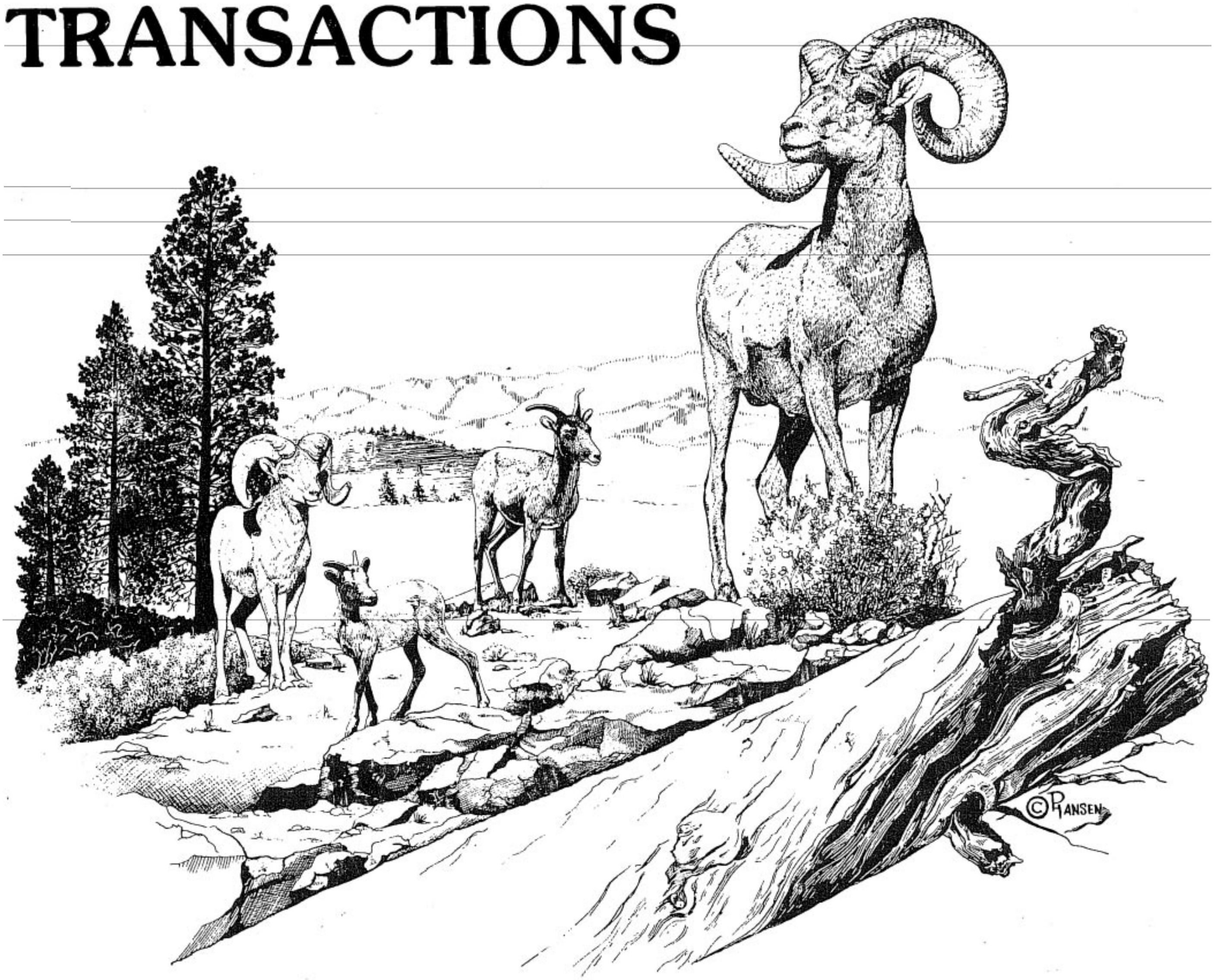
DESERT BIGHORN COUNCIL 1978 TRANSACTIONS



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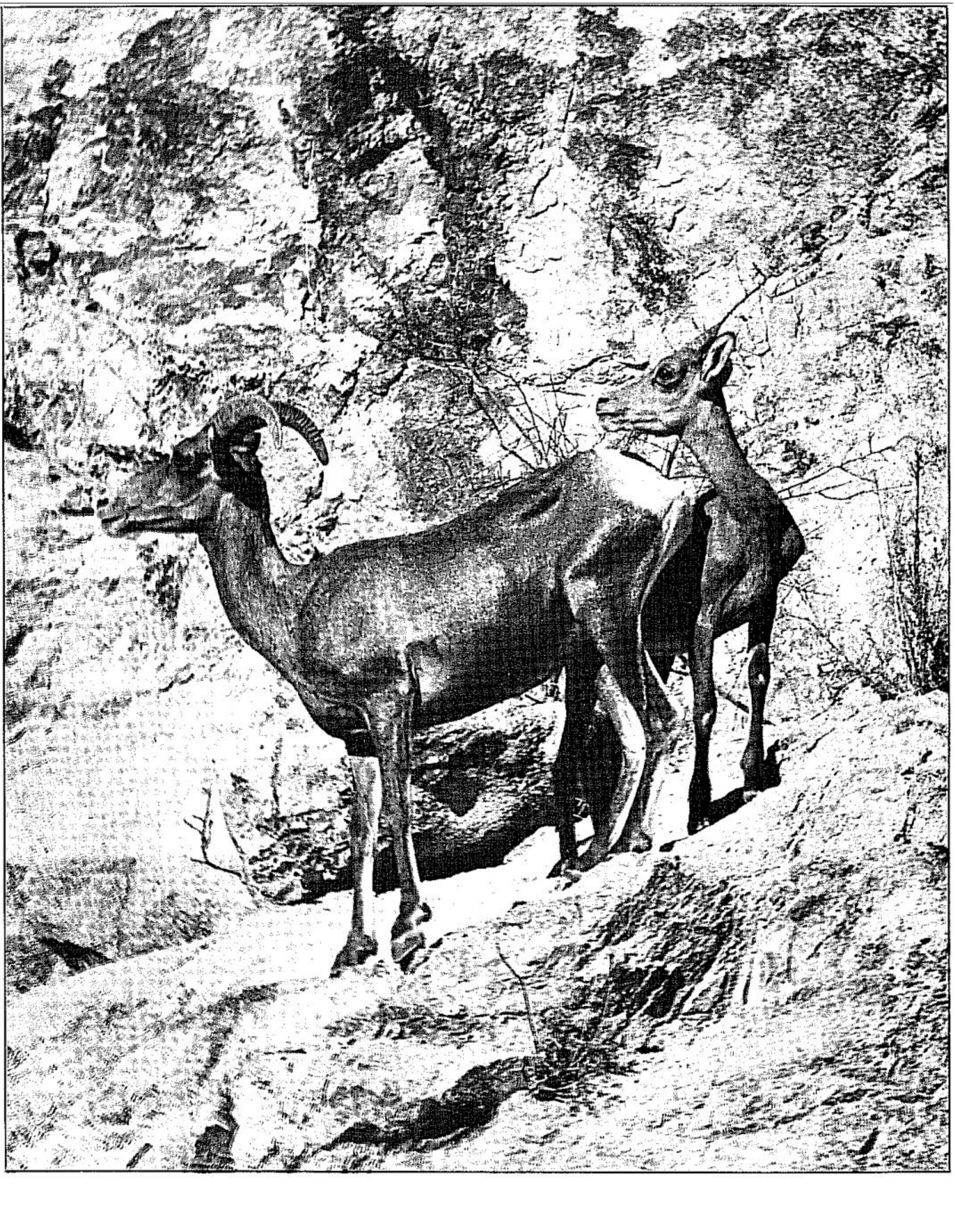

DESERT BIGHORN COUNCIL 1978 TRANSACTIONS

A COMPILATION OF PAPERS PRESENTED AT THE 22ND ANNUAL MEETING, APRIL 5-7, 1978 AT KINGMAN, ARIZONA

Edited by Charles Douglas (Chairman), David Leslie, Jr., and Theda O'Farrell

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Cover Drawing by Pat Hansen

BIGHORN SHEEP STATUS REPORT FROM NEVADA

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Abstract. The major emphasis of the sheep program in Nevada during the past year was aimed at implementing the management recommendations that were described in the recently published bulletin. Aerial surveys were continued with 1289 bighorn observed during the fall and 489 classified during the winter. A total of 58 rams were reported harvested by 81 hunters during the 1977 sheep season. Desert bighorn were reintroduced into the Stonewall Mountain area of Nye County and California bighorn were released into the Santa Rosa Range of Humbolt County.

In February of 1978 a bulletin describing the status and trend of bighorn sheep in Nevada was made available to the general public. The major emphasis of the sheep program in the State prior to that time was directed toward gathering, organizing, and presenting all of the available data relative to bighorn sheep. The major emphasis since that time has been to implement the management recommendations which includes a continuation of aerial surveys, continuation of the hunting program, acceleration of a reintroduction program, and the initiation of a water development program. This report describes the accomplishments of the above listed activities during the past year.

AERIAL SURVEYS

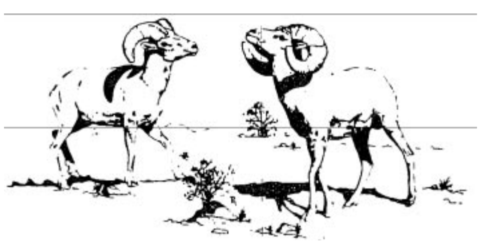
Intensive helicopter surveys continue to provide the most meaningful data on population parameters of individual bighorn herds in Nevada. Between September 21, 1977 and October 12, 1977 a total of 79.9 hours (66.3 survey hours and 13.6 ferry hours) were expended in classifying 1289 sheep on 12 mountain ranges. A summary of the survey results are presented in Table 1.

The data for individual mountain ranges show no significant changes when compared to past surveys with the exception that more total sheep were observed in seven of the 12 areas. The highest number of sheep classified on the Highland Range prior to last year, for example, was 45 individuals with a resultant population estimate of 56 animals. In 1977, however, a total of 64 individuals were actually observed on the range. Individual sample sizes also increased from 183 to 331 on the Sheep Range, from 143 to 177 on the River Mountains, from 154 to 202 on the Mormon Mountains, and from zero to 11 on the Pahranagat Range. Most of these sample size increases can be attributed to increased survey time and better familiarity of the pilot and observers with the habitat.

The 1977 fall data suggest that most bighorn populations in Nevada increased slightly during the past year (37 lambs per 100 ewes) as opposed to decreasing population levels the previous year (23 lambs per 100 ewes in 1976). Data from the River Mountains indicate an all time high production level with 80 lambs observed for each 100 ewes. Average lamb survival in Nevada since 1969 has been 32 lambs for each 100 ewes.

Table 1. Summary of the results from aerial bighorn sheep surveys conducted In Nevada during October and September of 1977.

Mountain Range	Survey Time	Total Obs.	No. Ewe	No. Lamb	No. Ram	Sheep Per Hr	Ratio Ram/Ewe/Lamb
Sheep Range	14.9	331	184	37	110	22.2	60/100/20
Desert Range	6.2	102	57	23	22	16.5	39/100/40
Pintwater Range	5.4	114	63	22	29	21.1	46/100/35
East Desert Range	3.8	91	50	22	19	23.9	38/100/44
Las Vegas Range	4.3	79	34	12	33	18.4	97/100/35
River Mountains	4.8	177	70	56	51	36.9	73/100/80
McCullough Range	5.9	73	30	11	32	12.4	107/100/37
Highland Range	4.0	64	41	10	13	16.0	32/100/24
Mormon Mountain	8.8	202	92	35	75	23.0	82/100/38
Meadow Valley Range	5.0	45	19	6	20	9.0	105/100/32
Pahranagat Range	2.7	11	3	1	7	4.1	--------
Black Hills	.5	0	0	0	0	---	--------
TOTALS	66.3	1289	643	235	411		
AVERAGES						19.4	64/100/37



Statewide ram ratios also showed no significant change during the past year. The 1977 ratio of 64 rams per 100 ewes is comparable to the nine year average of 60 rams per 100 ewes and last years (1976) ratio of 62 rams per 100 ewes. The variability in ratios for individual ranges (Table 1) is largely a result of differential home range and movement patterns. The low ratio noted for the Desert Range, for example, is offset by the comparatively high ratio on the Las Vegas Range. Both of these areas support wintering bighorn from the Sheep Mountain Range.

The age structure of the Statewide population showed a significant change because of the lack of lamb survival in 1976 (23 lambs per 100 ewes). The percentage of rams in the one through three year age class dropped from about 47% in 1976 to about 38% because of the low number of yearlings in the later year. There was also an increase noted in the number of older aged rams in 1977.

An additional 23.5 hours (19.3 survey and 4.2 ferry) were expended in surveying parts of the Desert National Wildlife Range in addition to the Pahranagat Range during February of 1978. The survey resulted in the classification of 483 bighorn as shown in Table 2. The surveys were conducted primarily to document distribution patterns during the winter months with respect to lambing and bachelor ram use areas. The recorded observation of 41 lambs in Table 2 represents only eight new lambs of the year in addition to 33 yearlings that could positively be identified.

Aerial surveys conducted during the past year bring the total number of bighorn classified in the state to 8063 animals for an average ratio of 60 rams and 32 lambs per each 100 ewes.

HARVEST TRENDS

The total number of desert bighorn sheep tags in Nevada was increased by 12.3% or nine tags for the 1977 season. The 81 total permits available were alloted to 72 residents and nine nonresidents. The increase in permits resulted largely from opening two new hunt units.

A total of 487 resident applications were received for the 72 permits (6.8 applications per tag) ranging from a low of seven applications for two permits in one area to a high of 66 applications for six tags in another area. A total of 525 nonresidents applied for the nine tags available (58.3 applications per tag) ranging between 34 and 91 applications for individual permits.

A total of 58 rams were reported harvested by the 81 hunters for a success rate of 71.6% as compared to 75.0% success last year (1976) and 36.1% success overall since 1952. Residents reported a success rate of 69.4% whereas nonresidents reported 88.9% success. The total harvest of bighorn sheep from Nevada since hunting was initiated in 1952 is 685 individuals.

The average age of sheep harvested in 1977 was 7.3 years ranging between three and 12 years. Approximately 39% of the rams harvested were estimated to be under seven years of age whereas 22.4% were 10 years of age and older. Six of the bighorn harvested during the past season were large enough to be entered into the Boone and Crockett Score Book (168 points minimum) while four sheep did not meet the minimum requirements of a legal ram as set by commission Regulation. The 1977 harvest represented a 1.4% reduction in the estimated statewide population.

Table 2. Summary of the results from aerial bighorn sheep surveys conducted in Nevada during February of 1978.

Mountain Range	Survey Time	Total Obs.	No. Ewe	No. Lamb	No. Ram	Sheep Per Hr.	Ratio Ram/Ewe/Lamb
Sheep Range	10.1	331	172	24	135	32.8	78/100/14
Desert Range	1.8	47	34	2	11	26.1	32/100/06
East Desert Range	1.8	45	25	6	14	25.0	56/100/24
Las Vegas Range	3.7	48	32	5	11	13.0	34/100/16
Pahranagat Range	1.9	12	8	4	0	6.3	00/100/50
TOTALS	19.3	483	271	41	171		
AVERAGES						25.0	63/100/15

TRANSPLANT PROGRAM

A total of 14 desert bighorn were trapped from the River Mountain population on August 9, 1977 and released directly into the wild on Stonewall Mountain, some 170 miles to the north. The composition of sheep transplanted included seven ewes, five lambs, and two-two year old rams. One of the ewes was equipped with a radio-collar while another was supplied with a T-lock ear tag. The release supplemented the introduction of eight bighorn that were transplanted to the same area during August of 1975.

