areas appears consistent with the bighorns evolved predator evasion strategies (McCutchen 1982).

Social rank appeared to influence lambing behavior of ewes. Nondominant ewes secluded themselves from other sheep prior to lambing and did not rejoin other ewes until a week or so after parturition. This is often observed in bighorn sheep (Geist 1971, Welles and Welles 1961). Dominant ewes (n=3) did not go into seclusion prior to lambing and allowed their 1 to 3 day old lambs to follow them while foraging with other sheep.

Mortality. Sixteen mortalities have been recorded since the initial release. Eight sheep perished after becoming trapped on a ledge. A ninth sheep, a young lamb, was observed on the ledge with the other sheep and was never seen again. In addition, predators have claimed 4 sheep (mountain lion 3, coyote 1), poachers 1 and there were 2 undetermined causes of death.

Two mortalities were recorded in 1982, both involving adult ewes from the 1981 release. A 3.5 year old ewe was found dead on 2 February. She was apparently killed by a lone coyote as she walked along the east rim of Devils Canyon. A dismembered fetus was found nearby. A 4.5 year old ewe was found dead in a densely vegetated drainage in Bangs Canyon on 24 April. Examination of the kill site and carcass indicated she was a victim of mountain lion predation.

WATER SOURCES

Snowmelt and spring rains provided the bighorn with numerous water sources during the spring of 1982. Standing water persisted in canyon bottoms and drainages through early June. Springs, seeps and rain filled potholes were used during the summer months when supplies were more limited. Water availability did not appear to be a critical problem for sheep in 1982 and radio location data indicate the sheep did not use the Colorado River as a water source.

DISCUSSION

Many factors are known to influence exploratory movements of desert bighorn including seasonal availability of food and water (McQuivey 1978), reproductive status, presence of conspecifics and predators (McCutchen 1982) and weather conditions (Ravey and Schmidt 1981). Early interaction with the established bighorn population and formation of groups soon after release appears to have been important in limiting individual exploration of 6 of the 9 ewes transplanted in 1981. The sheep exploring farthest were not observed or radio positioned near other sheep following the release. Since the period immediately after release seems most critical in dispersal, the use of a short term holding pen to allow reduction of transplant related stress and facilitate social interaction between the sheep to be released should be considered for future transplants.

This year's high lamb production and survival through the first 4-6 months of life is encouraging and compares favorably with data from other desert bighorn populations (Wilson 1968, McQuivey 1978, Hansen 1980). The lone lamb born in 1980 is still alive as are 4 of 7 lambs produced in 1981. Lamb survival in 1982 is expected to be high. Only 2 mortalities were noted during 1982 and the herd appears to be recovering quickly from the heavy losses sustained in 1981.

Timing of reproductive activities is thought to be the major means of modifying lamb survival (Bunnel 1982). When transplanting into different environments one would expect to see a shift in the estrous cycle and subsequent lambing period assuring births during periods most favorable to survival (Demming 1961). The lambing period for the ewes bred in Arizona began earlier and was nearly 3 times as long as that of ewes conceiving in Colorado. The observed difference in timing and duration may be the result of adaptation to the Colorado environment and will be further investigated in 1983.

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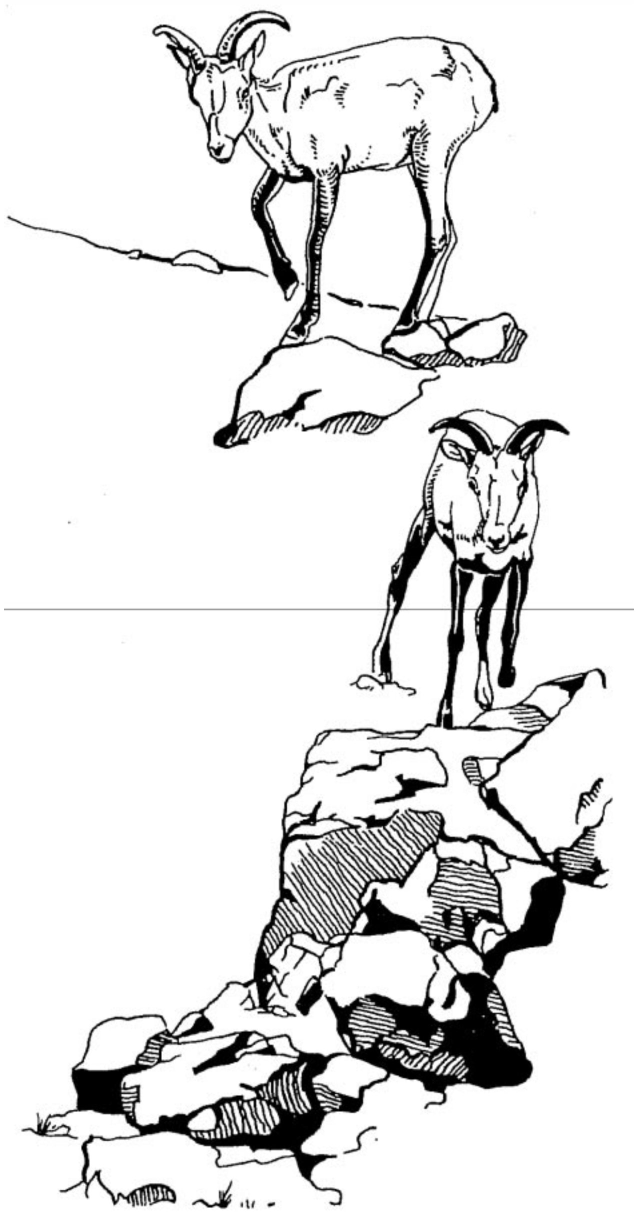


REPORT OF THE FERAL BURRO COMMITTEE

Steven D. Kovach, Chairman
Natural Resources Management Branch
Naval Facilities Engineering Command
San Bruno. CA

Last year's report was pretty much a mixed bag of good newslbad news. In general, this year's has much more good news than bad; things are improving, that is if you do not like free ranging feral burros.

NEVADA

No real change from last year. Burros are not a problem in or immediately adjacent to bighorn habitat. Some removals were proposed last year primarily for vegetation rehabilitation projects, however.

NEW MEXICO

Finally something is happening with the situation at Bandelier National Monument. In early 1983 the courts decided in favor of the National Park Service (NPS) and has allowed the NPS to implement their original proposal — allow Fund for Animals to round up all the burros they can, or, when it is no longer economically feasible, the NPS will shoot what is left. NPS is currently negotiating with Fund for Animals for the live capture effort. Fund for Animals will have 60 days, starting in late April, after which time the program will be evaluated for continuation of the live captures or the need to start the shooting phase. The burro population was censused one year ago at 50 head. Reasons for the low numbers are unknown.

ARIZONA

Between late April and September 1982, Bureau of Land Management (BLM) removed 500 burros, primarily from the Black Mountains outside of Kingman. Thus far in Fiscal Year (FY) 1983 (October to mid-March) only 55 burros have been captured. The storms have created numerous problems, the least of which were stuck vehicles and scattered animals. The goal for this FY is a total removal of 600 - 650 burros: 50 from the Arizona Strip; 450 from the Black Mountains, and 200-250 from the Colorado River area. Burro numbers within the Arizona Strip have been increasing and may soon become a serious problem. The NPS reports that no burros have been sighted in Grand Canyon during the past year.

CALIFORNIA

During the current FY, BLM crews have removed 500 burros from the California Desert Conservation Area (CDCA); an unspecified number of additional burros will also be removed from the CDCA. BLM officials and the capture crews remain optimistic, if adequate funding continues, all burro removals called for the CDCA Plan will be completed by the end of FY-85. Current removal efforts are being concentrated on BLM lands surrounding the China Lake Naval Weapons Center and Fort Irwin.

Recent censuses conducted along the California side of the Colorado River indicated a significant drop in burro numbers. Poaching and the removal efforts by the Arizona BLM are believed responsible for the reduced numbers. The California BLM has no plans to remove burros from this area as their numbers are already below the herd management levels specified in the CDCA Plan.