Follow-up efforts showed that four of the bighorn released onto Stonewall, including the radio-collared ewe, had moved 18 miles into an adjacent range to the north (six weeks after the 1977 release). An aerial survey conducted during mid-February of 1978 resulted in the observation of one two year old ram, four ewes, and one newborn lamb within one-half mile of the release site. It appears that some of the sheep remained on Stonewall Mountain while others drifted to adjacent areas.

Random observations of bighorn sheep on the Wassuk Range of Mineral County also provide initial indications of a successful transplant. Bighorn that were released into the Dutch Creek enclosure on Mount Grant between 1968 and 1975 were allowed to escape into the wild during June of 1976. Since that time, the sheep have been observed along the entire east side of the Wassuk Range between Lucky Boy Canyon on the south and U.S. Highway 95 on the north. The observation of three ewes and two lambs on the top of Mount Grant during the summer of 1977 also indicates that natural reproduction is occurring outside the abandoned enclosure.

A total of 16 Rocky Mountain sheep comprised of two yearling rams, nine ewes, and five lambs were wild trapped in Wyoming, transported to Nevada, and released directly into the wild in the vicinity of Mount Moriah on the Snake Range during February of 1975. An aerial survey conducted during March of 1978 resulted in the observation of 23 bighorn within one mile of the release site. The composition of sheep observed included five rams, seven ewes, and 11 yearlings. It is obvious that reproduction is occurring and that the population is increasing. An additional release of Rocky Mountain sheep is being planned at the present time for the southern portion of the same mountain range.

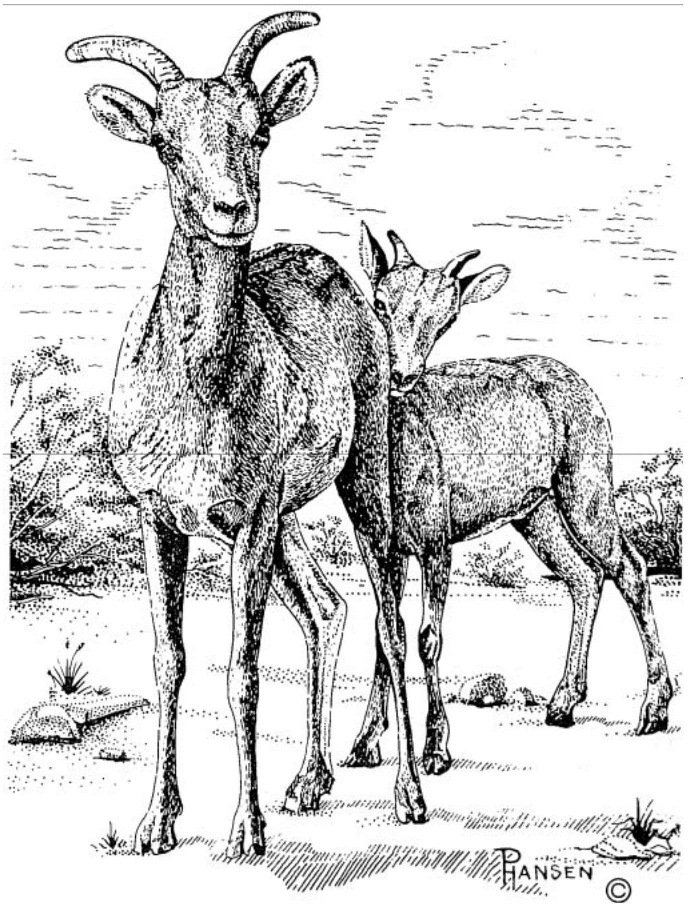
Observations near the Hell Creek enclosure indicate that an unintentional release of California bighorn occurred in that area. A total of eight bighorn were released into the enclosure in 1968. Several miscellaneous observations of sheep have been reported outside the enclosure since that time. One group of seven rams was observed outside the enclosure during an aerial survey in March of 1978. The bighorn appear to be moving in and out of the fenced area at will by jumping over the fence.

The most recent reintroduction of sheep in Nevada occurred during March of 1978 when 12 California bighorn were brought from British Columbia and released directly into the wild on the Santa Rosa Range of Humbolt County. The composition included two rams, seven ewes, and three lambs. Initial observations show that the sheep are remaining in the vicinity of the release site and thus far are doing well.

WATER DEVELOPMENTS

Proposed developments to increase water availability for bighorn sheep in Nevada was one of the major recommendations set forth during the past study. It is suspected that water developments in key areas of the state would increase population levels significantly by increasing the amount of critical summer habitat available. The project has been hampered, however, because of the multiple use concept related to range use on Public Domain. The present policy of the Las Vegas District of the Bureau of Land Management is to maintain use in most areas by wildlife, feral horses, wild burros, and/or domestic livestock cnder the multiple use concept.

It is known that bighorn sheep do not fare well under multiple use management because of competition for forage and water. Water developments that are designed to increase the distribution and numbers of bighorn might also increase the distribution and numbers of other ungulates unless precautions are taken. The guidelines regulating the type and amount of use for water developments in bighorn habitat are currently being negotiated with the BLM in order to insure the best interest of the native bighorn.



LAVA BEDS BIGHORN PROJECT – NEARING SUCCESS

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Abstract. Two good years in a row indicate that we may be reaching our goal of an initial transplant during the next four or five years, perhaps sooner. During the past year, the increase has been good. Porcupines and broken legs have made it interesting, however, and created some concern. The population now totals 31 animals with the potential of nine lambs this spring.

DISCUSSION

Reproduction. Lambing in 1977 occurred from April 26 to June 27, indicating the rut was from October through December. This may seem an odd time of year to most of you who work principally with the desert subspecies which, in most cases, breeds earlier in the autumn. Nine lambs were born to nine ewes. None of the four yearling ewes bred.

Loss. During the past year, four of the nine lambs have been lost and, except in one case, the cause is unknown. No carcasses were found. One lamb eventually lost was observed with a broken rear leg. At present, we have three ewe lambs and two ram lambs. Again, no disease problems were experienced. We have lost no sheep to disease since September, 1975, although one ewe was severely wounded on the face and in her right eye by porcupine quills. She has since recovered although she may still be blind on one side.

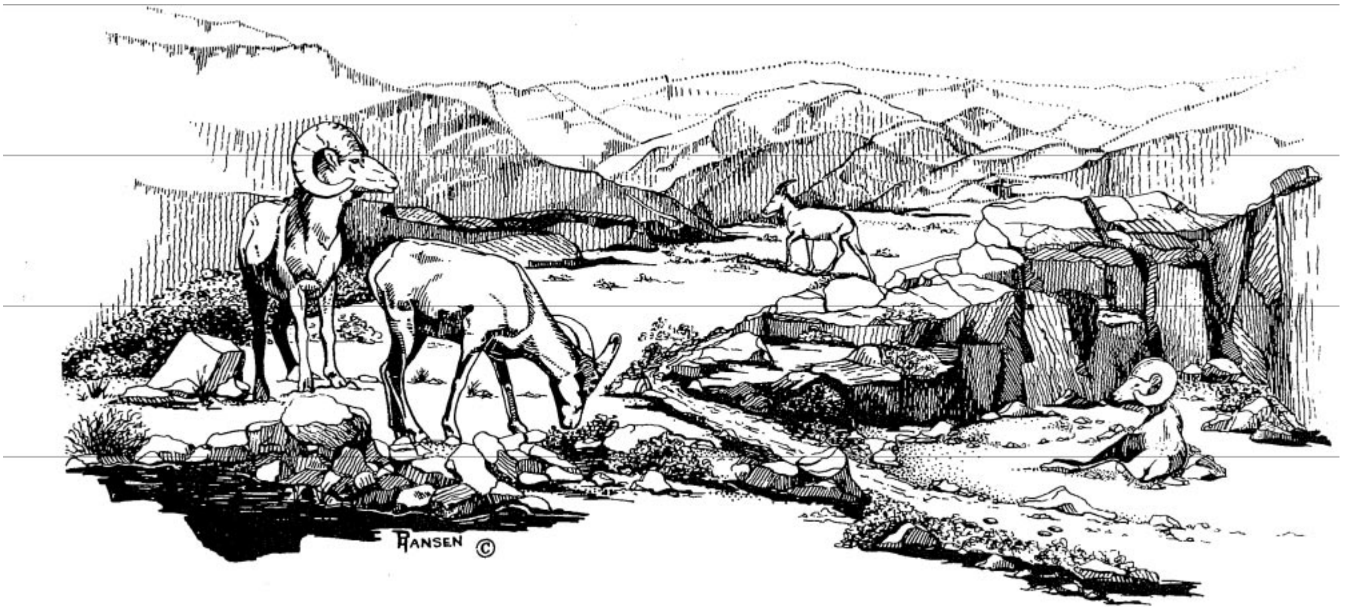
Composition., The male population has slowly been catching up with the females and the sexes are now in equal numbers in the yearling and adult age groups. Although a 50:50 ratio probably often exists in the wild, plenty of space on a mountain precludes too much stress. In our pen, also quite a large area (1100 acres), we wonder if this ratio is a good thing. We are constantly asked if such a ratio (especially since all of the present rams are offspring of the ewes in the pen) could not result in genetic or gene pool problems. I still have not found a geneticist who is willing to stake an opinion. It would seem the same thing occurs in a wild population where one herd lives together throughout the years.

Present structure of the herd is shown:

	Rams					Yearling		Ewes	Total
Age	?	2	3	4	5	Male	Female		
No.	2	5	1	3	2	2	3	13	31

You will note a question mark in the "age" column above, and two rams in that category. The reason for this is that two rams (ages presently unknown) have been counted this spring that have not been noted before. Total counts on 1100 very rough acres are difficult. Or have they been outside the pen for awhile? It is likely the answer will never be found.

Prospects. The five-agency committee involved in the project through a memorandum of understanding continue to meet and continue to be optimistic about transplants to other Northeastern California historical bighorn areas. According to the agreement, transplants will begin when the Lava Beds herd reaches a total of five breeding rams and 25 breeding ewes. The lamb crop during 1978 (this month and next) should number nine. Barring further difficulties (i.e., the poaching and diseases of past years) we should be at or near the transplant point about 1983. Our trap holding pen and squeeze chute are ready and in place.



UTAH'S DESERT BIGHORN SHEEP — A STATUS REPORT, 1978

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Abstract. Utah Division of Wildlife Resources has an aggressive management program for desert bighorn sheep. Desert bighorn populations have persisted within Utah from prehistoric times to the present. Several studies including history, distribution, behavioral and productivity investigations; telemetry work and transplants have been conducted. Currently, encroachment by expanding energy and industrial developments and the associated population increase that demands a myriad of recreational needs is the greatest threat to desert bighorns. Mitigation for losses is sought through cooperation with other state and federal agencies and industry to lessen negative effects on sheep. Limited hunting for trophy rams is allowed. Transplants of desert bighorns into historic and suitable habitats are proceeding. This paper summarizes work completed by many biologists working under Project W-65-R-D-23, Job A-2.

Desert bighorn sheep (Ovis canadensis) are not strangers to Utah. Archeological and historic evidence show that bighorns were once prevalent throughout most of what is now Utah. Father Escalante in 1776 stated that bighorns were abundant along the Colorado River. Other explorers, trappers and early pioneers in Utah also reported an abundance of bighorns. However, with the coming of the white man, a steady decline in bighorn numbers was experienced. Disaster for bighorns was almost inevitable as a result of year after year overgrazing, domestic livestock disease, mining exploration and development, poaching and a constant increase in disturbance by the recreating public (Dalton and Spillett 1971).

Present day bighorn distribution in Utah is centered in Grand and San Juan counties along the Green and Colorado Rivers from Canyonlands National Park south to the San Juan River. For practical purposes the present population can be considered as occupying five major geographic areas. Annual trend counts are conducted in the Canyonlands, North and South areas when program financing allows.

The Lockhart Basin unit extends south along the east side of the Colorado River from Moab into Lockhart Basin. At present the population of desert bighorns in this unit is small and its status is unknown, however, there have been recent sightings of bighorns in the vicinity of Anticline Overlook and Hurrah Pass.

The Canyonlands unit encompasses Canyonlands National Park and in population size this bighorn herd ranks third among the five units. Major concentrations of sheep are found in Monument Basin and Junction Basin in the Island in the Sky District (Dean 1975) and in Cross, Un-named and Lower Red Lake Canyons on the east side of the Colorado River.

On the east side of the Colorado River the remaining area below Canyonlands National Park is divided by Utah Highway 95 into the North and South units. The North unit possesses the largest population of bighorns of the five units. This is also the most remote and least disturbed area within the present distribution of the desert bighorns. The South unit extends south from Utah Highway 95 along the east side of the Colorado to the San Juan River. This unit harbors the second largest population of sheep. Research for two Master of Science theses was conducted in this general area (Wilson 1968 and Irvine 1969).

In addition, a fifth area may be identified on the west side of the Colorado River. Small remnant populations of bighorns have been reported periodically until the present along the west side of the Colorado in the main and tributary canyons from Canyonlands National Park south to the Arizona-Utah border. Sightings are most frequently reported from the Escalante River drainage, the Little Rockies and the eastern edge of the Kaparowitz Plateau. The population of desert bighorns in this area is extremely small and there is virtually no existing information regarding their distribution or movements.

Utah Division of Wildlife Resources (DWR) has an aggressive management program with desert bighorn sheep. The management program is geared to accomplish the following objectives.

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 nonconsumptive recreational uses of the bighorn resource by increasing the population of the desert bighorn sheep.

PAST, PRESENT AND FUTURE MANAGEMENT

Aerial Surveys. Winter aerial surveys flown in November and December were initiated in 1969 and have continued to the present to determine desert bighorn productivity and population trends. The surveys have indicated a steady increase in sheep numbers and an improved ewe-lamb ratio (Table 1).

In 1975 and 1976 DWR conducted spring aerial surveys flown in May and June to determine the peak lambing season and gain baseline data to evaluate lamb mortality. The results of the surveys show that lambing obviously is not completed by early June.

Range and Movement Study. From December, 1972 to December, 1975, DWR conducted a program of radio collaring and telemetry monitoring of desert bighorn sheep to gain knowledge of range and movements. A total of 33 sheep were captured with etorphine and instrumented (Bates et al. 1976).

In monitoring the instrumented bighorns it was found that the amount of movement between relocations was larger during each season of the year for rams than for ewes. However, analysis indicated that these differences were not statistically different. Movement between relocations varied by season although both rams and ewes displayed similar trends. Relocation distances were shortest during winter and summer, longer during the spring and longest during the fall. Analysis of the data indicated that fall movements of rams significantly exceeded movements during winter and summer ($P<0.05$) but did not exceed spring movements. For ewes, fall movements exceeded those of all other seasons ($P<0.10$) and in addition spring movements exceeded movements during the winter ($P<0.10$).

While relocation differences of rams and ewes did not differ significantly, the areas of their home ranges did (P10.025). The mean area of the home range for rams was 38.3 square miles, while for ewes the mean area was 15.4 square miles. In support of this observation, it was also noted that rams utilized more drainages than ewes. Home ranges of rams and ewes overlapped extensively and there was no indication that mutually exclusive home ranges of individuals existed.

There was a differential use of various elevations by the desert bighorns monitored in the study. Overall, rams were located at higher elevations than ewes ($P<0.10$). Seasonal fluctuations in elevation preference were greater for rams than for ewes. The elevational zones in which ewes were found did not vary significantly by season of the year. On the other hand, rams occupied the 6,000 plus elevational zone less often than expected during the winter ($P<0.05$) and more often than expected during the summer ($P<0.05$).