Plans for Death Valley National Monument are moving right along. The Final Environmental Impact Statement was released on 3 November 1982 and approved by NPS and Interior officials on 19 February 1983. The NPS filed their Record of Decision in the 8 March 1983 Federal *Register.* The option selected calls for burro removals in a three year effort of concentrated live captures starting 1 October 1983. NPS and BLM have entered into a Memorandum of Understanding (MOU) for the BLM to round up the burros, transport to holding facilities where the burros will be kept for up to one week. A consortium of animal protection groups will then take the burros and take care of branding (supplies paid by NPS), veterinary care, and the adoptions. The NPS plans to start their removals in the southern end at Butte Valley and work north thereby taking maximum advantage of the Navy's removals. Funds for the top priority fencing project (the northeast corner of the Monument), which will keep out trespassing cattle and burros, may become available in the upcoming FY.

Up until the census last August, Death Valley's burro population was increasing at a rate (minimum) of 15%. However, the 1982 census came up with 2,500 burros, no change from 1981. This apparent no growth by the burro population may be attributable to two factors: precipitation during the census which did scatter burros; and removals of Death Valley burros that had wandered onto Navy lands (more on this point later).

Last year this committee reported that burros had reached the Black Mountain Range. NPS attempted twice to remove these animals but was only partially successful. Since the last removal attempt in April 1982 more burros have crossed the valley and entered the Black Mountains. Death Valley's burros have now added approximately 200 square miles to their range. Despite these expansions NPS did manage to remove 90 burros between August 1981 and August 1982 for highway safety reasons.

The Navy continues with its effort to eliminate burros from their China Lake Naval Weapons Center. Between April 1982 and mid-March 1983 another 3,173 burros have been removed. This brings the total number of burros removed since March 1980 to 5,329. Present estimates indicate only 100 to 200 remain to be captured. In November 1982 the Navy started its feral horse reduction program. To date 221 feral horses have been removed, another 450 are targeted. This will bring the horse population down to 375 at which time studies will be initiated and an overall grazing management plan prepared. The grazing plan will address topics such as: should cattle be allowed to graze Navy lands again, final disposition of the feral horse population, deer herd size; and bighorn reintroductions.

As mentioned earlier, the Navy was taking some of Death Valley's burros which had wandered onto Navy lands. Although this has always been suspected, positive evidence for this came when two burros marked with identification collars, placed by Dr. Douglas in 1975 in Butte Valley, were captured in Panamint Valley approximately one mile northwest of Wingate Pass. Additionally, a radio-collared burro was seen at Wingate Pass on 14 February 1983. One burro was captured on the foothills of the Slate Range west of Layton Pass on 28 February 1983. It is unknown whether these 2 burros were one and the same. These locations are approximately 13 air miles and 20 air miles southwest of Butte Valley, respectively. However, the estimated travel routes through Goler Wash or Wingate Wash to the Panamint Valley location would have resulted in moves of 18 and 24 miles, respectively.

OTHER ITEMS

Problems with the use of helicopters has arisen. The 1959 Wild Horse Annie Act (PL 82-234) prohibited the use of aircraft for rounding up burros and horses. The Wild Free-Roaming Horse and Burro Act (PL 94-195) of 1971 allowed for the use of helicopters for management purposes only. In January 1983 Mr. Jim Clapp severely hampered the Navy's operations by bringing up PL 82-234. Numerous meetings between DOD legal and DOI legal resulted in a no contest decision and the use of helicopters was suspended. This action by Mr. Clapp has not only affected the Navy's capture efforts but has also affected Death Valley's plans. Current efforts to work out this problem involve introduced legislation by the BLM to have PL 82-234 repealed and a rider attached to the NPS FY-84 budget bill which would exclude Death Valley specifically from PL 82-234.

Recently four or five burros have been sighted near Joshua Tree National Monument. These animals have apparently been abandoned after previously going through the BLM's adoption processes, as the animals are wearing brands. To date one jenny has already foaled.

Adoption fees have been changed again. On 4 March 1983 both the BLM and the U.S. Forest Service dropped the fees for feral horses from $200.00 to $125.00. Additionally, persons who adopted approximately 2,700 horses while the fees were $200 will be receiving a $75 refund from these agencies. Agency officials insisted the move was necessary to maintain adoption requests. Also initiated on 4 March 1983 was a non-refundable $25 application fee for all persons wishing to adopt horses or burros. The application fee is applicable towards the adoption fee.

TEXAS BIGHORN STATUS REPORT 1983

Bob West
Texas Parks and Wildlife Department
San Angelo, TX

A comprehensive report of Texas bighorn reintroduction efforts was presented at last year's meeting. Consequently, this report will cover only what has transpired since then.

The one ram which was left in the 427 acre Black Gap brood pasture cannot be located. It is believed that he escaped through a hole in the fence. It is felt that no more than 5 to 10 free-ranging bighorns remain from the 1971 release of 20 sheep.

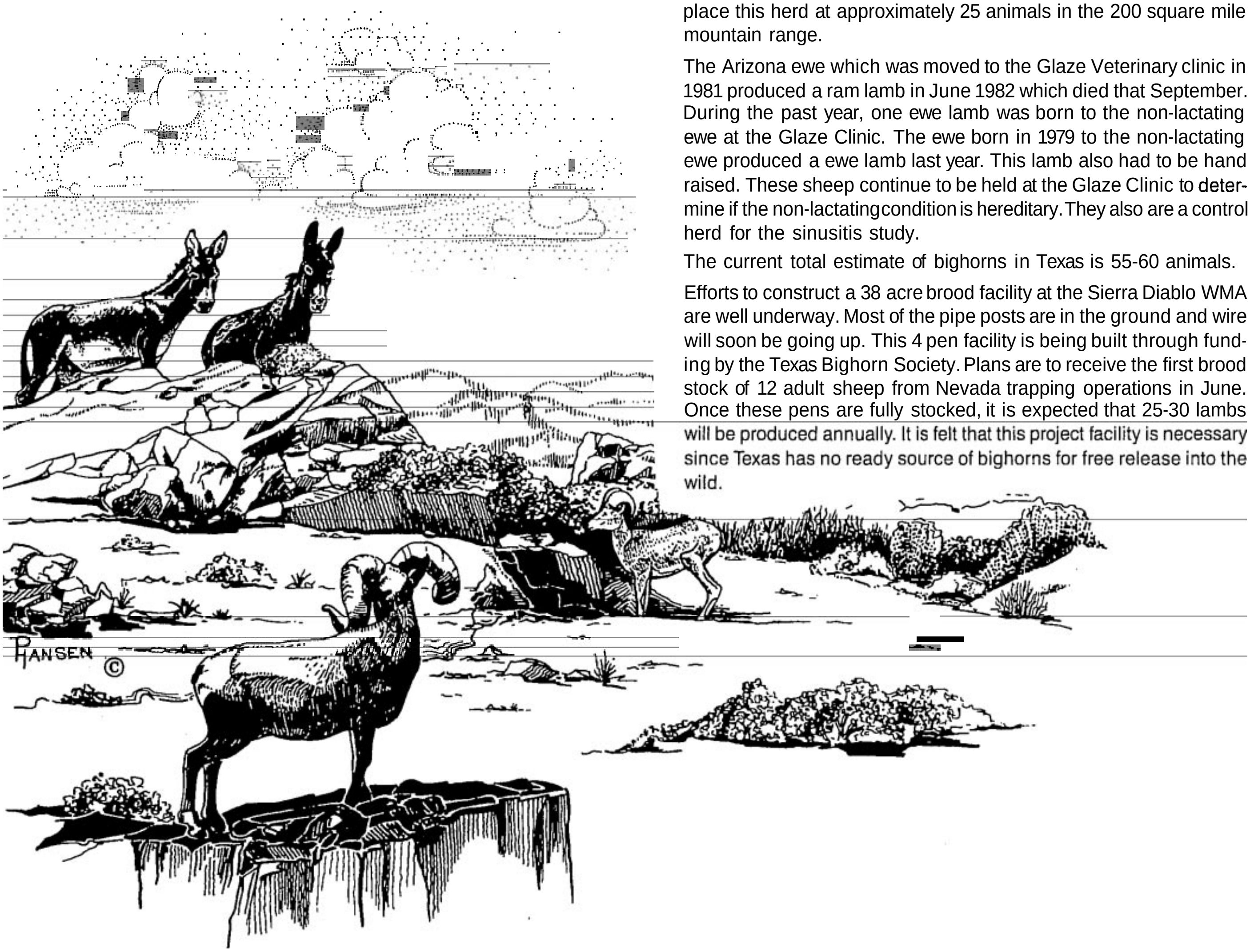
The captive herd of bighorns in the 600 acre Chilicote Ranch brood pasture produced 5 lambs last year. This herd consists of 6 rams, 6 ewes, and 5 lambs. One ram escaped from the pasture when a rockslide damaged the fence. This ram continues to range free in the vicinity of the brood pasture.

Several free-ranging bighorns from the 1973 and 1979 releases of 14 animals on the Sierra Diablo Wildlife Management Area were sighted in the Sierra Diablo Mountains during the past year. Estimates again place this herd at approximately 25 animals in the 200 square mile mountain range.

The Arizona ewe which was moved to the Glaze Veterinary clinic in 1981 produced a ram lamb in June 1982 which died that September. During the past year, one ewe lamb was born to the non-lactating ewe at the Glaze Clinic. The ewe born in 1979 to the non-lactating ewe produced a ewe lamb last year. This lamb also had to be hand raised. These sheep continue to be held at the Glaze Clinic to determine if the non-lactating condition is hereditary. They also are a control herd for the sinusitis study.

The current total estimate of bighorns in Texas is 55-60 animals.

Efforts to construct a 38 acre brood facility at the Sierra Diablo WMA are well underway. Most of the pipe posts are in the ground and wire will soon be going up. This 4 pen facility is being built through funding by the Texas Bighorn Society. Plans are to receive the first brood stock of 12 adult sheep from Nevada trapping operations in June. Once these pens are fully stocked, it is expected that 25-30 lambs will be produced annually. It is felt that this project facility is necessary since Texas has no ready source of bighorns for free release into the wild.



ARIZONA BIGHORN SHEEP STATUS REPORT 1983

Richard Remington
Arizona Game and Fish Department
Yuma. AZ 85365

Abstract. A total of 1716 bighorn sheep classified on ground and aerial surveys consisted of 456 rams, 883 ewes, 298 lambs and 79 yearlings. Forty-two hunters harvested 36 rams for 86% hunter success. Research is continuing in Arizona to determine bighorn sheep and livestock interactions in Aravaipa Canyon. Studies have also begun on the U.S. Army, Yuma Proving Ground to document bighorn use of the military installation. Research is continuing to compare successes of enclosure and wild releases of bighorn in Arizona. A research project funded by electrical utility companies to access impact of power line construction and existence on bighorn has entered its sixth year. Research on impacts of the Central Arizona project on bighorn sheep is continuing. These studies are funded by the U.S. Department of the Interior, Bureau of Reclamation and is in its fourth year. Monitoring is continuing on the Virgin Mountains, Redfield Canyon-Muleshoe, and Goat Mountain-Painted Cliffs transplants. Ten bighorn ewes were captured in southwest Arizona and transported by New Mexico Department of Fish and Game personnel to the Peloncillo Mountains of southwest New Mexico to supplement the existing transplant. Some 33 bighorn transplant sites have been identified within Arizona. Planning is continuing for future bighorn sheep capture techniques and transplants within Arizona.

During 1982-83 bighorn sheep surveys were conducted within 19 Game Management units, some with several mountain ranges, within the state of Arizona. Bighorn surveys were conducted both on the ground and with the aid of helicopters. During the survey period a total of 1716 bighorn were classified, consisting of 456 rams, 883 ewes, 298 lambs, and 79 yearlings. Calculated sex and age ratios are 52 rams to 100 ewes and 34 lambs to 100 ewes. The majority of the 1982 aerial surveys were conducted during the fail months.

As in the past, Arizona again conducted a conservative bighorn sheep hunt. A total of 42 permits was authorized for the 1982 bighorn sheep hunt, not including those authorized by the Hualapai Indian Reservation; This was a decrease of three permits from.1981. The 1982 bighorn permits were distributed over 19 hunting areas. The number of permits varied within each hunt area from 1 to 5 permits.

A total of 2585 first choice applications were received by the Department for the 42 permits (not including the Hualapai Indian Reservation). This was an average of 62 first choice applications for each bighorn permit. Total applications received by the Department for the 1982 bighorn hunt were comprised of 1858 resident and 728 nonresident applications.

During the 1982 bighorn hunt a total of 42 hunters harvested 36 rams for 85.7% hunter success.

As shown in Table 1, hunter success has remained fairly stable for the past six years with the exception of the lower success shown in 1980.

Ages of bighorn harvested ranged from 3 to 11 years and averaged 7 years. Green Boone and Crockett scores ranged from 120 018 to 188 218 and averaged 156 018 from the 1982 bighorn hunt.

During the 1982 bighorn hunting season, restrictions on the size of a legal bighorn ram were relaxed in 3 hunt areas. Current restrictions for a legal bighorn ram in Arizona read "Mature Ram means

Table 1. A Ten Year Summary of Arizona Desert Bighorn Sheep Harvest.

1973 to **1983**

Year	Permits	Hunters	Harvest	% Hunter Success
1973	71	68	38	56
1974	62	62	41	66
1975	60	57	35	61
1976	61	61	46	75
1977	57	57	50	88
1978	58	54	45	83
1979	59	59	47	80
1980	50	50	39	78
1981	45	45	39	87
1982	42	42	36	86

a ram with at least a three-quarter curl or with a minimum horn length of 28 inches." These restrictions are in effect for 16 bighorn hunt areas. However, within hunt areas 15A and 15B, 448 north and 44B south, this restriction has been amended to allow the taking of any ram. The legal definition for these units reads, "Ram, means any male bighorn sheep excluding male lambs." These restrictions will be in effect in these units for 3 years to determine increases or decreases in the ages of rams in the harvest. Essentially the "any ram" hunt areas are an attempt to deter hunters from harvesting unbroomed younger age rams. During the 1982 bighorn hunting season, rams harvested within the "any ram" unit of 15A and 15B showed an increase in the age of rams harvested (4.3 years in 1981 to 6.2 years in 1982) while the green Boone and Crockett scores remained stable (154 318 in 1981 and 153 418 in 1982). Rams harvested in units 44B north and 448 south showed a slight decrease in age (7.3 in 1981 and 7.0 years in 1982). Green Boone and Crockett scores also showed a slight decrease (162 018 in 1981 and 154 518 in 1982).

This is the third consecutive hunt conducted on the Aravaipa Canyon transplanted bighorn population. A total of 5 mature rams have been harvested from the herd during the last 3 years. Green Boone and Crockett scores of rams harvested in Aravaipa during the 1982 bighorn season were 174 218 and 188 218 with both being 8 years of age.

Transplant Update: Aravaipa Canyon is the site of the Arizona Game and Fish Department's first bighorn sheep transplant. Bighorn were transplanted into the Aravaipa Canyon enclosure from 1958 to 1972. The herd grew to 22 bighorn in 1973 when a portion of the fence was removed and the sheep were released. The transplant is considered to have been a successful reintroduction effort. The population now numbers 80-100 sheep and the population has dispersed since the release. Lamb survival has declined over the summer of 1982 to approximately 19 lambs per.100 ewes. This has caused some concern since past year's surveys have shown twice that figure in yearlings per 100 ewes. Yearling survival will be closely monitored over the summer of 1983. Dispersal of the Aravaipa sheep have been documented since the initiation of the radio telemetry study in 1980. Some dispersal into new nursery band use areas has been documented in the last 3 years. Movement of young rams have occasionally been substantial (up to 70 airline, miles).

A more recent transplant has been the Muleshoe-Redfield release about 40 miles southeast of Aravaipa. Twenty-one sheep were released in a pen at the Muleshoe Ranch in 1980 and 1981. Adult mortality was relatively high from a variety of causes throughout 1981. Lamb survival was poor inside the enclosure, probably due to predation. Two lambs survived during 1981. One of these was born outside the enclosure to an escaped ewe. The enclosure was opened on 13 April 1982 as the result of lion predation of a ewe in the enclosure and a subsequent observation of a lion in the enclosure.

Sheep surviving at the time of the release were 6 rams and 10 ewes.

In addition to the Muleshoe transplant, in November 1981, 17 sheep

(4 rams and 13 ewes) were released at Redfield Canyon within the Galiuro Mountains between the Muleshoe Ranch and Aravaipa Canyon. Two additional rams were released at Redfield Canyon in January 1982. Mortality of these sheep has not been high, although one known lion kill and one undocumented mortality have occurred.