Past and Proposed Transplants. The DWR has adopted a program of transplanting desert bighorn sheep into suitable and historic habitat from which the species has been extirpated. Currently two projects have been completed and at least six others are approved or in progress.

In 1975, 1976 and 1977 twenty-three desert bighorns were captured from the Glen Canyon, Red Canyon and White Canyon areas and subsequently released into the Moody Canyons of the Escalante drainage. The releases consisted of seventeen ewes and six rams. Seven of these bighorns were instrumented for telemetry work. Reproduction has resulted at the transplant site and indications are that the sheep are doing well (Floyd Coles, DWR game manager, personal communication, March 1, 1978).

Table 1. Winter Desert Bighorn Sheep Aerial Surveys, 1969-1978.

Year	Unit	Rams	Ewes	Lambs	Unclassified	Total	Lambs per 100 ewes	Rams per 100 ewes
1969	North	5	11	4	0	20	36	45
	South	18	18	7	0	43	39	100
	Total	(23)	(29)	(11)	(0)	(63)	(38)	(79)
1970[1]	North	2	13	9	0	24	69	15
	South	2	14	8	0	24	57	14
	Total	(4)	(27)	(17)	(0)	(48)	(63)	(14)
1971	North	15	20	7	1	43	35	75
	South	19	24	7	0	50	29	79
	Total	(34)	(44)	(14)	(1)	(93)	(32)	(77)
1972	North	15	14	5	1	35	36	107
	South	12	16	5	6	39	31	75
	Total	(27)	(30)	(10)	(7)	(74)	(33)	(90)
1973	North	13	27	17	2	59	63	48
	South	9	19	5	0	33	26	47
	Total	(22)	(46)	(22)	(2)	(92)	(48)	(48)
1974	North	~~18~~	~~42~~	~~27~~	~~0~~	~~87~~	~~64~~	~~43~~
	South	15	19	12	0	46	63	79
	Canyonlands	4	6	4	0	14	67	67
	Total	(37)	(67)	(43)	(0)	(147)	(64)	(55)
1975	North	23	32	22	41	118	69	72
	South	24	29	17	0	70	59	83
	Canyonlands	7	15	11	0	33	73	47
	Total	(54)	(76)	(50)	(41)	(221)	(66)	(70)
1976	North	73	86	62	4	225	72	85
	South	10	19	11	0	40	58	53
	Canyonlands	12	15	7	0	34	47	80
	Total	(95)	(120)	(80)	(4)	(299)	(67)	(79)
1977	North	56	76	42	0	174	55	74
	South	21	25	12	0	58	48	84
	Canyonlands	21	27	14	0	62	52	78
	Total	(98)	(128)	(68)	(0)	(294)	(53)	(77)

[1]The winter survey in 1970 was not flown until January, 1971, after the rams had separated from the ewes and had moved into the higher mesa areas.

An earlier transplant in 1973 involved the capture in Nevada of twelve desert bighorns that have been released into an 80-acre holding paddock at Zion National Park. The purpose of the enclosure was to serve as a holding and propagation pasture until numbers increased to the point where a release into the wild could be effected. In January and February of 1977, 13 bighorns were removed from the paddock and ultimately released into the wild at another location in Zion National Park (McCutchen 1975 and 1977).

The Zion herd has experienced 45 percent mortality in sheep one year or older as a result of sinusitis. This condition threatens the success of the transplant (Bunch et al. 1978).

Desert bighorns will be transplanted into habitats that are suitable for their needs and within their historic range at Beckwith Plateau, San Rafael Desert and San Rafael Swell in Emery County, Westwater Canyon along the Colorado River in Grand County, and Little Rockies and Orange Cliffs in Garfield County.

Harvest Information. The first desert bighorn sheep hunt in Utah was held in 1967 after studies revealed that a limited, huntable population existed east of the Colorado River in San Juan County. The regulations have specified in all hunts that only mature trophy rams are legal. Legal trophy rams are defined as those rams seven years old or older and/or attaining a Boone and Crockett score of 144 points minimum. The hunt was a once in a lifetime opportunity for only Utah residents, however, in 1978 the once in a lifetime opportunity was extended to non-residents.

All permit holders have been required to attend an orientation and training session prior to the hunt. Interest by the sporting public in sheep hunting has been high with a long term average of 31 applications per permit. A total of 49 rams have been harvested with an average hunter success of 41.1 percent.

ENCROACHMENT ON DESERT BIGHORN SHEEP HABITAT

Mineral and Energy Development. Lands inhabited by desert bighorn sheep harbor deposits of copper, phosphate, potash, placer gold, uranium and vanadium. The area is also underlain by large basins of oil and gas as well as reserves of coal and oil shale.

Desert bighorn sheep habitat has been invaded by mineral interests several times in the past. Interest in placer gold peaked between 1833 and 1900.

The first uranium boom began during World War II and extended into the 1950's when prospectors and miners penetrated into even the most inaccessible regions of bighorn habitat. The result was the decline of bighorn populations to extremely low levels. Currently a second uranium boom is in full swing. Prices of uranium ore almost doubled in 1975 and continue to remain high, making it profitable to mine even the lower grade ores that remain in the area. Again remote areas are being prospected, resulting in not only disturbance but competition for limited sources of free water between man and desert bighorns.

Large potash deposits are located extensively throughout existing and potential bighorn sheep habitat. In the early 1970's a large mining and processing plant was opened on the Colorado River (Cane Creek) near Moab in bighorn country. The complex's 23 evaporation ponds cover about 400 acres of ground and the site is served by a 37½ mile railroad spur built especially for the purpose of shipping potash. Disturbance associated with the potash operation are believed to negatively impact bighorns. Natural movement may be inhibited by the railroad and placement of the evaporation ponds.

Currently, other large scale proposals exist to develop additional potash deposits in desert bighorn habitats. The impetus for increased production of potash is that U.S. suppliers are falling behind domestic demands (Bureau of Mines 1976:60 and W. Aubrey Smith, potash specialist, Buttes Gas and Oil Company, Moab, Utah, personal communication, May 1977).

Exploration by any natural resource company is their life blood. The large companies are staking claims by the thousands with the aid of crews of people transported into remote areas by helicopter. In addition, these same companies are buying claims from smaller private concerns. The County Recorders in Grand and San Juan Counties report that filing activities oriented to uranium and oil and gas exploration have shown dramatic increases since about 1975.

The recent deterioration of the world's energy reserves has revived the necessity for exploratory work and extraction of oil, gas and coal. The Bureau of Land Management has designated portions of the bighorn range as a no lease area, however, other interests are trying to overturn the designation to allow exploration and development of this resource.

As part of the nation's mandate for energy self sufficiency, huge coal fired, electric generation plants have been constructed. Others including nuclear powered plants are proposed. These plants lie within close proximity to bighorn habitats. Water, land and air are needed for the coal mines, plants, powerlines, railways and pipelines. It also creates the need for other raw materials such as uranium, copper and vanadium.

Sulfur Dioxide (SO,) is a by-product of the combustion of coal. In addition, several heavy metals are released into the air. Air pollution arising from the sulfur emissions and heavy metals can be regional and not confined to the immediate proximity of the power plant. Concern for damage to vegetation by gaseous SO, and its associated acid rain along with potential build-ups of heavy metals in all biotic systems exist.

Development of mineral and energy reserves have resulted in a myriad of social and economic pressures including more plants, more mines, more construction workers and more professional and secondary industry. There has been accompanying increases in service accommodations such as roads, housing developments, schools, social services and recreational facilities. All of these pressures continue to increase and cannot fail to have a severe impact on the desert bighorn and its habitat.

Recreation. Habitats occupied by desert bighorns are highly scenic and contain a tremendous recreational resource. A measure of this potential is the existence of five national parks (Zion, Bryce, Arches, Capitol Reef and Canyonlands), two national monuments (Cedar Breaks and Natural Bridges), the Glen Canyon National Recreation Area and three float boating rivers (Green, Colorado and San Juan) within their historic range. In addition, a wealth of archeological sites, boating, fishing, backpacking, hunting and picnicing and back country camping areas are found in bighorn country.

Recreation uses have accelerated in the past few years and will be compounded by local growth associated with energy developments. Improved access and greater pressure on the recreational resource brought about by increased human populations in the region have impacted canyon habitats. Desert bighorns are a wilderness animal and their survival and well being are dependent on seclusion.

The recreational dollar is being ardently sought through colorful brochures and daily commercials extolling the beauty and grandeur of southern Utah. As an example, total visitation in the Glen Canyon National Recreation Area amounted to 2,129,419 people during 1977. This figure represents a 325 percent increase over the first total of 654,600 visitors in 1968. Another example is Canyonlands National Park. The numbers of visitors there also increased three fold from 1968 (26,318 people) to 1977 (75,621 people). Back country campers in the park numbered 33,142 during 1977 as compared to only 8,623 in 1971. River runners are also building in numbers. Only 889 river runners toured the adventurous Cataract Canyon in 1970 as compared to 4,998 in 1977 — nearly a 6 fold increase. It appears that back country camping and river running activities are increasing at a more rapid rate than other recreating activities in bighorn habitat. These types of recreating activities place man in direct conflict with peace and tranquility demanded by desert bighorns.

Encroachment upon desert bighorn populations is reaching down from the mesa tops and extending up from the canyon bottoms. Along Lake Powell, back country campers using either conventional vehicles or house boats have had considerable impact on documented sheep range. Heavy recreational use has moved the sheep off the Castle Butte and Scorup Canyon areas. Little sheep sign is noted now in Blue Notch, Hidden Valley and the immediate surrounding areas. What will the impact upon bighorns from recreational activities amount to in the future — how much can desert bighorns tolerate?

Roadways. Increased use of roadway systems by recreators and industry has resulted in the paving of Utah Highway 95 from Blanding to Hanksville. The highway runs through sheep country and provides access to many of southern Utah's recreation areas. The improvement of this highway will increase tourism, aid in development of mineral resources, provide access to segregated public lands and further the deterioration of bighorn habitat.

Numerous dirt roads, some represented by only a worn set of tracks and others of high quality, have been made along ridge tops and valley floors. Each week new roads appear. In many instances industry has cut these roads up through the talus slopes to the mesa tops. One recent example is Mancos Mesa which was never penetrated by roads until late 1976. Now about 30 miles of roads are present. Such roads persist indefinitely in the fragile desert environment.

SUMMARY

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

At present the bighorn population is expanding and maintaining a high level of productivity. However, increased energy, mineral and recreational developments could well have a severe impact upon the sheep and their remote habitat. There is no doubt that the entire region will continue to experience unprecedented growth brought about by industrial development. Some restraints on development and recreation will eventually need to be imposed to reduce impacts on desert bighorn populations. There is vacant habitat available and it is our responsibility to provide for the bighorn's future, secure their habitat and protect their basic requirements. In spite of the overwhelming impacts taking place, we can ensure that desert bighorns do survive and flourish.

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EVIDENCE OF FERAL BURRO COMPETITION WITH DESERT BIGHORN SHEEP IN GRAND CANYON NATIONAL PARK

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Abstract. This report presents information on burro surveys in Grand Canyon National Park, and the relationship of burro and bighorn distributions. Food habits of burros were determined for 10 localities from fecal samples. Samples also were collected for mule deer and desert bighorn sheep from six of these localities. Data from these collections indicated a 52 percent overlap between diets of burros and bighorn, and an overlap of 6-12 percent between burros and deer.

The February 1977 edict by the Secretary of the Interior to draft a full Environmental Impact Statement regarding management of feral burros (Equus *asinus)* in the Grand Canyon precipitated a variety of research efforts by the National Park Service. Of primary concern was the need to better understand the ecological relationship of burros in the blackbrush, pinyon-juniper and Mohave desertshrub plant communities within the park. Of secondary concern was the need to provide a better understanding of the relationship of the feral burro with the park's population of desert bighorn sheep *(Ovis* canadensis mexicana).

During 1972 thru 1975, Guse (1975) conducted a survey of the park's sheep populations based upon observation cards submitted by concession river runners. From results of this study, and observations submitted by park staff and backcountry hikers, the park's sheep population was estimated at 400 to 500 animals. The park recognizes this number as being only a ball park figure.

Numerous sightings of bighorn sheep were made during extensive low level helicopter surveys directed at developing baseline data on burro populations and herd distribution. A total of 70 animals was observed during the September 1976 and May-June 1977 burro surveys (Walters 1977a). An additional 12 animals were observed on Havasupai traditional use lands during survey flights conducted for support of the Land Use Environmental Impact now being prepared under contract by the Bureau of Indian Affairs (Walters 1977b).

Figure 1. Feral Burro Distribution, Grand Canyon National Park, Mohave and Coconino Counties, Arizona.