The Muleshoe and Redfield sheep have interchanged regularly. Mortality has not been excessive of the radio collared sheep from both transplants. However, lamb survival has been low during 1982. Surveys to document lamb production and subsequent survival will be performed within the next few weeks. Regular radio tracking flights have provided the majority of the monitoring effort up to this time.

In November of 1980, 20 bighorn sheep (7 rams and 13 ewes) were captured in the Kofa and Plomosa Mountains and released near Goat Mountain north of Apache Lake in south central Arizona. In November of 1981, 11 additional sheep from the Castle Dome Mountains were released near Painted Cliffs, approximately 3 miles west of Goat Mountain. Total known mortalities for these two transplants include 4 ewes and 1 young ram. Bighorn sheep from each transplant site have interacted on a regular basis. Surveys conducted in May 1982 located 5 rams (2 yearlings) 16 ewes (1 yearling) and 13 lambs within the Goat Mountain, Painted Cliff area. Additional surveys conducted in October 1982, located 10 rams (1 yearling) 22 ewes (3 yearlings) 7 lambs and 1 unclassified yearling for a total of 38 bighorn.

Locations of radio collared sheep and observations indicate that these bighorn are principally occupying the release area although some dispersion is apparent. At least one ram has wandered approximately 50 miles to the northwest of the release site. Reproduction has been exceptionally good, lamb to ewe ratios from fall surveys indicate lamb survival has remained high (fall lamb: ewe ratios were 70:100 in 1981 and 41:100 in 1982).

A total of 20 Rocky Mountain bighorn sheep have been released in the Blue River area of eastern Arizona. In the spring of 1979, 2 rams and 6 ewes were released; during March of 1980, 5 rams and 7 ewes were released in the same location. Currently, winter surveys produced sightings of 31 bighorn in the upper Blue, with 46 sheep believed to currently inhabit the area. The Rocky Mountain bighorn are spending their summers at approximately 1980 meters (6500 feet) in lower Blue River. However, 3 radio collared ewes have stayed on the summer range during the winter of 82-83. Winter range of these sheep include the mixed conifer belt of the river canyons from 2430m to 2740m (8000 to 9000 feet) of elevation. The New Mexico Rocky Mountain bighorn herd released near Glenwood, New Mexico appear to be expanding their range into eastern Arizona. Approximately 25 bighorn from the Glenwood herd were located in the Clifton area during June of 1982. These were all young sheep and probably moved back to New Mexico during the winter of 1982-83. In addition, 16 bighorn sheep were located in the Frisco drainage of eastern Arizona during 1982.

During the winter of 1981-82 sixty-two desert bighorn sheep were released in the Virgin Mountains of northwestern Arizona. These releases include the Hendricks Canyon transplant, in which 21 of 25 bighorn were released from a 700 acre enclosure in January of 1982. An additional 20 bighorn were released in Sullivan Canyon of the Virgin Mountains north of Hendricks Canyon. A third release of 21 bighorn was made at Buck Spring north of the Nevada state line.

Thirty-one of the 62 bighorn released in the Virgin Mountains were fitted with radio transmitter collars. Aerial locations are obtained twice a month to monitor movements and mortality. Since the releases, 14 mortalities (7 rams, 6 ewes, 1 lamb) have been recorded, 12 of which occurred within the first 6 months of the release. Overall surveys conducted within the transplant area, observed 19 lambs for 24 ewes. Continued aerial and ground observations will determine yearling survival rates for these transplants.

Currently 10 bighorn sheep (3 rams, 5 ewes, 2 lambs) remain within the Hendricks Canyon enclosure. These bighorn will be continually monitored and perhaps supplemented for future releases into the Virgin Mountains.

The capture of free roaming desert bighorn sheep was limited in Arizona during 1982. Ten ewes were captured in the west Kofa Mountains of southwestern Arizona in November 1982. These bighorn were transported by New Mexico Department of Game and Fish personnel to the Pelocillo Mountains of southwestern New Mexico to supplement the existing transplanted population.

Other captures include two desert bighorn lambs (1 ram and 1 ewe) from the Plomosa Mountains of southwest Arizona to be reared in the Sonoran Desert Museum.

Within the State of Arizona the Game and Fish Department has identified 33 possible bighorn sheep transplant sites. As priority transplant areas are determined and planning with the land management agencies is completed, some transplants may occur as early as the summer of 1983.

Research. The Arizona Game and Fish Department initiated a livestock-bighorn sheep interaction study in the Aravaipa Canyon area of south central Arizona in 1980. To date, field work has been mostly completed and data are currently being analyzed with results and recommendations to be documented. Data obtained from this research will aid the Department and land management agencies in proper livestock stocking rates and grazing practices that may have the least significant impact on bighorn sheep populations.

Research is continuing in the Catalina Mountains just north of Tucson on a remnant bighorn population of about 50-70 bighorn. This study was undertaken to document movements, seasonal habitat selection, lamb production and survival of the population located on the Pusch Ridge Wilderness area of the Coronado National Forest. Currently only 15-20 $mi.^2$ of habitat are utilized by the population although more suitable habitat exists. Major problems with this population may be continued development and heavy human use of the area.

Research is also ongoing in Arizona to determine the relative success of the different types of bighorn sheep transplants within Arizona. Monitoring of movements, extent of habitat utilization, and net production of bighorn will be compared from the Aravaipa Canyon herd, the Virgin Mountains, and Galiuro Mountain enclosures and subsequent free releases in Redfield Canyon, Goat Mountain Painted Cliffs, and Virgin Mountains, to determine the most suitable transplant method of each of the priority release sites.

A ten year research plan for bighorn sheep as well as other big game species has been drafted and will outline needed research projects and priorities to be conducted by the Arizona Game and. Fish Department.

Desert bighorn sheep studies have been initiated within the U.S. Army, Yuma Proving Ground Installation. This study is being funded by the U.S. Army to determine extent of habitat utilization, movement corridors and critical habitat of desert bighorn sheep within the installation. These studies will assist the U.S. Army in future planning to minimize impacts of installation operations on existing bighorn population.

Private and federally funded research projects involving desert bighorn sheep are presently ongoing within Arizona. A desert bighorn sheep study initiated and funded by Arizona Public Service and Southern California Edison Electric utility companies is presently in its sixth year. This research project was designed to determine impacts from powerline construction and post construction existance of a 500 kv electrical transmission line throughout bighorn sheep habitat in the New Water, Dome Rock Mountains, and the northern portions of the Kofa National Wildlife Refuge. A great deal of data on home range, movements, seasonal habitat, forage selection and lambing chronology of bighorn have been documented from this research.

In addition, a desert bighorn sheep and mule deer movement study is presently in its fourth year of research. This research project is being funded by the U.S. Dept. of the Interior, Bureau of Reclamation to determine movements of bighorn sheep and mule deer in relation to the Granite Reef Aquaduct portion of the Central Arizona Project near the Little Harquahala, Harquahala and Granite Wash Mountains of southwest Arizona. Considerable data on seasonal movements, herd interchange, lamb production, habitat and forage selection have been documented from this project.

Planning. Previous recent captures of free roaming desert bighorn sheep in Arizona have been exclusively done by aerial drugging of individual sheep. Current planning is to investigate the possibility of capturing desert bighorn sheep with a drop net using apple pomace as bait. This will be attempted along the shoreline of Lake Mead in July and August of 1983. It is hoped that large numbers of sheep can be removed from the existing high density population and utilized for transplant purposes.

Since the passage of the Bighorn Sheep Strategic Plan by the Arizona Game and Fish Commission in 1978, management planning for continuing research, transplants, and habitat improvement to Arizona's bighorn sheep will continue into the future.

UTAH'S DESERT BIGHORN SHEEP STATUS REPORT, 1983

James G. Guymon
Utah Division of Wildlife Resources, Cedar City, UT

James W. Bates
Utah Division of Wildlife Resources, Price, UT

Abstract. Desert bighorn population has persisted within Utah from prehistoric times to the present. Productivity investigations indicate that most herds are stable and in some cases increasing. Since 1967, when Utah held its first bighorn hunt, seventy-seven sheep have been harvested. Average hunter success has been 39 percent. In 1980, Utah put up for bid a trophy ram permit which was purchased for $22,000. Three research studies on nutrition needs and behavior of desert sheep are underway or have concluded. Transplants of desert bighorn into historic and suitable habitat is proceeding.

INTRODUCTION

Historically, desert bighorn sheep *(O. c. nelsoni)* inhabited much of the geographic area that is now known as southeastern and southern Utah. Prehistoric and historic evidence indicates that desert sheep were well known to various Indian tribes of the area. Trappers and earlier explorers documented the fact that bighorn sheep were common in many areas of Utah.

Records seem to indicate that desert sheep were holding their own in some remote portions of southern Utah until the mid-1940s. After this time, the only population of desert bighorn that remained were located along the Green, San Juan and Colorado Rivers in Grand and San Juan counties.

The decline of desert bighorn sheep in Utah can be attributed to many factors. Overgrazing, domestic livestock, disease, mining exploration and development, all seemed to take their toll. More recently, a constant increase in disturbance by a recreation seeking public have had impacts on sheep populations (Dalton, L.B. and J.J. Spillett, 1971). The bighorn sheep in Utah — past and present. Trans. No. Amer. Wild Sheep Conf. pp. 32-53.)

Currently, bighorn populations are being managed in eleven different geographic areas. Four of these populations are native and seven are transplants.

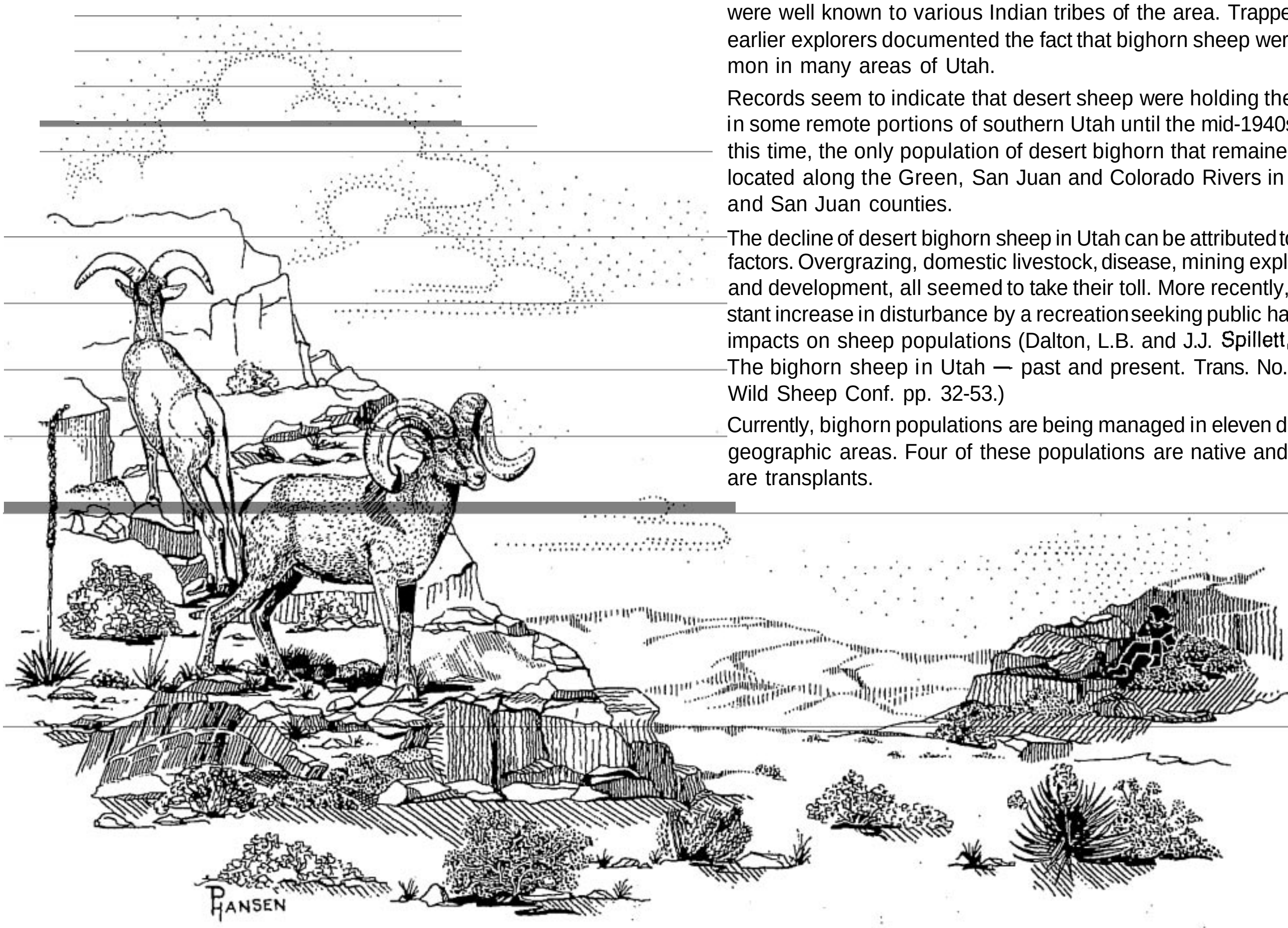


Table 1. Bighorn management units in Utah.		
	Unit	Status
1.	San Juan, North	Established native population
2.	San Juan, South	Established native population
3.	Potash	Established native population
4.	Escalante Canyon	Transplant completed in 1978. Appears to be successful.
5.	Westwater	Transplant completed in 1978. Appears to be successful.
6.	San Rafael Swell	Transplant completed in 1981. Appears to be successful.
7.	Kaiparowits Plateau	Transplant completed in 1982. Appears to be successful.
8.	San Rafael Reef	Transplant completed in 1983. Too early to tell if successful.
9.	Canyonlands	Established native population.
10.	Zion Canyon	Transplanted in 1973. Success is still uncertain.
11.	Mase (Part of Canyonlands)	Transplanted in 1982. Appears successful.

Note: All transplants have been made into historic habitat. Remote populations may still have been present.

MANAGEMENT OBJECTIVES

Management objectives have not changed significantly for the past several years. They are:

1. To increase understanding and knowledge of the life history, distribution, behavior, population and habitat requirements of desert bighorn sheep as well as the effects of human intrusion and activity.
2. To maintain the current distribution of desert bighorn sheep by reducing impact on present desert bighorn habitat and populations.
3. To expand the present distribution of desert bighorn sheep into suitable and historic habitats through natural expansion and selected transplants.
4. To provide increased opportunity for consumptive and noncomsumptive recreational uses of the bighorn resource by increasing the population of the desert bighorn sheep.

POPULATION TRENDS

Utah has conducted aerial trend counts on its desert sheep population since 1969. During the 1982 survey, more sheep were noted in the Potash Unit. It is felt that due to trapping activities in the adjacent Canyonlands National Park area, some of the sheep from that area may have shifted to the Potash Unit.

The lamblewe ratio varied from a low of 36 lambs per 100 ewes on the South San Juan Unit, to a high of 73 lambs per 100 ewes on the Potash Unit. The South San Juan Unit with the low lamb/ewe ratio, did, however, have the highest ramlewe ratio (76 rams per 100 ewes) compared to the Potash Unit with the lowest ramlewe ratio (67 rams per 100 ewes).

HUNTING

From 1899 to 1967, bighorn sheep were protected from hunting. Studies begun in 1966 indicated that Utah had a limited huntable population of desert bighorns east of the Colorado River in San Juan County. Ten resident permits were issued in 1967 for trophy rams. Legal rams are defined as those rams seven years and older and/or attaining a Boone and Crockett score of 144 points minimum.