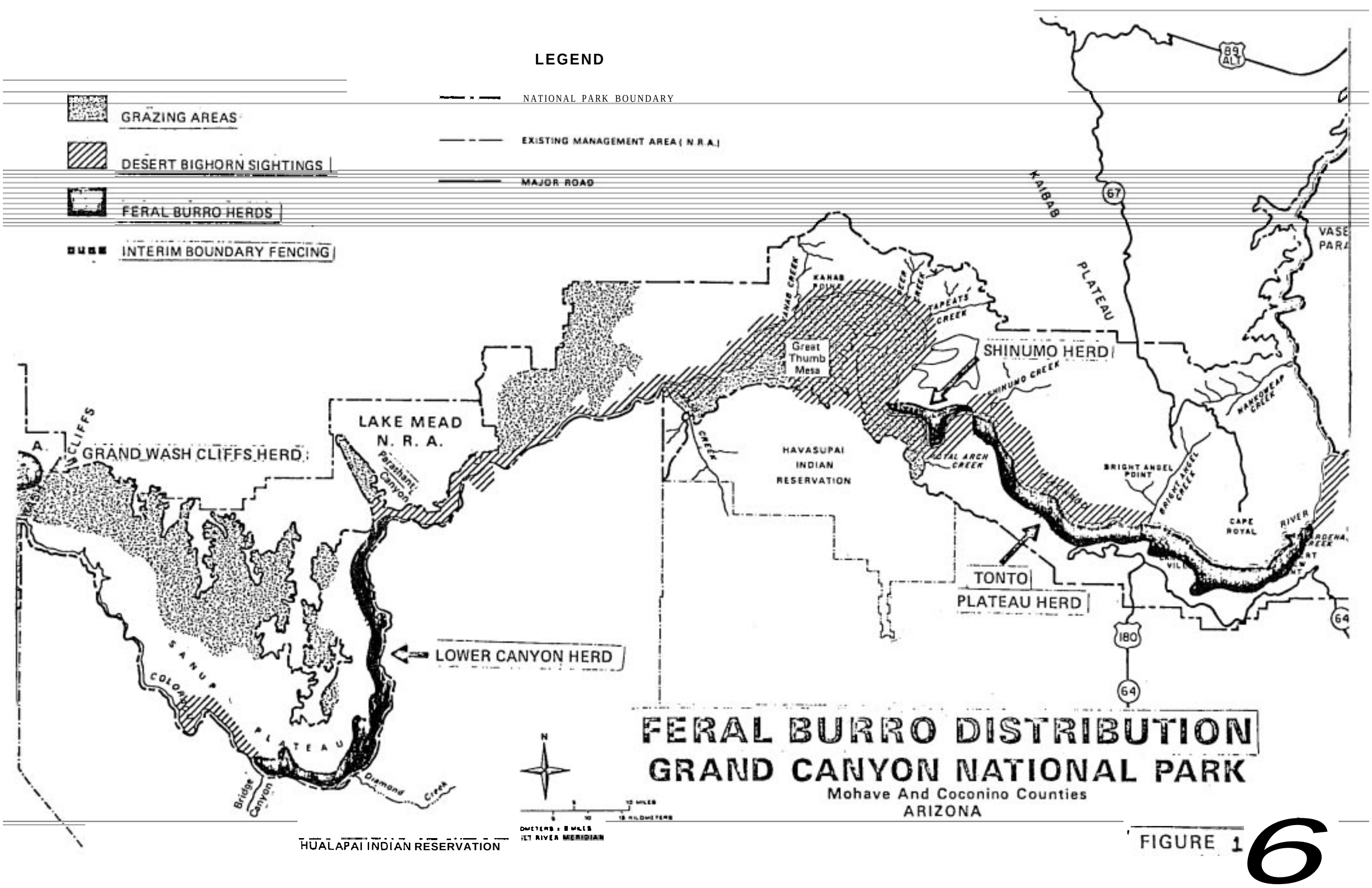
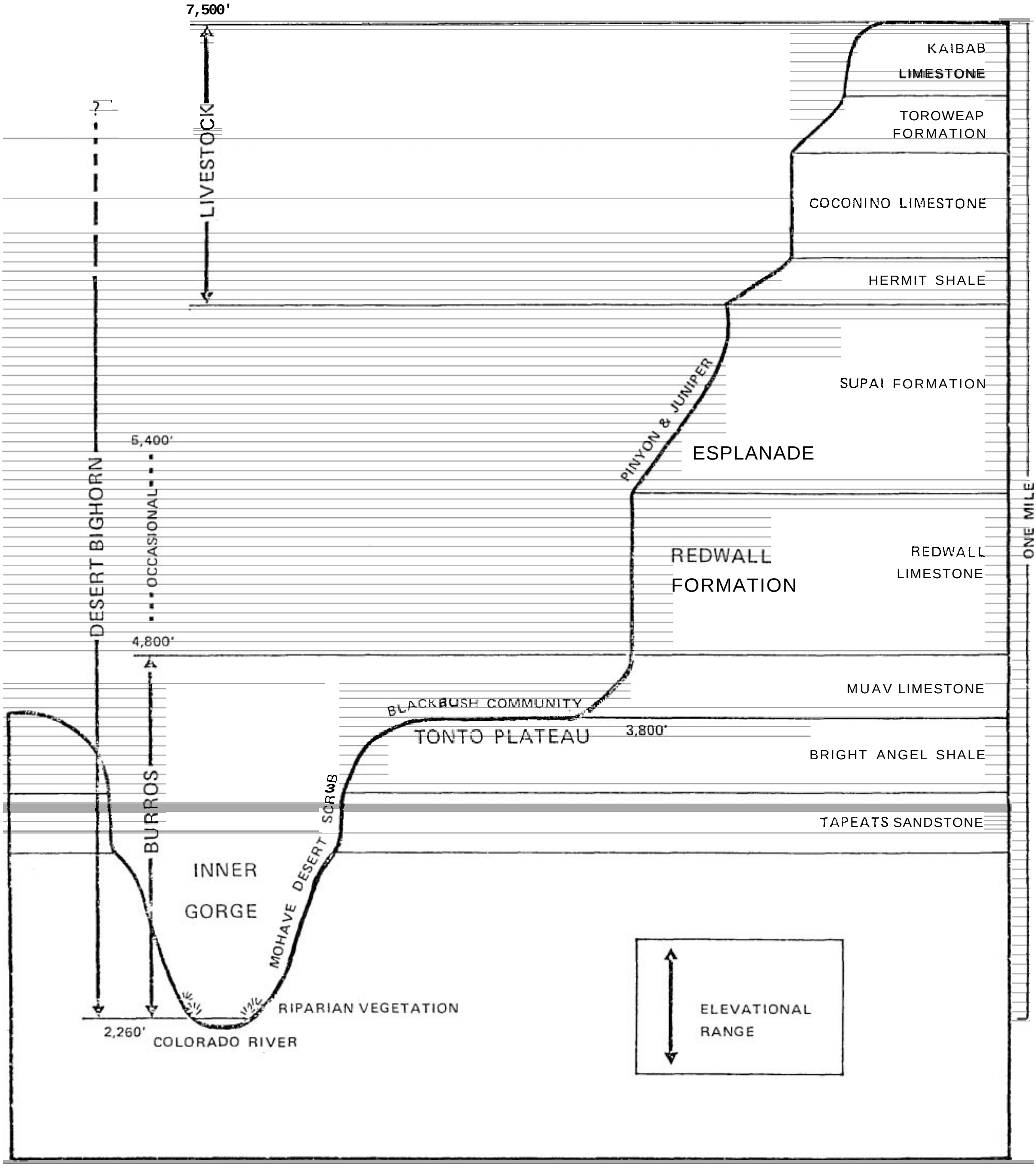


Figure 2. Generalized Biotic Distribution sf the Grand Canyon.



The 1976 and 1977 burro survey flights revealed several important aspects of the park's burro population that radically changed the park's understanding of the problem. Instead of an estimated 2,500 animals in the park, it was learned the actual number was closer to 300 animals scattered in three distinct herds (Figure 1). This estimate was made on the basis of marked vs. unmarked individuals, and use of the Lincoln Index by Ohmart (1977). Of equal importance was the development of distribution data showing burro herds to be, for the most part, beneath the sheer Redwall Formation (elevation 4800') and restricted to areas well within the Inner Canyon of the park (Figure 2). The two exceptions to this rule include a small herd occupying the pinyon-juniper community on the Mount Huethawali area and an equally small number which moves onto park lands by following the lake terrace in the Grand Wash Cliffs area. Both populations are suspected of being transient in nature, with the Mount Huethawali herd descending the Bass Trail to the Tonto Plateau and the Grand Wash Cliffs population moving westward onto Lake Mead National Recreation Area lands. Exact data confirming this migration do not exist at this time.

Obviously an understanding of exact numbers and the distribution of burros in the park is basic to determining the extent of competition with bighorn sheep. An understanding of these same parameters for the bighorn sheep population is mandatory in understanding the.total picture. To attempt to make broad inferences concerning the decline of bighorn sheep due to burros or other adversities without this information is to underestimate the substance of the criticism of burro removal plans by burro preservation groups and the effect this lack of information has when dealing with political ramifications of this problem. The mere citing of accepted ecological principals as proof bighorn sheep will decline through competition with burros is not enough. The emotionalism involved in the national horse-burro problem quickly makes any lack of exact data fatal to burro management efforts.

Accordingly, the park has identified in its forthcoming burro management EIS the fact that no exact numbers of bighorn sheep are available and, in fact, today's population is still basically an estimate. Therefore, the document doesn't assume the park's bighorn sheep population has declined, is declining, or will decline, due to competition with feral burros. The document has, however, substantiated the fact that direct overlap of burro and bighorn sheep range exists within the park and that there is a direct competition for available forage, at least on the Tonto Plateau.

Range Competition. Because burro distribution was shown to be confined to areas below the Redwall Formation, further surveys for bighorn sheep were not made above this formation. All observations of bighorn sheep included attempts at identifying sex, ages, elevations, associated vegetative communities, and behavior. Particular attention was given to places where sheep use the same range as burros. Eighty percent of the sheep observed during the feral burro surveys were in areas which are within the park's newly determined range of burros.

A common belief held by the public is that burros are basically grazers and, therefore, are restricted to "flat" areas of the park. Bighorn sheep are thought by the public to be dwellers of the "rocks and cliffs" and it is, therefore, impossible for these animals to compete with one another since they do not "live in the same place." Observations of both animals within the varied topography of the park demonstrates neither of these common beliefs to be totally true. Burros do use heavily the steep (up to 60°) talus slopes below the Redwall Formation. It would seem the only thing actually stopping further ascent is the sheer cliff-forming character of this limestone formation. Ironically, the animals seen by river runners silhouetted high among the craggy formations is just as likely to be a burro as a bighorn. Burros were observed as high as 1300 feet above the river in the Lower Canyon section of the park and are commonly seen 1200 feet above the levels of the Tonto Plateau (USDI 1976b).

The reason for the use of this "un-burro-like" terrain becomes clearer when distribution of park vegetation is examined. With the exception of riparian habitat the lower elevations of the canyon offers plants an abundance of solar energy but minimal levels of water. The largest variety of plants are found on the talus slopes; consequently, that is where both the burros and bighorn sheep go for nourishment. Steep terrain seems not to impede mobility of burros. Animals pursued during marking operations were observed to move easily, quickly, and gracefully over slopes ranging up to 60° incline and composed of loose rocks and soil. At least two animals were timed at 45 miles per hour over terrain of a 55° incline and composed of loose aggregate. Animals pursued on foot would invariably climb to the highest points of the talus slopes to avoid managers. Burros also seem to exhibit little hesitancy about re-climbing high points after having been driven down several times.

Of the total acreage now occupied by burros, (114,000 acres or 117 square miles), an estimated 250 linear miles consists of talus slopes (USDI 1976). The majority of this terrain exhibits the latticework of trails produced by foraging burros. Soil deflation is extensive along these systems and is suspected of having ecological influences on bighorn sheep (Carothers et al. 1977).

In turn, bighorn sheep use terrain considered by the public to be unnatural. Fourteen observations of bighorn sheep were made of animals occupying the Tonto Plateau, on either side of the Colorado River, during the 1977 burro survey (Walters 1977b). Typically, an observation of a sheep within the park is one of animals peering down from extreme heights or of white rumps running along steep slopes. Few observations have been made of animals in behavior other than flight. Unfortunately the use and need of level terrain by the park's sheep population is poorly understood.

Food Competition. During August 1977, burro fecal samples were collected along a 40-mile stretch of the south side of the Tonto Plateau. Samples were taken from Red Canyon, Mineral Canyon, Cottonwood Canyon, Grapevine Canyon, Burro Springs, Garden Creek, Monument Canyon, Boucher Canyon, Turquoise Canyon, and Copper Canyon. Mule deer and desert bighorn sheep pellets were collected from six of the above sites. All samples were collected without bias towards freshness and it is presumed that these collections represented all seasons.

Fecal samples were prepared for microscopic examination under the processes identified by Sparks and Malechek (1968). Percent relative density values for the samples were tabulated and means and standard deviations calculated. A Simdex Computer program was used to determine similarity of diets between the three herbivores (Table 1 thru 4).

The results of this study indicate that a large percentage of burro diet is composed of grasses. Seventy percent of the annual burro diet along the Tonto Plateau is composed of brome (Bromus), muhly (Muhlenbergia), hilaria (Hilaria), dropseed (Sporobalus), and needlegrass (Stipa). The remainder of the diet consisted of a variety of shrubs and forbs. In fact, 74 species of plants were identified in the burro diet (Hansen 1977). It also was noted that, with one exception, the annual diets of burros in the individual study areas were similar. The exception was Monument Canyon where fecal samples showed Muhly made up 75 percent of the annual diet. This strong preference for grasses supports diet analysis conducted in 1975 and 1976 in the Lower Canyon and Bedrock Canyon area (Carothers, et al. 1976).

When diets of deer and bighorn sheep were considered under the broad grouping of "native herbivore" and compared with burro diets, there did not appear to be a plant taxon which was of major importance to both native herbivore groups. Saltbrush (Atriplex), cliffrose (Cowania mexicana), blackbrush (Coleagyne ramossissima), and snowberry (Symphoricarpos) were major components of native herbivore diets but were represented only in low percentages in burro diets. But when the native herbivore groups were classified into deer and bighorn sheep diets by computer analysis, diet overlap with burros took on an entirely new perspective. Deer diets were relatively dissimilar to burro diets, with a similarity index of from 6 percent to 12 percent.

Table 1. Percent relative densities of major plant taxa in fecal droppings of feral burros from the **Tonto** Plateau, Grand Canyon National Park, 1977.

Plant species	Monument Canyon	Boucher Canyon	Burro Springs	Turquoise Canyon	Grapevine Canyon
Agropyron	2.14 ± 4.74	0.50 ± 1.16	3.19 ± 9.69	2.75 ± 1.93	1.11 ± 2.17
Aristida	3.94 ± 6.65	2.11 ± 2.91	1.69 ± 2.37	3.03 ± 4.08	1.86 ± 3.38
Bouteloua	6.08 ± 14.75	0.31 ± 1.14	6.47 ± 8.16	0.33 ± 0.99	0.33 ± 0.86
Bromus	18.47 ± 13.24	3.94 ± 4.32	13.81 ± 16.29	19.86 ± 20.78	45.39 ± 25.02
Hilaria	5.14 ± 6.63	1.36 ± 1.74	7.19 ± 8.25	0.67 ± 2.16	1.89 ± 3.12
Muhlenbergia	9.50 ± 10.49	75.86 ± 23.17	3.11 ± 4.50	2.97 ± 4.14	4.22 ± 7.46
Oryzopsis hymenoides	5.69 ± 7.52	0.47 ± 1.46	1.89 ± 3.25	1.14 ± 3.20	1.72 ± 2.66
Poa	4.00 ± 10.80	0.14 ± 0.59	2.03 ± 5.06	2.69 ± 7.70	5.97 ± 8.17
Sporobolus	12.67 ± 14.74	0.94 ± 2.38	2.28 ± 3.61	1.56 ± 3.34	1.97 ± 3.43
Stipa	7.97 ± 9.62	0.44 ± 1.56	11.08 ± 10.51	1.89 ± 4.54	4.75 ± 16.61
Tridens	1.11 ± 2.16	0.44 ± 1.13	1.44 ± 2.29	1.03 ± 2.62	0.31 ± 1.06
Antennaria	5.31 ± 10.57	3.97 ± 15.43	9.89 ± 11.54	9.11 ± 10.23	2.14 ± 3.77
Artemisia	1.86 ± 6.06	2.81 ± 10.66	10.81 ± 14.61	2.14 ± 4.78	0.44 ± 1.05
Coleogyne	0.75 ± 2.29	0.28 ± 1.50	3.97 ± 6.99	2.97 ± 4.89	1.44 ± 3.78
Ephedra	2.14 ± 2.74	0.94 ± 1.77	3.06 ± 3.22	6.42 ± 8.08	3.44 ± 4.51
Opuntia	3.97 ± 5.50	1.08 ± 2.31	8.36 ± 13.65	20.36 ± 23.45	5.64 ± 7.48
Other	9.26	4.41	9.73	21.08	17.38
sample size	36	36	36	36	36

Table 1. Feral burro **diets** continued.

Plant species	Bright Angel Trail	Mineral Canyon	Copper Canyon	Cottonwood Creek	Red Canyon	**AVE.**
Agropyron	2.56 ± 4.26	2.36 ± 5.66	0.67 ± 1.77	1.19 ± 2.46	1.28 ± 2.61	1.78
Aristida	1.75 ± 3.38	4.00 ± 6.94	4.58 ± 5.66	4.44 ± 5.50	1.96 ± 2.67	2.97
Bouteloua	3.19 ± 5.88	2.81 ± 3.85	2.22 ± 3.10	10.00 ± 14.51	4.08 ± 4.14	3.58
Bromus	24.61 ± 21.96	16.22 ± 24.71	11.39 ± 14.62	13.10 ± 11.40	17.36 ± 14.44	18.42
Hilaria	10.56 ± 10.76	17.75 ± 22.78	20.92 ± 22.42	8.61 ± 9.29	8.36 ± 13.13	8.25
Muhlembergia	2.71 ± 3.61	6.14 ± 8.09	10.68 ± 9.97	6.92 ± 9.22	5.56 ± 9.55	12.71
Oryzopsis hymenoides	3.94 ± 8.92	4.03 ± 5.52	3.61 ± 4.98	3.53 ± 3.81	9.19 ± 8.79	3.52
Poa	3.89 ± 7.54	1.47 ± 3.27	1.44 ± 5.25	3.39 ± 6.42	0.92 ± 2.23	2.59
Sporobolus	9.89 ± 13.85	4.64 ± 6.09	6.47 ± 6.73	8.69 ± 8.92	2.03 ± 4.03	5.11
Stipa	10.69 ± 12.02	2.92 ± 3.58	3.03 ± 5.42	4.86 ± 7.13	5.64 ± 5.49	5.33
Tridens	0.58 ± 1.79	1.19 ± 2.30	3.50 ± 6.77	3.08 ± 6.75	1.92 ± 2.37	1.46
Antennaria	6.22 ± 13.26	4.56 ± 8.31	4.69 ± 8.29	2.11 ± 3.01	3.33 ± 6.61	5.13
Artemisia	2.94 ± 7.85	4.92 ± 10.62	5.58 ± 12.87	2.89 ± 3.61	4.83 ± 7.85	3.92
Coleogyne	0.78 ± 1.88	0.28 ± 0.81	0.89 ± 3.25	0.81 ± 1.85	0.75 ± 2.10	1.29
Ephedra	0.19 ± 0.67	1.28 ± 3.83	0.83 ± 1.73	1.67 ± 2.18	7.56 ± 8.15	2.75
Opuntia	10.00 ± 16.99	13.61 ± 17.44	2.19 ± 3.89	7.50 ± 9.85	16.64 ± 18.65	8.94
Other*	6.04	11.82	17.31	17.21	8.59	12.28
sample size	36	36	36	36	36	360

*Other taxa include: *Carex*, Cynodon, Eragrostis, Festuca, Juncus, Koeleria cristata, Leptochloa, Lycurus, Phragmites, Sitanion, Agave, Atriplex, Astragalus, Berberis, Compositae, Cowania mexicana, Croton, Cruciferae, Cryptantha, *Draba*, Equisetum, Eriogonum, Eurotia lanata, Fraxinus, Garrya, Glossopetalon, Gutierrezia sarothrae, *Hoffmanseggia*, Juniperus, Larrea, Leguminoseae, Lepidium, Lesquerella, Liliaceae, Mortonia, Moss, Notholaena, Penstemon, Phlox, Phoradendron, Plantago, Polygonum, Potentilla, Prosopsis, Ranunculus, Rhamnus, Rhus, Rosa, Seed, Sida, Sphaeralcea, Symphoricarpus, Spherdia, Typha, Yucca.

Table 2. Percent relative densities of plant taxa identified from apparent mule deer (Odocoileus hemionus) **fecal pellets collected on the Tonto Plateau, Grand Canyon National Park, 1977.**

Plant species	Monument Canyon	Boucher Canyon	Burro Springs	Turquoise Canyon	Grapevine Canyon	Bright Angel Trail	AVE.
Bromus	0.09	0.86		5.35	0.20		1.08
Poa	-	-	0.28	4.94	1.34	0.10	1.11
Artemisia	3.24	2.35	1.32	2.76	0.18	0.79	1.79
Atriplex	26.73	18.65	37.70	16.37	16.85	17.50	22.30
Coleogyne	25.62	37.04	3.84	5.27	0.23	17.64	14.94
Cowania	4.57	19.44	8.38	6.87	43.44	9.87	15.43
Ephedra	3.54	4.17	0.27	5.41	0.97	1.24	2.60
Garrya			0.97	17.15	10.16		4.71
Glossopetalon	22.17	8.42	6.48	6.09		18.22	10.23
Juniperus	0.80		2.25	0.31	1.05	0.40	0.80
Potentilla	0.69	0.27			2.75		0.62
Prosopis	2.27			5.41	0.70	5.92	2.38
Rhamnus				0.66		5.36	1.00
Seed		0.26		2.38	0.05	4.19	1.15
Sphaeralcea	1.11	0.42	0.64	11.36	1.61	1.18	2.72
Symphoricarpos	2.89	1.78	34.05	0.57	15.71	3.39	9.73
Unknown	3.85	3.18	0.85	2.52	2.63	7.71	3.46
Other*	2.43	3.16	2.57	6.58	2.13	6.49	3.69
sample size	28	15	26	11	33	25	

"Other minor taxa include: Agropyron, Aristida, *Carex*, *Hilaria*, Koeleria, Muhlenbergia, Oryzopsis hymenoides, Sitanion, Sporobolus, Stipa, Acacia, Ambrosia, Antennaria, Berberis, Cercidium, Cirsium, Composite, Croton, Cryptantha, Eriogonum, Eurotia lanata, Grayia, Gutierrezia sarothrae, Lepidium, Notholeana, Oenothera, Opuntia, Phoradendron, *Pinus*, Rhus trilobata, Ribes, Sida, Verbascum, Yucca.

Table 3. Percent relative density of plant taxa in fecal pellets of apparent desert mountain sheep (Ovis canadensis) from the Tonto Plateay, Grand Canyon National Park, 1977.

Plant species	Monument Canyon	Boucher Canyon	Burro Springs	Turquoise Canyon	AVE.
Agropyron	2.08		0.84	2.48	1.35
Bouteloua	2.99				0.75
Bromus	24.73	16.74	19.32	17.81	19.65
Hilaria	8.56	2.59	0.46	4.85	4.12
Muhlenbergia	4.14	14.91	1.11	2.08	5.56
Qryzopsis	3.31	2.58	4.86	0.40	2.79
Poa	7.22	11.47	4.39	15.90	9.75
Sporobolus	13.03			7.14	5.04
Stipa	0.28	1.18	3.50	1.71	1.67
Artemisia	3.85	3.30	2.99	4.57	3.68
Atriplex	12.51	8.86	18.83	12.71	13.23
Coleogyne	4.14	11.58	15.84	1.84	8.35
Cowania	0.31	6.76	3.33	4.04	3.61
Ephedra	0.21	0.82	0.75	1.44	0.81
Eriogonum	0.31	1.68		0.37	0.59
Garrya	1.98		13.70	5.38	5.27
Glossopetalon	0.96	4.40	4.56	1.59	2.88
Prosopis	2.27	0.88		4.38	1.88
Seed	0.31	4.10		1.32	1.43
Sphaeralcea	1.89	1.40		3.32	1.65
Unknown	0.11		2.39		0.63
Other*	4.81	6.75	3.13	6.67	5.34
sample size	18	5	9	31	

"Other minor taxa include: Aristida, *Carex*, Koeleria, Lycurus, Sitanion, Tridens, Antennaria, Composite, Cruciferae, Eurotia lanata, Gutierrezia sarothrae, Juniperus, Lepidium, Opuntia, Phlox, *Pinus*, Potentilla, Ribes, Symphoricarpos.

Table 4. Percent similarity of feral burro diets between sampling sites on the Tonto Plateau, Grand Canyon National Park, 1977.

Canyon	Monument	Boucher	Burro Springs	Turquoise	Grapevine	Bright Angel	Mineral	Copper	Cotton-wood	Red
Monument	100	32	66	54	56	75	70	66	75	67
Boucher		100	25	25	23	23	29	35	28	27
Burro Springs			100	60	51	69	66	57	66	69
Turquoise				100	53	56	59	46	50	65
Grapevine					100	57	50	42	60	54
Bright Angel						100	72	59	68	66
Mineral							100	77	71	77
Copper								100	69	59
Cottonwood									100	69
Red										100

The average bighorn sheep diet was 52 percent similar to the feral burro diet. In individual sampling sites, the similarity index varied from 29.6 percent to 61.1 percent. Grass species common to both bighorn and burros were wheatgrass *(Agropyron)*, ricegrass (Oryzopsis), brome, hilaria and bluegrass *(Poa)*.

Grass species dominated feral burro diets in the Grand Wash Cliffs area of the park (Hansen and Martin 1973). In this study, four grasses: muhly, three awn *(Aristida)*, tridens *(Tridens)*, and reedgrass (Phragmites) plus the shrub salt-cedar (Tamarisk) made up 70 percent of the annual diet of feral burros. Woodward and Ohmart (1976) found burros used only 3.9 percent grass. They found 91.1 percent forbs and browse made up the remainder of diets of burros in the Chemehuevi Mountains of California. Seegmiller (1977) found burros used 22.7 percent grasses, 32.8 percent forbs, 39.7 percent browse, and 4.8 percent unknowns in annual diets of animals in the Bill Williams Mountains of Arizona. This diet offered a 64 percent overlap with bighorn sheep. McMichael (1974) showed a 50-58 percent similarity index in burro-bighorn diets.

Based upon the study conducted by Hansen (1977) the diets of feral burros in the park as compared to native ungulates in general would at first appear to be dissimilar. But when analyzed on a species basis, data show the diets of burros to be similar to that of desert bighorn sheep and, thus, the burro offers direct competition with sheep for available food. (However, it should be remembered that diet.similarity does not preclude the occurrence of possible seasonal on-site specific trade-offs of food resources.)

Hansen concludes his study with the statement, ". . .Feral burros have the ability to utilize coarse, low quality forage efficiently in the Grand Canyon National Park. It appears that feral burros are not primarily browsers by preference in the Grand Canyon National Park, but are opportunistic generalists and tend to consume grasses when they are present. If burros were removed from the park, the food they now consume would become available to native species."

Water competition: Emotionalism runs high on both sides of this problem. Claims are made from both sides that, for the most part, are not substantiated. It is common to hear some bighorn sheep promoters claim that burros dominate desert waterholes, thus preventing utilization by bighorn. Claims also are made as to direct physical conflict between these two animals at water sites and that burros characteristically trample, muddy, and foul water sites. The facts, however, do not verify this as being absolutely true in all situations. Welles and Welles (1961) found this was not the case in the drinking habits of burros at Death Valley National Monument. They also observed the two animals were often seen together. Welles further states that many of the commonly held beliefs of waterhole competition, i.e., fouling, trampling, and direct assaults were not observed during their 6-year study, but postulate there may be a critical competition when conditions make water very scarce. Jones (1969) maintains that competition for food and water by these two animals does exist, and at times is severe, but the burro is no more an anathema to bighorn sheep than any other competition. Farrell (1973) considered the impact of burros using four water holes in southern. Arizona as not being severe.

Sumner (1959) and Bendt (1957) maintain a belief that burros are the main threat to bighorn sheep populations through food and water competition but also say data to statistically illustrate this impact is lacking.

Buechner (1960) noted the possible existence of water hole competition on the Tonto Plateau and recommended further analysis of the problem. He comments on springs on the Tonto Plateau which have been "completely or partially, 'destroyed'." This, however, seems to be a subjective determination by the author. Impacts do exist on the springs but their effect on bighorn sheep and other wildlife remains unknown. Burros do impact seeps and springs with fecal pollution along the Tonto Plateau and this impact is especially adverse to humans. Whether this impact is adverse, or beneficial, to bighorn sheep must await the thorough and objective research of this question.

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CHRONIC SINUSITIS IN THE DESERT BIGHORN (Ovis canadensis nelsoni).

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Abstract Chronic sinusitis with subsequent osteolysis and anomalies of the skull are described in a population of desert bighorn *(Ovis canadensis nelsoni)* maintained in an 80-acre enclosure at Zion National Park, Springdale, Utah. The incidence of occurrence is 41 percent in sheep 1 year or older, and is believed to be terminal. The sinusitis appears to be similar to the disease that resulted in necrosis of desert bighorn skulls from Arizona and Nevada. The etiological agent causing the sinusitis may be the sheep bot fly larvae *(Oestrus ovis)* with secondary infections caused by corynebacteria. Physical and behavioral symptoms associated with sinusitis are: progressive debilitation which often results in weight losses of nearly 50 percent; draining lesions of forehead; blindness; and seeking seclusion. The only effective treatment is to bore a hole into the frontal sinus and another into the horn core and then flush the infected cavities with antibacterial and antiseptic agents.

Osteonecrosis and skeletal anomalies have been observed in skulls of desert bighorn sheep *(Ovis canadensis nelsoni)* from Arizona and Nevada (Hansen, 1961; Arizona Game and Fish, 1963; and Allred and Bradley, 1965). The skulls exhibited varying degrees of necrosis ranging from spongy, porous bone to areas of extensive osteolysis in the frontal bone, horn sheath and horn core. The necrosis was more variable in ewe than in ram skulls, covered a wider area of the skull and did not produce large lesions or cavities in the frontal bone. Several ram skulls differed in the basal circumferences of the two horns. The horn differentials were associated with changes in the palatal suture and occipital condyles. In addition to the gross anomalies in the frontal region of the skull, necrotic bone was also observed as porous areas of the tooth arcade, which extended through the infraorbital foramen and into the orbital and lacrimal bone. Allred and Bradley (1965) reported that the incidence of necrosis of the frontal bone and horns was 23 and 3 percent of ewe and ram skulls, respectively; and that 75 and 49 percent, respectively, exhibited bone anomalies associated with necrosis of the infraorbital foramen.

Observations of osteonecrosis of the Arizona desert bighorn come mainly from hunters and taxidermists. During the 1962 hunting season, 27 rams were killed, two (7 percent) of which exhibited noticable necrosis. a taxidermist reported that, during the previous three years, he had seen osteonecrosis in at least one bighorn sheep mounted. More recently, an Arizdna desert bighorn ewe was treated for typical signs of hypocalcemiaand possible central nervous system disorders (Hospital Admission Record, 1977. Approximately 2 months after the beginning of treatment, the ewe died. The autopsy findings included 2 abscesses in the left hemisphere of the ewe's brain which resulted from an infected left horn that caused a lesion in the brain case. *Corynebacterium* pyogenes was isolated from the brain abscesses.

The most recent descriptions of osteonecrosis in a living population of desert bighorn are based on animals in a captive herd maintained at Zion National Park, Utah. Twelve Nelson's desert bighorn were captured in Nevada during 1973 and relocated in an 80-acre enclosure in the Park. Ten of these sheep (1ram, 5 ewes and 4 lambs) had been taken from the River Mountains during July, with 2 additional rams coming from Corn Creek in October. By 1976, the population had increased to 22.

In October, 1975, a ram that appeared to beseverely debilitated was captured, and observed to have extreme osteolysis and abscessation in the frontal region of the head (Fig. 1). Earlier clinical signs of a problem (draining lesions of the nasal and frontal areas of the skull) were evident in December of 1974, but attributed to fighting during the rut. The ram was found dead in the park October, 1975 (Fig. 2). The skull exhibited extreme necrosis of the frontal bone which extended over and within the left orbit (Fig. 3 and 4). There also was a thinning of the brain case that resulted in two holes which most likely brought about death through abscessation of the brain. The trabeculae within the horn cores were completely desttoyed. The ram was 7 years old at the time of death and weighed only 100 Ibs. The diagnosis was of chronic sinusitis.

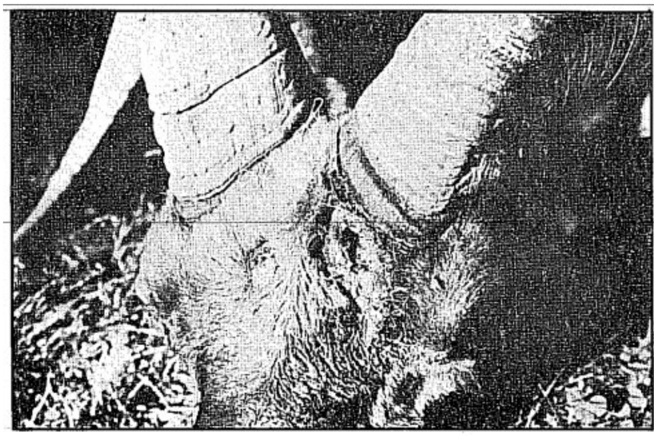


Figure 1. Draining lesion from chronic frontal sinusitis in a desert bighorn raw.