Table 2. Desert **bighorn** sheep aerial **surveys, 1978-1982.**

Year	Unit	Rams	Ewes	Lambs	Uncl.	Total	Lamb per 100 Ewes	Rams per 100 Ewes
1978	North San Juan	47	66	25	--	138	37	71
	South San Juan	22	51	23	--	96	45	43
	Potash	20	19	11	--	50	57	105
	Canyonlands	99	101	31	--	231	31	98
	Total	**188**	**237**	**90**	--	**515**	**24**	**79**
1979	North San Juan	36	21	6	--	63	28	171
	South San Juan	17	12	7	--	36	58	141
	Potash	16	16	7	--	39	44	100
	Canyonlands	67	61	33	--	161	54	109
	Total	**136**	**110**	**53**	--	**299**	**48**	**123**
1980	North San Juan			--------No Count--------				
	South San Juan			--------No Count--------				
	Potash			--------No Count--------				
	Canyonlands			--------No Count--------				
1981	North San Juan	**83**	**144**	**98**	--	**325**	68	58
	South San Juan			----Data included in North San Juan----				
	Potash			--------No Count--------				
	Canyonlands			--------No Count--------				
	Total	**83**	**144**	**98**	--	**325**	**68**	**51**
1982	North San Juan	**30**	**41**	**25**	--	**96**	**60**	**7[illegible]**
	South San Juan	**44**	**63**	**23**	--	**130**	**36**	76
	Potash	**21**	**31**	**21**	**2**	**75**	**67**	67
	Canyonlands	**46**	**63**	**46**	--	**155**	**73**	**7[illegible]**
	Total	**141**	**198**	**115**	**2**	**456**	**58**	**7[illegible]**

All successful applicants are required to take hunter training and an orientation course.

Since 1967, Utah has sold 198 trophy ram permits. Seventy-seven sheep have been harvested for an average hunter success rate of 38.8 percent. Table 3 shows harvest trend summary by unit.

Table 3. Harvest trend summary, bighorn sheep, 1967-1982.

	Permits Sold	Ram Harvest	Percent Success
North San Juan	119	42	35
South San Juan	72	31	43
Potash	7	4	57
Total	**198**	**77**	**39**

In 1980, in addition to the regular ram permits, the Board of Big Game Control authorized the Division of Wildlife Resources to advertise one trophy ram permit to go to the highest bidder. Minimum bid was set at $20,000. The first year (1980), a bid of $20,000 was made by Fred Morris of Salt Lake City. In 1981, a bid of $22,000 was received. In 1982, $22,500 was the high bid. In bidding just concluded for the 1983 season, the Division received a top bid of $32,000.

All monies received for this trophy ram permit have been placed in a special account to be used only for bighorn sheep work. It is with this money that all transplants and most of the research work is being accomplished.

RESEARCH

Three research projects under the direction of Dr. Gar W. Workman of Utah State University, have been completed or are underway in Canyonlands National Park and adjacent areas to the south (North and South San Juan hunting units).

An M.S. study conducted by J. William Bates on "Desert Bighorn Sheep Habitat Utilization in Canyonlands National Park," was concluded in 1982. A companion study on nutritional requirements of bighorns by Bill Hull, a M.S. candidate, should be completed by 1984. A behavioral study with special emphasis on land changes and development and their impacts on desert sheep is being conducted by Mike King, a Ph.D. candidate. This study is two-thirds complete and is scheduled to be finished in September of 1984.

TRANSPLANTS

Utah has maintained an aggressive transplant program since 1973 when 12 bighorn were procured from the Nevada State Department of Fish and Game and released on an 80 acre enclosure in Zion National Park. A total of 133 sheep have been relocated in seven different areas that historically had bighorns but had since been extirpated.

While it is too early to properly evaluate some transplants, it is generally agreed that the Escalante Canyon, San Rafael and Kaiparowits Plateau transplants have been successful. The Westwater and Zion herds remain uncertain until more data are gathered.

Other areas of suitable habitat are being explored. An attempt to document historic habitat is underway. Developing and maintaining a priority list of potential transplant sites is being accomplished.

Two things have greatly enhanced Utah's transplant program. One is the sale of a trophy ram permit to the highest bidder (mentioned earlier) that provides funding for the program. The other is a cooperative agreement, signed in 1980, between the Division of Wildlife Resources and the National Park Service. This agreement allows for trapping operations to be carried on in Canyonlands National Park. One-half of the sheep that are captured remain in the park system and the other half is given to the state for release on predetermined sites. The system has worked well. Removal of select sheep should enhance the herd within the park boundaries while providing the state with a reservoir to draw from without impacting huntable herds.

CAPTURE METHODS

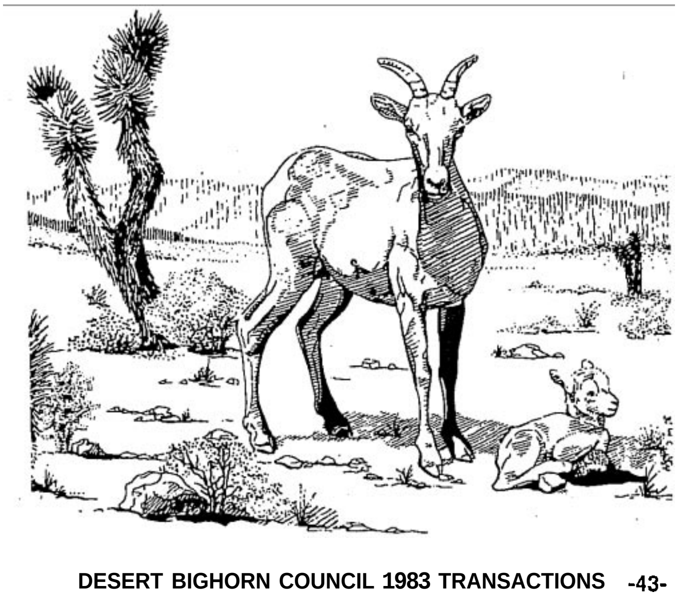
Utah has greatly modified and improved capture techniques using information reaped from past trapping experiences. In 1972, the Division began capture work with desert bighorns. Utilizing a helicopter, biologists searched for bighorns in their native habitat. Once located, the sheep were immobilized by a dosage of etorphine (M-99) ranging between 2.4 and 3.5 mg. In some instances, acetylpromdzine (6 mg) and/or atropine sulfate (1.2 to 2.4 mg) were used in combination with etorphine. Using this method was never completely satisfactory. The risk involved with personnel was high and the mortalities encountered with the sheep caused the Division to seek alternate capture methods.

In 1980, the Division purchased 1,500 feet of tangle-net. The net came in 100 foot panels, 8 feet high, with a mesh size of 8 inch squares. Utilizing this net in areas that are known to be frequented by bighorn, it is possible with the aid of a helicopter to drive the sheep towards the nets where they become tangled and caught. This method has proven to be far superior to the tranquilizer dart method. It has reduced the cost of capture per sheep substantially while at the same time, it has lessened the danger to the helicopter and its crew. Very little injury to bighorns has been encountered using this method. It appears that until a better capture method is conceived, Utah will continue with the tangle-net in its trapping operation on desert bighorn sheep.

SUMMARY

Utah Division of Wildlife Resources will continue an aggressive management program for desert bighorn sheep. This program will remain flexible, based on scientific findings, to adapt to future needs of the sheep and Utah's public.

Future demands, both energy and recreational oriented, will no doubt have their impact on bighorn and their remote habitat. There is vacant habitat available and it is our responsibility to provide for the bighorns' future. By following the course we have outlined, we feel we can meet our objective.



THE STATUS OF BIGHORN SHEEP IN CALIFORNIA

Richard Weaver
California Department of Fish and Game, Sacramento, CA

Abstract. The bighorn population of California is estimated at 3,900 animals. They are fully protected by the Legislature. Three transplants made between 1979 and 1982 give us reason to be guardedly optimistic about the success of the reintroduction program. Several more reintroductions are planned.

The water development program is paying off and definitely increasing the bighorn population in some areas. The program of constructing 2 or 3 catchments per year has been increased.

The problem areas are being investigated in cooperation with other agencies or conservation groups. A bighorn management plan is being developed for each range where bighorn occur:

Status. California has approximately 3,900 bighorn at this time. Over 2,800 Nelson bighorn (Ovis canadensis *nelsoni),* approximately 750 peninsular bighorn *(O. c.* cremnobates) and a minimum of 300 California bighorn *(O. c. californiana).* The last two are listed as rare by the Fish and Game Commission.

Bighorn have not been legally hunted in California for over 100 years. The California Legislature included bighorn with elk, antelope and female deer when it gave protection to these animals at a time when market hunting was making inroads into the populations of those animals. Today, we hunt all of these species under stringent rules established by the Fish and Game Commission, except the bighorn.

There is, however, a bill in the Assembly to remove the Nelson bighorn from the list of fully protected mammals. Bills to change the legal status of all bighorn failed in 1968, 1979 and 1982.