Figure 2. Progressive debilitation of ram with sinusitis. Note keratitis of left eye.

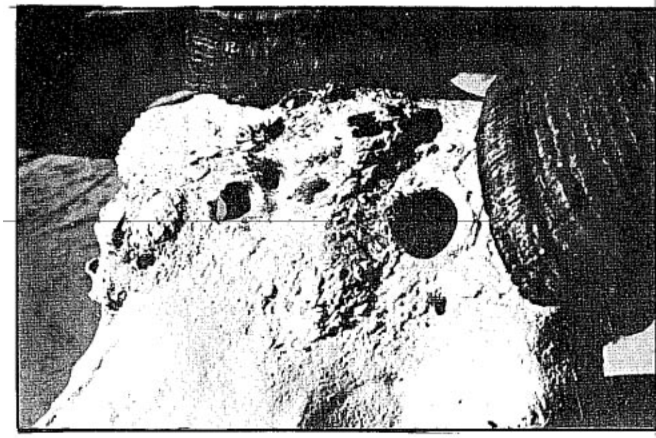


Figure 3. Lesions and porousity of frontal bone resulting from sinusitis.

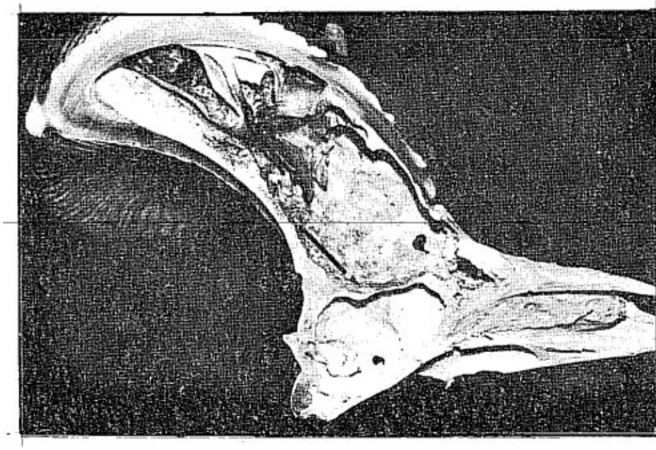


Figure 4. Sagital section of ram that had sinusitis. Note the extensive osteolysis of the frontal sinus, thinning of bone of upper brain case with subsequent lysis (see arrow), and total destruction of trabeculae within the horn core.

Since that initial observance, another ram and three ewes have been diagnosed as having sinusitis with varying degrees of osteomyelitis and osteonecrosis. The second ram was first treated in November of 1976 for abscessation of the forehead. Lesions were drained and then perfused with hydrogen peroxide. There was temporary imrovement in the ram's condition, but by December inflammation had re-occurred in the surface lesions of the forehead. The ram was recaptured during November 1977 and given intensive treatment. The frontal sinus was drained by boring a ½" diameter hole (trephining) through the frontal bone of the right sinus. A catheter was inserted approximately 2" into the sinal cavity and the sinus was flushed with "Nolvasan" (an antiseptic) and "oxytetracycline" (an antibacterial agent). The sinus was flushed daily for three weeks. The ram kept in isolation for 3.5 months while the disease was monitored, but then unexpectedly died from progrsssive pneumonia. The ram was 3.5 years at death and weighed 110 Ibs. An autopsy revealed that the sinusitis had not been arrested, but had formed a large 3" dia. abscess in the lower right horn core (Fig. 5). The abscess was encapsulated by a ½" fiberous layer.

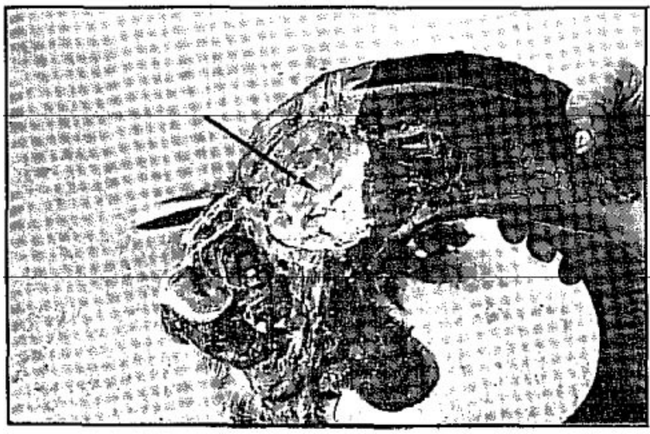


Figure 5. Large encapsulated abscess in sectioned horn or ram with sinusitis.

At the posterior base of the infected horn, the abscess was draining through a small opening that had resulted from osteolysis of the horn core and lysis of the horn sheath. Three other small, non-draining lesions were observed at the posterior wall of the right orbit. In addition to the osteonecrosis, the chronic sinusitis had caused the basal circumference of the right horn to be ¾" larger than the left (Fig. 6).

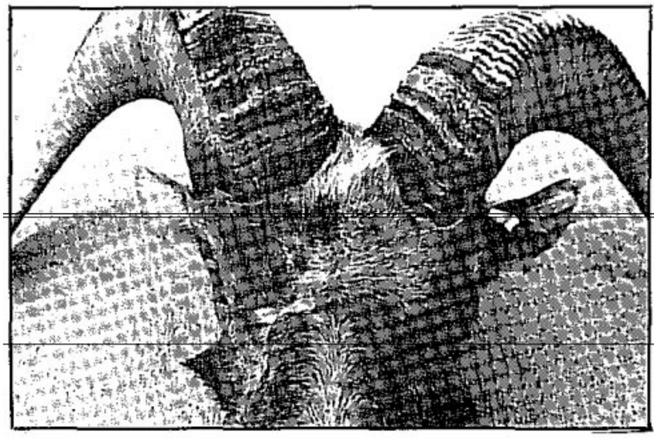


Figure 6. Left horn has become enlarged at base as a result of the infection in the horn core.

Two of the three ewes that were diagnosed as having chronic sinusitis were captured because of their progressively worsening body condition and subsequently died 24-30 hours after being confined for treatment. The first of the two ewes that died was an adult (approx. 4 years) and weighed only 69 lbs. at death. Her frontal sinuses were filled with a thick purulent exudate. The left eye was extremely ulcerated, with its interior chamber exposed and filled with dark red irregular material and flv larvae. The fly larvae were secondary invaders parasitizing the sinusitis-induced open lesions. The right eye contained irregular opague plagues of the cornea which were symptomatic of a past pink-eye infection. There was no evidence of osteonecrosis; however the skull was not thorouahlu examined for bone lesions. The second ewe, approximately 7 years old, was extremely debilitated and weighted only 85 lbs. at death. The left horn core was fractured at the junction of the frontal bone (Fig. 7). The skin in the region of fracture was broken and there was slight hemmorrhage in one foci near the posterior lateral area of

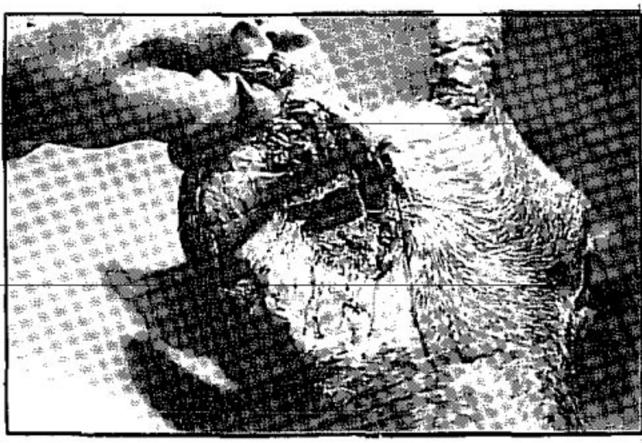


Figure 7. Fracture at base of horn which resulted from weakening of frontral bone in a ewe that had sinusitis.

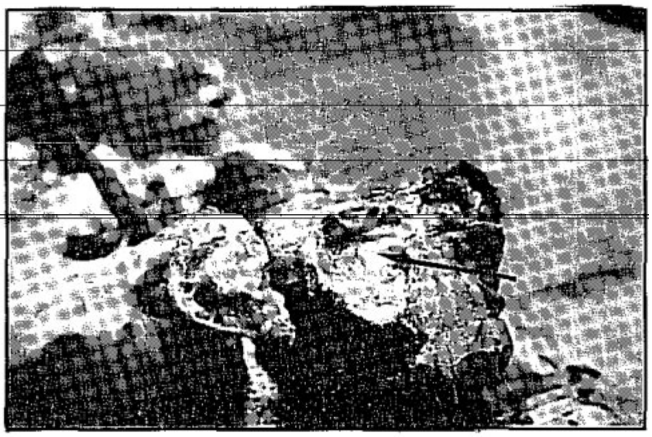


Figure 8. The left frontal sinus and disattached horn core is filled with a pus-like exudate. The left horn was fractured from skull (Fig. 7).

Figure 9. Sinusitis is treatable by boring a hole in the frontal sinus and another into the horn core and then flushing with antibacterial and antiseptic agents.

the fracture. The right frontal sinus contained granular purulent necrotic material and fragments and remnants of nasal bot larvae (Fig. 8). A dead, but intact nasal bot larva was found in the posterior dorsal nasal cavity. The third ewe that was captured had a draining lesion in the frontal bone just anterior to the left horn. This ewe was in good body condition and weighted approximately 120 lbs. The ewe was first trephined at the base and then a second hole (3/8" dia.) was bored into the horn core approximately ⅓ the distance from the tip of the horn (Fig. 9). The boring of the scond hole was necessary to insure adequate flushing of the the horn core and frontal sinus. The ewe underwent intensive treatment for three weeks as was used previously on the ram, and then returned to the Zion Park enclosure.

Microbial agents isolated from the sinal infections have been coliform, proteus, bacillus, streptococci and corynebacteria. Corynebacteria was the most common agent and is believed to cause the pus-like exudate. There was no evidence of microbial agents, other than bacteria.

Four additional sheep (2 rams and 2 ewes) had died within the Zion enclosure between 1974 and 1977 without cause (one exception) of death being determined. Both ram skulls and one ewe skull have since been examined and have been positively identified as having had sinusitis. The sinusitis in one of the ram skulls resulted in what was described as a broken skull resulting in death. The left horn core, left frontal bone and part of the orbit were fractured away from the rest of the skull (Fig. 10). The ewe whose skull has not yet been recovered was observed at death to have had an infection at the base of the horn. The incidence of occurrence of sinusitus in the desert bighorn at Zion National Park is 41 percent.

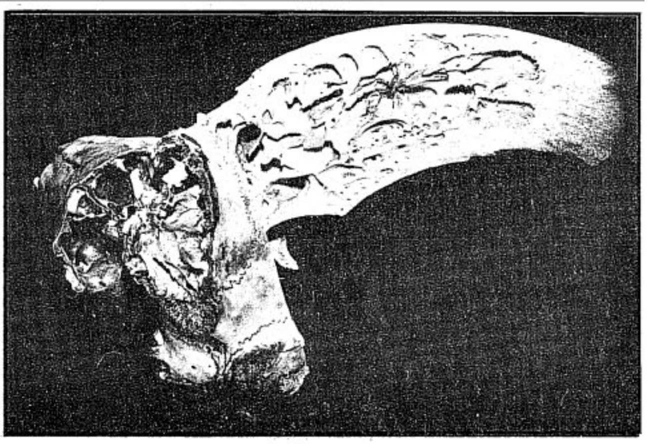


Figure 10. Weakening of bone overlaying the right frontal sinus resulted in massive fracture of horn, frontal bone and orbit. Sagittal section of left horn core shows evidence of bone porosity caused by sinusitis.

The disease occurring in the Zion captive desert bighorn sheep appears similar to that reported in the Arizona and Nevada populations of wild sheep. If untreated, it appears to be terminal, following a progressive debiliation over 7-12 months. Progressive symptoms can be related to abnormal behavior, frontal bone lesions of the skull, blindness, nasal lesions, harassing by other sheep, and extensive weight losses. Previously dominant rams with the disease may become less or non-competitive during ruts, and may seek total isolation. Ewes that lamb after the disease begins may not be able to properly rear their lambs because of improper nurtrition and decline in mothering ability. The diseased ewes also often seek seclusion. The cause of the osteonecrosis observed in the Nevada sheep skulls was believed responsible for the demise of the sheep. Those sheep probably underwent physical and behavior changes similar to those seen in the Zion sheep prior to their death.

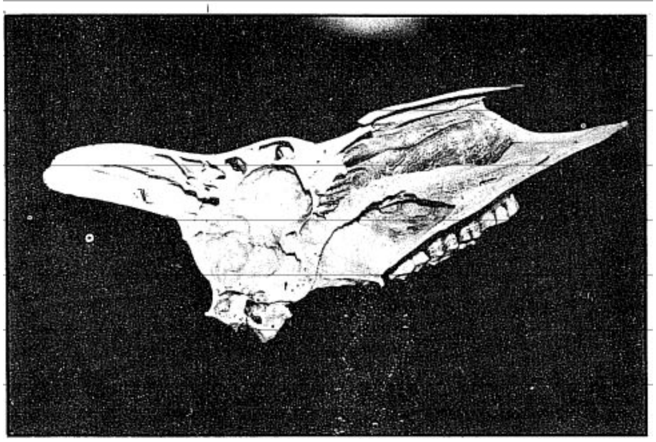
Necrosis in the desert bighorn has been previously ascribed to possible mechanical damage (Hansen, 1961; Arizona Game and Fish, 1963; and Allred and Bradley, 1965), but in combination with other factors. Our obervation of necrotic bot fly larvae in the sinal exudate of diseased sheep suggests that sinusitis and osteomyelitis, followed by osteonecrosis, may result from bot fly larvae *(Oestrus ovis)* which became trapped in the upper frontal sinuses.

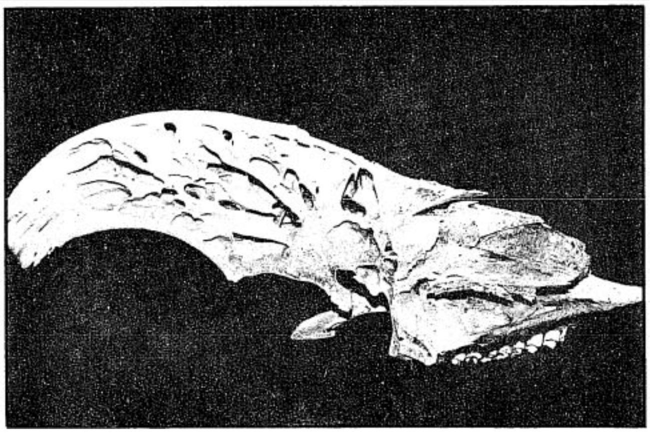
Although little is known about the effects of bot flies in wild sheep, the etiology has been reported for domestic sheep (Fallis, 1940; Cobbert and Mitchell, 1941; Capelle, 1966; Cole, 1969; Krull, 1969; David and Anderson, 1971). From early summer to autumn, the sheep bot fly deposits living young (Ovoviviparous) in the nostrils of sheep and occasionally goats and deer. After deposition the larvae migrate up the nasal passages into the maxillary and frontal sinuses, often reaching as far as the horn core in rams. The larvae attach to the mucous membranes and may be found lying close together and in various stages of development. The larvae pass through two molts within 2-10 months. The mature larvae then return to the nostrils and are sneezed out. Once outside the sheep they enter the soil and pupate through a period of 27 to 36 days. The adult flies live 24 to 28 days, with each female, after mating, producing up to 500 larvae.