Transplants. California's first effort at reintroducing bighorn to historic range was made in 1971. That year 10 California bighorn caught in British Columbia were trucked to an 1,100 acre enclosure at Lava Beds National Monument. In 1980 the population numbered 43 and a release was planned for the Warner Mountains in Modoc County.

In the summer of 1980 with 33 bighorn in the enclosure the total population succumbed to pneumonia. Circumstantial evidence implicates domestic sheep. Reintroduction will not be tried again as long as domestic sheep allotment exists adjacent to the bighorn habitat.

We have made three captures of bighorn from the Baxter herd of California bighorn. This herd winters low on the east slope of the Sierra Nevada range. In 1979, 9 animals were captured using a drop net with fermented apple pulp bait and darting two rams. In 1980, 31 animals were captured using the drop net and the drive net. In 1982, 19 animals were trapped using the drive net. An additional one escaped the handlers and returned to its home range wearing a collar, and we experienced one mortality, a ram that crushed its trachea in the drive net. This herd remains at about 180 animals and we believe we can trap from it about every other year. The releases have all been free ranging (no enclosure).

The capture of bighorn in the Lava Bed enclosure by driving to a permanent corral trap went badly and we lost six animals. We released 4 into the Warner Mountains, Modoc County and added 10 from the Sierras, bringing this 1980 release to 14. Today, the population stands at 20. There is a potential of 7 lambs for 1983. They are staying in excellent habitat near the release point. We are optimistic that this effort will succeed. The known mortality has been two ewes that died of falls.

Bighorn were released at Wheeler Ridge, about 30 airline miles from the capture site in 1979 (9 animals), and augment with 10 more in 1980 and augmented with four rams in 1982. The reason for the later augmentation was to continue to have some functioning radio collars in this population to help get visual contact with the bighorn. This has worked well. This population now has a minimum of 29 animals and seems to be on the way of establishing a new herd.

The third California bighorn release was made at Lubkin Creek about 20 airline miles south of the capture site. A release of 11 animals was made in 1980. Although equipped with 6 radio collars there were no functioning collars after 6 months and the fate of the release could not be determined. In 1982, 15 additional animals were released in the same location and at this time 7 radio collars are working. The 1982 released animals now have some of the 1980 released animals with them. Recent observations have been made on 14 bighorn located in good habitat and we believe there is a good chance for the success of this effort.

We had plans to make our first desert sheep transplant'in 1982 but repeated rains scattered the population in the trapping area and it was necessary to put it off. This will be the first of 3 releases to be made in the Whipple Mountains near Parker Dam. The BLM has successfully taken 300 burros out of this range, and now only a few remain.

In the near future (5 years ±) about 12 more capture-transplant efforts can be made with both Nelson and California bighorn. Private dollars and volunteers have and will be making significant contributions to this effort. The largest single contributor is the Sacramento Safari Club.

Research. Several investigations are underway or recently completed on bighorn in California. Some of these are being reported on in greater detail at this meeting.

In the White Mountains, Inyo-Mono counties, California, Dr. John Wehausen has been working under contract to the Inyo National Forest. This final report is now being printed. Highlights of his investigation include an accurate census. The minimum population for this range has increased from 48 to 78 between 1978 and 1982. It is believed to be recovering from a decline that occurred about 1969. There are two ewe bands in the range. Habitat used extends from 6,000 feet winterrange up to 14,000 summer range. He observed their food preference, compared this population with Sierra bighorn. White Mountain lambs grow faster than in the Sierras. Phosphorous and different soils may be a factor. He also noted behavior differences. Bighorn here take flight at greater distance than elsewhere while on the summer range. The summer range with high quality forage is not particularly craggy or rocky. In the canyons, behavior is similar to other populations. Hang gliding, a popular recreational activity puts bighorn into full flight and they will drop up to three thousand feet to escape this threat.

John Wehausen is now investigating the Inyo Mountains bighorn, on a short term contract with the Inyo National Forest. This is a range that we have great concern about. Bighorn numbers are very low but preliminary work indicates there are probably more than the 30 I estimated in 1971.

Several years of work by or under the leadership of Steve Holl have been done in the San Gabriel Mountains. The Forest Service has just printed a report on this research and you will be learning from him at this meeting. Just to highlight the finding, we estimate over 700 bighorn in this mountain range and it is the largest population of bighorn in California today. We don't think we can hold the population at this density and it will probably decline. Recreational use or vehicle traffic does not appear to be suppressing this population.

In the north end of Santa Rosa Mountains, Riverside County, the Desert Bighorn Research Institute (Jim DeForge et al) under a cooperative agreement with DFG is investigating 6 years of poor lamb survival. Nineteen free ranging and six captive peninsular bighorn have been serologicaly examined for exposure to selected diseases. Titers for 4 viruses have been found, parainfluenza-3, bluetongue, epizotic hemorrhaegic disease and ecthyma. Any of these or any combination of these could initiate the pneumonia that is fatal to the lambs. This is an ongoing project and more animals will be captured next month and a trial vaccination program initiated.

Further south in the range of the peninsular bighorn, the Anza Borrego Natural History Association has made a grant to put an investigator in the field to determine lamb survival in different areas in and adjacent to the state park.

The Department entered into a contract with Shikar Safari Club and is investigating the capture myopathy syndrome to determine and publish information on the best techniques to use in capture, handling and transporting bighorn. We will be receiving a progress report on that endeavor at this meeting.

Habitat Development. Beginning in 1971 the Department has been constructing water catchments (guzzlers) in bighorn habitat identified as water deficierit. The Department relies heavily on a volunteer work force to accomplish this. Today there are 31 of these devices in bighorn habitat. Although each one is adapted to the site, a typical installation consists of a dam, a filtering screen, a short pipeline to a series of tanks, storing 5,000 gallons of water and a flat valve controlled drinker. An effort to evaluate these drinkers is done with a time-lapse camera and permanent pellet transects. Some have been in long enough to get acceptance and increase the bighorn population. Some have been used dry and additional units constructed within three miles to meet the water needs of the expanding bighorn population. In some instances to make sure that burro and cattle ranges were not expanded into bighorn habitat, heavy fence exclosures were constructed using pipe rails. They have worked well. This has also been done at springs — one was to exclude cattle.

Volunteers also inspect and do minor maintenance of the springs and seeps that occur in desert bighorn habitat. Usually one volunteer accepts a mountain range to be responsible for inspecting the guzzlers and springs and to muster his own crew and make a summer count for us. The latter volunteer effort is never complete.

We have yet to use prescribed fire to improve bighorn habitat. However, it is being considered.

The Future. The only complete inventory of bighorn herds in California was made by the author between 1968 and 1972. We need to update this inventory to determine'trend and changes in the population. Where investigations have been made, we are recording an upward trend.

Except in the Santa Rosa Mountains where the current disease and high lamb mortality investigation is going on, we need to determine how widespread the diseases identified in this range are in bighorn populations in California.

It appears that some of the mountain ranges have a static and suppressed bighorn population below range carrying capacity. The tools now exist to determine if inbreeding is a factor in these ranges. It would entail capturing a large number of animals and making sereological studies of several populations. A study plan to do all of the above has been developed, but has a price tag of $400,000 and of this date is not funded.

I feel the future of bighorn in California is bright. We have demonstrated that we can increase their range and numbers, It will require a continuing management and investigations program, for which funds will always be short. It has been demonstrated that private dollars are available to assist in these programs. And just possibly a few old rams might be legally taken in the near future.