Even though nasal bots are considered merely minor pests of domestic sheep, they set up an irritation that results in increased drainage of mucus from the nose, which resembles the effects of a head cold. If accompanied by bacterial infection, the discharge often becomes thickened and discolored, giving the appearance of a "snotty nose" (Krull, 1969). Other symptoms are frequent sneezing, difficult breathing, inflamed eyes, lachrymation and head carried low. Sheep that are infected may temporarily stop or restrict eating activity and may grate their teeth. Sheep that are unable to readily expell the copious mucus often die from suffocation or from abscesses induced by necrotic larvae in the deeper recesses of the head. Cobbett and Mitchell (1941) reported that bot fly associated abscessation of the mucosa is always associated with necrotic larvae and that secondary bacterial invasions probably bring about death of sheep.

Cobbett and Mitchell (1941) generally found the heaviest larval infections in heads of horned sheep, in which the frontal sinuses tend to be larger and more spacious than otherwise. Consequently, the incidence and severity of sinusitis in desert bighorn may be aggravated by the extensive pneumation of their skulls (Figs. 10 and 11). The brain of the bighorn is overlayed by two stratifications of bone which are separated by cross connections of bone. The double roof of bone extends from about 2-2.5 in. in the front of the brain to the occiput. The highly pneumated horn cores are formed from the upper skull roof and the chambering is continuous with the frontal sinus. The spaces surrounding the lower brain case are probably derived from the frontal sinus. The sinuses in male primitve wild sheep like the mouflon and urial are greatly enlarged but do not continue past the horn cores. Pneumation in domestic sheep is equal to or less than that in primitive wild sheep.

Although the frontal sinus of the intensively treated desert bighorn ram was trephined and flushed, the back of the horn core remained fevered. An infection in that region, which lies posterior and dorsal to the brain, has no outlet for draining and is consequently extremely difficult to treat. This was obvious with the post-mortem findings of the ram. The infection in the base of the horn core would have eventually spread again throughout the frontal sinus. Treatment of sinusitis must therefore involve trephining of both the frontal sinus and horn





Figures 11 & 12. Sagittal section of normal ewe and ram skull which illustrates the trabeculation of frontal sinus and horn core. The extensive chambering particularly posterior to the brain and within the horn core provides pockets for the disease to become established.

core to be effective. This pneumated region also extends to the posterior area of the orbits, where a high incidence of osteonecrosis has been observed in ewe skulls and may contribute to eye inflammation and blindness. The extent of disease proliferation and pressures created can result in diferential enlargement of horns in ewe and rams and may cause the high incidence of necrosis associated with the infraorbital foramen of ewes. Drainage through the infraorbital foramen could subsequently result in necrosis in the tooth arcade, which was observed particularly in the Nevada ewe skulls.

Sinusitis and subsequent osteonecrosis in the desert bighorn appears to be a major mortality factor that may have led to the demise of some populations of wild sheep and restricted population increases in others. The disease had already challenged the success of the re-introduction of the desert bighorn into Zion National Park by killing 4 rams and 4 ewes of breeding age. Too little is yet known about the etiology of sinusitis and its possible effects to ascribe management guidelines. Several critical questions still remain to be answered by research that will require the cooperative efforts of all who are concerned with the survival of the desert bighorn.

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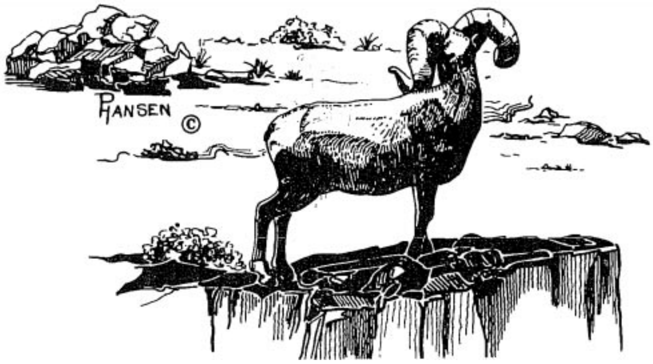

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RADIO-TELEMETRIC STUDIES OF MOVEMENTS IN DESERT BIGHORN SHEEP, JOSHUA TREE NATIONAL MONUMENT

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Abstract. Bighorn sheep are being studied in Joshua Tree National monument to gather data that will help manage this species more effectively. A concentration of sheep in the Stubbe Spring area has caused concern about possible overutilization of the surrounding range, and dependence upon one water source by this herd, which is thought to be the largest group of sheep in the monument. A study of sheep movements in the Stubbe Spring area was undertaken to assist in selecting another guzzler site in the Little San Bernardino Mountains. It is hoped that installation of an additional guzzler will enable the herd to expand its range and numbers. Nine sheep were fited with radio-telemetry collars in July of 1977. A total of 81 locations was recorded between July, 1977 and April, 1978, and are reported herein.

The bighorn sheep research and management program at Joshua Tree National Monument was expanded to include a telemetric study of movements of sheep in the Stubbe Spring area. It was noted in earlier studies that a large group of sheep inhabit the area, and water at Stubbe Spring. Precise numbers of sheep have been difficult to ascertain, but have been estimated from waterhole counts by various investigators. A summary of previous studies was given by Douglas (1976, Studies of Bighorn in Joshua Tree National Monument, DBC Trans. 32-35).

Two weeks of trapping were conducted at Stubbe Spring in July of 1977. A drop-gate corral trap was constructed of heavy nylon mesh, supported by upright poles as described by Cooper and McLean (1974, Cooperative management and research of the River Mountain herd, DBC Trans. 53-60). Trapping was conducted for only three consecutive days each week so as not to deprive those individuals that would not enter the trap of water.

Nine sheep were captured and equipped with radio-telemetry collars (Telonics, Mesa, AZ) having lithium chloride batteries. Five ewes and four rams were collared (Table 1). Since July, 1977, a total of 81 locations has been recorded for these individuals. The distances of travel from Stubbe Spring have ranged from 1.25 to 5.5 miles (Table 1).

Figure 1 illustrates composite ranges for all rams and ewes recorded to date. Rams tend to move farther south and east from the spring than ewes. Ewes tend to utilize those areas to the west and southwest of Stubbe Spring. Additional study of movements is necessary before seasonal use areas can be defined for the sexes.

We were somewhat surprised to see considerable utilization of the arid and sparsely vegetated hills on the western side of the Little San Bernardino Mountains. This area to the west of Stubbe Spring has extensive trail systems that were noted on earlier survey flights. Closer inspection revealed that grasses and herbaceous species occur in drainage areas and on protected slopes. Although the vegetation is quite sparse, there is enough to attract the sheep.

A helicopter survey of sheep habitat was conducted from October 3-5, 1977, for a total of 13 hours. A total of 51 individual sheep were counted throughout the monument (Table 2). The most encouraging aspect of the flight was that seven lambs and 33 ewes were seen. The majority of lambs were seen about two miles west of Stubbe Spring.

It is interesting that 27 ewes and three lambs were seen in the Stubbe area during the helicopter flight, whereas only seven ewes and no lambs were seen during the two weeks of trapping. Five of the seven ewes were equipped with transmitters (Table 1). Only one yearling was observed at the spring in July. Of the 38 sheep seen in the Stubbe Spring area, three were marked. Since six of the marked individuals were not seen, this brings the known herd size in the Stubbe area to 44 animals. It is possible

Table 1. Data on individual desert bighorn sheep trapped in Joshua Tree National Monument in July, 1977 and equipped with radio-telemetry collars. Ages of ewes were estimated; rams were aged by the horn ring method.

Collar Number	Sex	Age	Number of Observations	Date last Observed	Maximum distance from Stubbe Spring
1	male	12 years	10	12/2/77	4 miles
3	female	2 years	14	12/23/77	4 miles
4	male	8 years	not relocated		
5	female	4 years	18	2/7/78	3 miles
6	female	1 year	6	8/6/77	1¼ miles
7	female	3 years	8	2/7/78	2 miles
8	male	9 years	4	8/7/77	2 miles
9	male	8 years	9	11/21/77	5½ miles
10	female	5 years	12	2/6/78	3 miles

that sheep in the Stubbe Spring area may be utilizing a water source other than Stubbe Spring. To date we have not located such a source, but we hope that further locational data may facilitate doing so.

Table 2. Numbers and locations of bighorn sheep observed during a helicopter survey of Joshua Tree National Monument, conducted from October 3-5, 1977.

Number of Individuals Seen				Location
Ewes	Rams	Lambs	Total	
1	1	1	3	49 Palms Oasis
4	1	2	7	Barker Dam
27	8	3	38	South to West of Stubbe Spring
1	1	1	3	Eagle Mountains
33	11	7	51	TOTALS

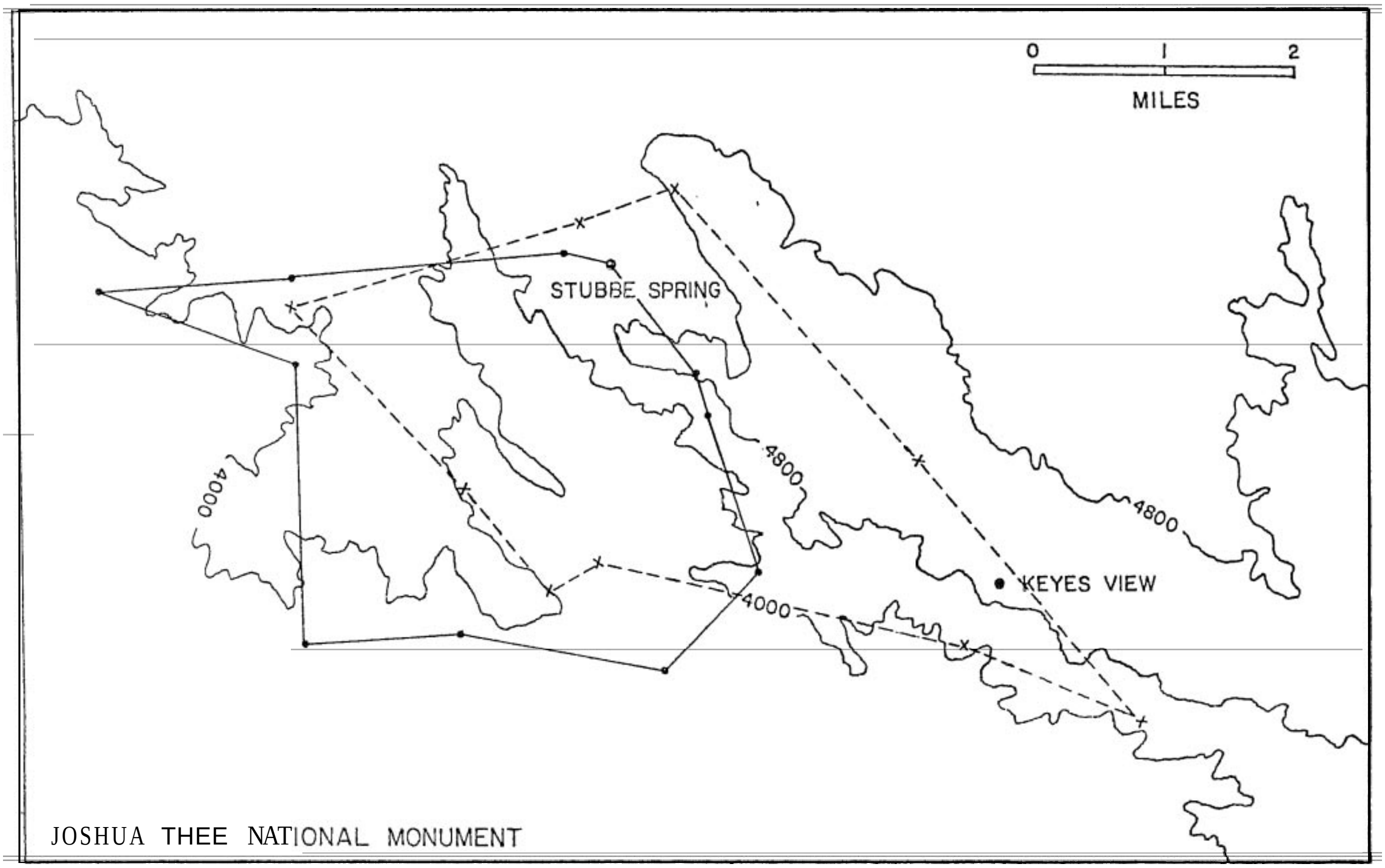

Figure 1. Composite home ranges of five radio-equipped bighorn ewes (solid line) and four rams (dotted line) in the Stubbe Spring area, Joshua Tree National Monument. Data are from July, 1977 through April, 1978.

DIFFERENTIAL UTILIZATION OF WATER SOURCES BY DESERT BIGHORN SHEEP IN THE RIVER MOUNTAINS, NEVADA

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Abstract. More than 7600 observations of desert bighorn sheep in the River Mountains have documented that the population is distributed unevenly throughout 90.1 sq km of available habitat. In 1976, approximately 60 percent of the population used one permanent water source on a regular basis throughout the summer, while the majority of the remaining 40 percent used another source only 3.2 km southeast of the primary source. A few animals were observed watering at a third source, located 5.2 km south of the primary source. It was hypothesized that this differential utilization of permanent water sources in the River Mountains was due to the relative amounts of forage available within a 3.2-km radius of these sources, allowing one area to support more animals than another during the critical summer months.

INTRODUCTION

Desert bighorn sheep (*Ovis canadensis nelsoni*) in the River Mountains, Nevada have been the focus of intensive research since 1973 (Cooper and McLean 1974, Leslie 1977, McQuivey and Leslie 1977, McQuivey 1978, Leslie and Douglas, In Press). Under cooperative agreement, the National Park Service and the Nevada Department of Fish and Game trapped and marked 82 sheep between 1973-1975. Additionally, 32 sheep were trapped and transplanted to various locations in central Nevada and southern Utah (McQuivey 1975) between 1973-1977. In 1975, radio telemetry was employed to document movements and home range patterns within the population (Leslie 1977, Leslie and Douglas, In Press).

More than 7600 observations of sheep in the River Mountains have documented that the population is distributed unevenly throughout 90.1 sq km of available habitat. The most even distribution of the population occurs during the mild winter months when rams and ewes display social and varying degrees of spatial separation (Leslie 1977, Leslie and Douglas, In Press). During the summer months, when high temperatures, extreme aridity, and decreasing forage quality act synergistically, the population is limited to the area within a 3.2-km radius of permanent water sources (Leslie 1977, Leslie and Douglas, In Press).

In 1976, approximately 60 percent of the population used one water source on a regular basis during the summer, while the majority of the remaining 40 percent used another source 3.2 km southeast. A few animals watered irregularly at a third location, 5.2 km south of the primary water source. Generally, this pattern was observed during the summers of 1975, 1977, and 1978. These percentages do not, however, reflect individual preference, but only distributional patterns of the River Mountain herd. Some individuals, particularly rams, frequent more than one water source (Leslie and Douglas, In Press). It was hypothesized that this differential utilization of permanent water sources by the population was the direct result of forage availability (i.e. relative densities and cover) within a 3.2-km radius of these sources. This area is a key limiting factor to population size and growth (McQuivey 1978).