MEMBERSHIP LIST, DESERT'BIGHORN COUNCIL 1983-1984

Alien. Larry (USFS)
2401 West Dante Way
Tucson, AZ 85741

Armentrout, Donald J. (BLM)
P.O. Box 521
Winnemucca, NV 89445

Barrett, Jim (AZGBF)
Box 134
Payson, AZ 85541

Blaisdell, James A. (NPS Ret)
5425 Indian Beach Lane
Friday Harbor, WA 98250

Bieich. Vern (CalF&G)
P.O. Box 1741
Hemet, CA 92343

Brigham, William R. (BLM)
P.O. Box 1806
Carson City, NV 89702

Burger. William P. (US-FWS)
Box 14 Route 89011
Las Vegas, NV 89101

Burke, William J. (NPS)
601 Nevada Highway
Boulder City, NV 89005

Burns, Jennifer (NPS)
Grand Canyon National Park
Grand Canyon, AZ 86023

Carpenter, Marguerite M.
(Same as Lew carpenter)

Carpenter, Lewis E. (SCBS)
815 West Gettysburg
Fresno. CA 93705

Cochran, Mark H. (SCE/APS)
P.O. Box 2731
Quartzite, AZ 85346

Cocking, Eddie (AZGBF)
3661 West Suffield Lane
Tucson, AZ 85741

Cooper, L.J. (AZGBF)
Box 678
Roosevelt, AZ 85545

Creeden, Paul J. (CSU)
1600 Plum #20K
Ft. Collins, CO 80521

DeForge, Jim (DBRI)
P.O. Box 262
Palm Desert, CA 92261

Delaney, Dan (NDOW)
6997 Mt. Meadow Lane
Las Vegas, NV 89117

DeVos, James C., Jr. (AZGBF)
3519 E. Monica Ave.
Phoenix, AZ 85032

Di Rosa, Roger (USFWS)
Cabeza Prieta NWR
P.O. Box 418
Ajo, AZ 85321

Dodd. Norris (AZG&F)
1210 East Southern #3
Phoenix, AZ 85040

Donaidson, Byron (NMGBF)
Villagra Bldg.
Santa Fe, NM 87503

Douglas, Charles (NPS)
1444 Rawhide Road
Boulder City, NV 89005

Elenowitz, Amy (NMSU)
Box 4901
Las Cruces, NM 88003

Fuller, Arthur F. (AZGBF)
1025 Hillside
Kingman, AZ 86401

Garlinger. Bruce H. (Humboldt St.)
P.O. box 4251B
Arcata, CA 95521

Gionfriddo, James P. (UofAZ)
6817 No. Montrose Drive
Tucson, AZ 85741

Gould, Larry (BLM)
Box 1293
McCall, ID 83638

Grunigen, Randy
158 S. Golfwood Dr.
Pueblo West, CO 81007

Guymon, Jim (UDWR)
90 So. 200 West
Parowan, UT 84761

Haderlie, Milton (USFWS)
P.O. Box 6290
Yuma, AZ 85364

Hansen, Pat
P.O. Box 596
Kenwood, CA 95452

Hawkes, Mike (USFWS)
604 Loma Encantada
Socorro, NM 87801

Holl, Steve (USFS)
U.S. Forest Service
Star Route 100
Fontana, CA 92335

Holmes, Kenneth E. ((BLM)
1714 Royal
Las Cruces, NM 88001

Hull, William B. (USU)
Dept. Fisheries & Wildlife
Utah State University
Logan, UT 84322

Hutchinson, Bill (USFWS)
P.O. Box 1246
Socorro, NM 87801

Jacot, Francis H. (NPS)
1333 Gough St. No. 2F
San Francisco, CA 94109

Jorgensen, Mark (Cal St. Pks.)
P.O. Box 491
Borrego Springs, CA 92004

Karp, Peter W. (USFS)
4050 W. Pyracantha
Tucson, AZ 85741

Kelly, Warren (USFS)
317 So. Glenvista
Elko, NV 89801

Kitpatric, Jack (TXP&W)
Box 1228
Marfa, TX 79843

King, Mike (USU)
619 North 500 East
Logan, UT 84321

Kovach, Steven D. (US Navy)
P.O. Box 1'701
San Bruno, CA 94066

Krausman, Paul (UofA)
325 Biological Sci
East Bldg. SRNR
Unlversity of Arizona
Tucson; AZ 85721

Landell, Paul E., Jr. (UTBHS)
Box 368
Torrey, UT 84775

Majerowlcz, Eugene I.
4449 Presidio Drive
Los Angeies, Ca 90008

McClintock, Ralph W
3232 Shari Way
Sparks. NV 89431

McCutchen, Henry (NPS)
6508 S. Allison Ct.
Littleton, CO 80123

Miller, Gary
Box 1037
Quartzite, AZ 85346

Monson, Gale
8831 N. Rlveria Dr.
Tucson, AZ 85704

Morrison, Bruce (NMGBF)
Villagra Bldg.
Santa Fe, NM 87503

Munoz, Richard (USFWS)
P.O. Box 756
Las Cruces, NM 88004

Olding, Ronald J. (AZGBF)
10651 N. Oldfather
Tucson, AZ 85741

Peek, George F.
P.O. Box 1039
Safford, AZ 85546

Poglayen, Inge
Rt. 9 Box 900
Arizona Sonora Desert Musuem
Tucson, AZ 85743

Puiliam, Dave (BLM)
601 Greenhurst Road
Las Vegas, NV 89128

Remington, Richard (AZGBF)
3005 Pacific Ave.
Yuma, AZ 85364

Roy, Cordell J. (NPS)
Capitol Reef National Park
Torrey, UT 84775

Sanchez, Peter G. (NPS)
P.O. Box 276
Death Valley, CA 92328

Sandoval, Andrew (NMGBF)
949 S. Melendres
Les Cruces, NM 88005

Schemnitz. S.D. (NMSU)
Box 4901
Dept. Fish & Wildlife Science
NMSU
Las Cruces, NM 88003

Schmidt, John L. (CSU)
1730 Miramont Drive
Ft. Collins, CO 80524

Scott, Joan (DBRI)
P.O. Box 262
Palm Desert, CA 92261

Seibert, Linda K. (BLM)
Bureau of Land Management
Box 1420
Las Cruces, NM 88004

Seidler, Scott D. (UofA)
2246 E. 7th Street
Tucson, AZ 85719

Shaw, Harley G. (AZGBF)
P.O. Box 370
Chino Valley, AZ 86323

Smith, Dave (UofA)
Bio Sci East Room 214
Tucson, AZ 85721

Smith, Nick (NMGBF)
1900 Market Street Box 3
Silver City, NM 88061

Spillett, Juan (USFS)
Box 278
Rockiand, ID 83271

Stirn, Kenneth L. (AZGBF)
Rt. 2 Moonridge #68
Parker, AZ 85344

Sumner, Lowell (NPS Ret)
P.O. Box 278
Glenwood, NM 88039

Supernaugh, William R. (USDI-NPS)
7424 Chatham Street
Springfield, VA 22151

Taylor, Daisan E. (US Army)
2914 Majestic Ridge #B
Las Cruces. NM 88001

Temple, Larry J. (NMGBF)
1480 N. Main Street
Las Cruces, NM 88001

Torres, Steven G.
Ariz. Coop. Wildlife Res. Unit
University of Arizona
Tucson, AZ 85721

Turner, Jack C. (Dr.)
Division of Life Sciences
Sam Houston State University
Huntsville, TX 77341

Turner, Kim
1416 22nd Street
Huntsville, TX 77340

Valdez, Raul (NMSU)
Box 4901
Las Cruces, NM 88003

Vanden Berge, Robert J. (USFWS)
1180 So. 13th Ave.
Yuma, AZ 85364

Ward, Don (USFS)
Rt. 2 Box 27G6
Price, UT 84501

Watt, Larry (AZGBF)
1516 E. Glencove
Mesa, AZ 85203

Weaver, Richard A. (Cal F&G)
P.O. Box 1383
Loomls, CA 95650

Webb, Paul (AZGBF)
3201 W. Wescott
Phoenix, AZ 85027

Welsh, George W. (AZGBF)
1954 Golden Ave.
Kingman, AZ 86401

Werner, Bill (AZGBF)
3005 Pacific
Yuma. AZ 85365

West, Robert L. (TX PBW)
3407 S. Chadbourne
San Angelo, TX 76901

Wilson, Lanny O. (BLM)
Rt. 3 Box 164
Cottonwood. ID 83522

Workman, Gar W. (USU)
Dept. Fisheries & Wildlife
Utah State University
Logan. UT 84522

Wylie, Thomas C. (NPS)
440 N. Apple Lane
Moab, UT 84532

Wood. Marvin (SCBS)
19 N. Byron Dr.
Lemoore. Ca 93245

Yancey, Myrna J. (NPS)
4805 Heidi #2
Las Vegas. NV 89109

Yardman, Steven G. (NMG&F)
1098 Mansion Ridge Rd.
Santa Fe. NM 87501

Zeller, Bruce (USFWS)
1500 N. Decatur Blvd.
Las Vegas, Nv 89108