THE STUDY AREA

The River Mountains are located about 24 km southeast of Las Vegas, Nevada. The range extends northwest of Boulder City, east of Henderson, and south of Las Vegas Wash (Figure 1). The eastern half of the range lies within Lake Mead National Recreation Area; the remainder is under the jurisdiction of the Bureau of Land Management.

The area supports two biotic communities: the creosote bush community and the desert wash community. The reader is referred to a description of these communities in southern Nevada given by Bradley and Deacon (1965). Climate and fauna within each community is essentially the same; however, more water from run-off is generally available to plants in the desert wash community. As a result, this community has a greater diversity of floral species, particularly desert shrubs.

At least 40 families of plants are represented in the range; the co-dominant species are creosote bush, *Larrea divaricata*, and Burro brush, *Ambrosia dumosa*. Herbaceous vegetation generally is more pronounced and diverse in washes. Numerous annuals are present, but growth and density varies yearly, depending on precipitation. No elevational change in floral communities is evident in the River Mountains, which have a vertical rise of about 700 m.

No natural springs or seeps are located in the River Mountains. Desert bighorn sheep depend on artificial, permanent water sources located on the eastern periphery of the range (Figure 1). The chronological availability of water as it relates to the demographic history of the population has been discussed by McQuivey and Leslie (1977) and Leslie and Douglas (In Press). The water sources are designated as SNWP (Southern Nevada Water Project), HC (horse corrals; Figure 1), and C (cottonwood tree, located 2 km south of HC).

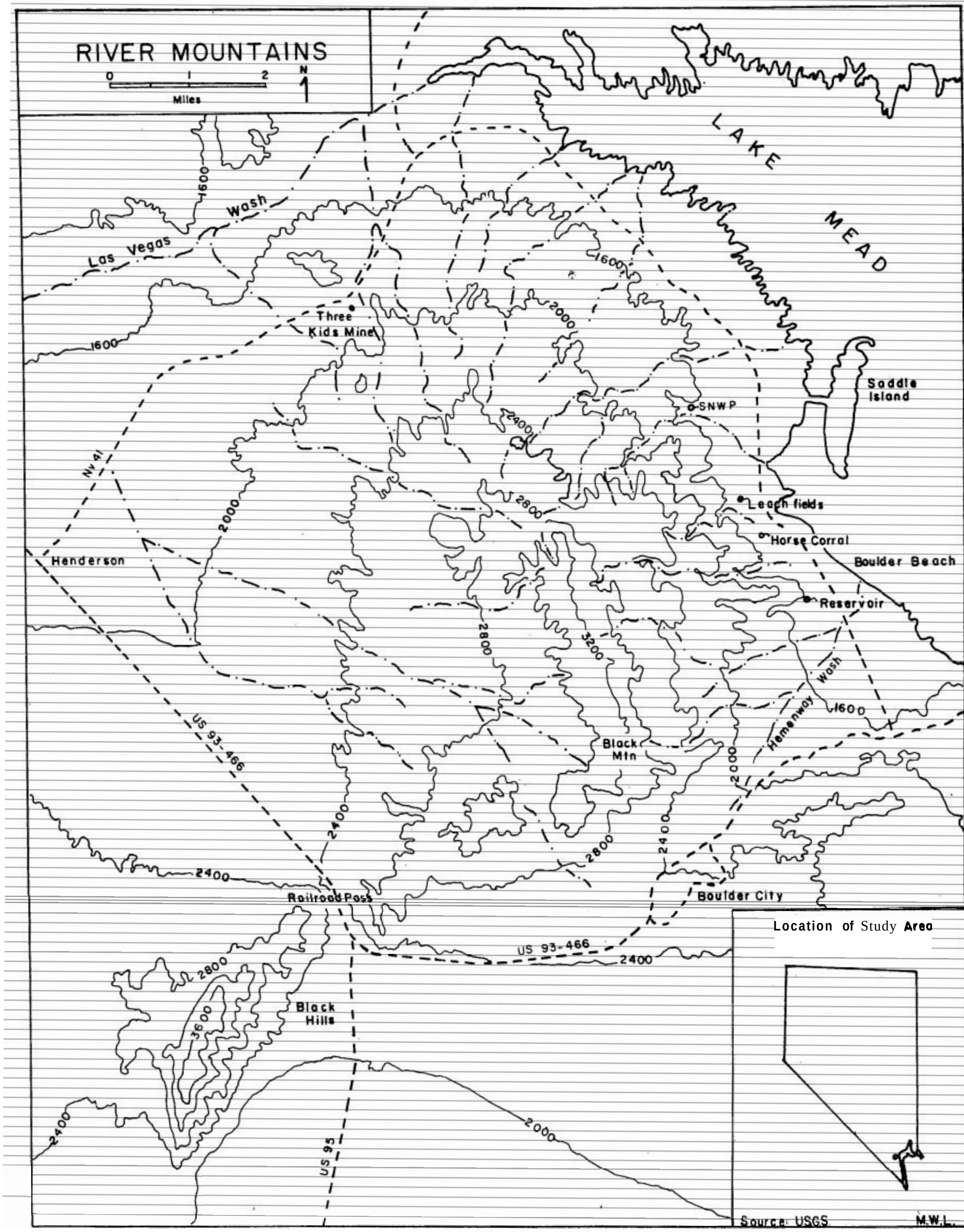

Figure 1. Topographical map of the River Mountains.

MATERIALS AND METHODS

The step-point method of vegetation analysis was used to test the hypothesis that differential utilization of water sources was due to relative amounts of forage within a 3.2-km radius of water. This technique allows one observer to cover a large area in a minimum amount of time, while giving data on frequency of species and percent cover. Bradley (1964) used this method to assess the vegetation of the Desert Game Range, Nevada, in relation to desert bighorn sheep. Leary (1977) also used it to describe the floristics of Joshua Tree National Monument, California.

Twenty transects were run; a minimum of 300 points and 100 hits were required in each transect. The transects were arranged in a stratified manner on four lines running westerly from SNWP, HC, C, and between SNWP and HC, designated as LF. On each of the four lines, five step-point transects were run at .8

km (.5 mi) intervals in a north-south direction. Sorensen's Index of Similarity (Sorensen 1948, from Odum 1971) was used to compare lines and step-point transects. The index value ranges linearly from 0 to 1, with a high value indicating a high degree of similarity. The index compares only species composition between samples.

Transects were run in January and February, 1978; only perennial vegetation was sampled. Perennial species were used as "indicators" of the relative amounts of annual species which may be present in a given area. For example, Hymenoclea salsola is restricted to desert washes, and generally more annuals, and thus forage, are available in washes. Such areas are used extensively by sheep in the River Mountains (Leslie 1977, Leslie and Douglas, In Press). Conversely, a species such as Haplopappus *linicifolius* occurs on steep, rocky slopes and is likely to indicate an area that supports fewer annuals and grasses than washes and thus, less forage for sheep.

RESULTS AND DISCUSSION

Preliminary data tend to support the hypothesis that differential utilization of permanent water sources in the River Mountains is correlated with the relative amount of forage around these sources. The data are preliminary since only the perennial vegetation was sampled. Also the sampling rate was no doubt minimal, considering the size of the area examined.

Most of the transects displayed a high degree of similarity; indices ranged from .45 to .92. Transect lines had similar species composition (Table 1). The floral homogenity of the River Mountains is apparent from these data.

Table 1. Sorensen's Index of Similarity (1948) comparing species composition on stratified lines (five transects each) in the River Mountains.

	SNWP	LF	HC	C
SNWP	-	.79	.80	.74
LF			.78	.90
HC				**.73**
C				

Table 2. Average percent cover of dominant perennials on stratified lines (five transects each) in the River Mountains.

	SNWP	LF	HC	C
Percent Cover	27.6	24.4	19.6	20.8
No. of Species	12.4	10.2	11.2	9.2
Larrea divaricata	4.14	3.72	3.18	2.38
Ambrosia dumosa	6.58	6.30	4.48	3.28
Encelia sp.	1.54	4.36	1.80	4.28
Bebbia sp.	1.02	0.04	0.20	0.58
Hymenoclea salsola	1.42	0.18	-	0.14
Ephedra sp.	1.30	1.20	1.30	1.64
Acacia greggii	0.76	0.10	0.10	0.32
Sphaeralcea ambigua*	1.88	2.94	2.40	1.42
Eriogonum *inflatum**	2.36	3.10	1.90	4.12
Eriogonum *fasiculatum*	1.34	1.20	1.90	1.68
Stipa speciosa**	1.18	0.14	0.30	
Hilaria rigida**	1.52		0.40	-

* Perennial forb

** Perennial grasses

The average percent cover of dominant perennials on each stratified line (five transects each) is listed in Table 2. Although a variance could not be calculated due to the lack of independence, it should be noted that total percent cover and number of species were higher on the SNWP line than on any of the others, as were percent covers of seven dominant perennials. Species such as Bebbia sp., H. salsola, and Acacia greggii are strongly indicative of wash communities. These species were best represented on the SNWP line and were lacking or poorly represented on the other lines (Table 2). It is significant to note that H. salsola was not observed on the HC line (Table 2). The perennial grasses, Stipa speciosa and *Hilaria* rigida, are poorly represented on all lines except SNWP (Table 2). Both of these grasses are utilized heavily by sheep in the River Mountains.

Data from Table 2 are illustrated graphically in Figure 2 and reflect a general decrease in total percent cover and a decrease in percent cover of three wash species as one moves south from SNWP. Total percent cover reached its lowest point at HC, while the desert wash species were encountered least at LF (Figure 2). This trend is also reflected by the topography, which is most precipitous at HC and LF, less at C, and least at SNWP. The area west of SNWP is the most diverse, physiographically, with a greater frequency of desert wash communities. Thus, if the basic assumption that wash communities provide more forage for sheep is correct, it would appear from the data that the area west of SNWP can support a greater percentage of the population.

The stated hypothesis does not account for infrequent use of water by sheep at C and the greater percent cover at C over HC (Table 2, Figure 2). If desert wash species are indicative of areas which support more forage, why does such a small proportion of the River Mountain herd use the water at C? The reason is probably due to the specific location of the water at C. The water is located about .5 km from adequate escape terrain, which is an important habitat requisite (McQuivey 1978, Leslie and Douglas, In Press); powerlines cross between the water and the

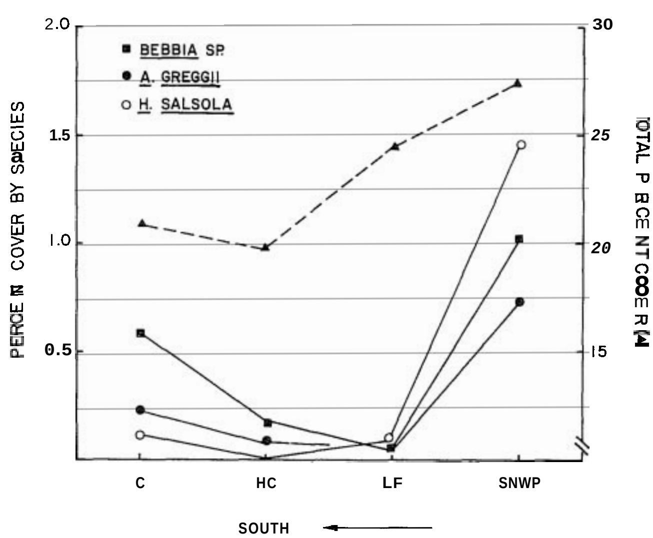

Figure 2. Change in the percentage of total cover between sites as related to percentage cover of three important wash species. Transects were run between the cottonwood tree (C), the most southerly location and the Southern Nevada Water Project (SNWP), the most northerly location. Intermediate locations are discussed in text.

limited cover. Additionally, there is only a single avenue of approach and exit. The habitat west of C receives use by some individuals; however, they rarely use the water at C, preferring to move to HC.

Due to time and manpower constraints, only preliminary examination of the vegetation in a 3.2-km radius of permanent water was conducted. Further studies may expose and quantify the yet unknown relationships of carrying capacity of desert bighorn sheep. The River Mountains remain one of the most ideal locations for studies on this elusive subspecies.

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THE BARBARY SHEEP: A THREAT TO DESERT BIGHORN SURVIVAL

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Abstract. Some biological parameters of Barbary sheep are reviewed in light of the potential threat this species represents to some populations of desert bighorn sheep. Recent findings on population growth and dispersal, home range and individual movement, feeding habits, parasites and disease, and a brief discussion on interspecific competition are presented to better understand the seriousness of the uncontrolled dispersal of this exotic.

INTRODUCTION

For some time, concern has been expressed about the introduction of the exotic Barbary sheep or aoudad ***(Ammotragus lervia)*** in the Southwest United States. Despite this, however, little research has been undertaken on the basic biological paremeters of this species which poses a serious threat to our endemic fauna. Although this exotic is presently sympatric with several North American ungulates, the greatest potential danger of competitive exclusion lies with its nearest ecological counterpart in America, the desert bighorn sheep.

Barrett (1967a) noted that there were at least 100 miles between then existing Barbary sheep populations and the nearest desert bighorn ranges and indicated there did not "seem to be any immediate danger of the aoudad invading present bighorn ranges." Thaf was ten years ago; today's picture is different. We are fortunate that no desert bighorn populations have been invaded as yet by free-ranging Barbary sheep. However, the present distribution of this latter species has either already encompassed suitable desert bighorn habitat, or is within easy distance of doing so in the very near future. Some potential desert bighorn release sites in Texas and eastern New Mexico are presently threatened with invasion. If the Barbary sheep ever gain foothold in the rugged canyon country of the southern Guadalupe Mountains, it would be an extremely costly or even an impossible task to remove them. Should this occur, another suitable habitat area may be permanently lost to the already beleaguered desert bighorn.

Some years ago the problem of the Barbary sheep was brought before the Desert Bighorn Council, and the matter was discussed again at the 1977 meeting in Las Cruces, New Mexico. Last year the membership voted to establish a Barbary Sheep subcommittee but no action has yet been taken. We present this paper, based on the literature and our own Barbary sheep research, in an attempt to alert the Council to the highly competitive potential of Barbary sheep as well as to encourage the active preservation efforts on dwindling habitat resources of desert bighorn sheep.

POPULATION GROWTH AND DISPERSAL

Historically in the United States, Barbary sheep have shown an immense dispersal capacity,' as well as an ability to survive in virtually any rugged terrain.

The release of 44 animals in 1957 and 1958 in Palo Duro Canyon, Texas has been highly successful. Jackson (1964) estimated 450 Barbary sheep in the Canyon in 1964, and the 1977 annual census of this population indicated some 1,200-1,500 animals (Texas Parks and Wildlife Department records). Research on aerial census techniques used in bighorn sheep surveys has shown a discrepancy between animals counted and population estimates (McQuivey 1977). We consistently have counted approximately 50 percent of the marked Barbary sheep known to be in our study area during individual surveys. Thus, it seems that the Palo Duro population may be as high as about 2,500 animals if this error is applicable to Barbary sheep in the annual population surveys. Furthermore, the first Barbary sheep hunt on the Palo Duro population was conducted in 1963, and approximately 800 sheep have been taken out of this population against 2,496 permits in 14 years (Texas Parks and Wildlife Department records).

The two release sites in Palo Duro Canyon were approximately 30 miles apart. In the past 20 years, the sheep have spread along 90 miles of the canyon and caprock and presently occupy most of the 8,000 square miles of rough, broken country suitable for Barbary sheep.

A recent survey of the Hondo-Guadalupe population in southeastern New Mexico showed a similar situation. The exact number of sheep that escaped from the McKnight Ranch in the 1950's is unknown, but it is thought to have been 30-40 animals. Our information indicated a total population of about 550 Barbary sheep between the Hondo Valley and the Texas state line in December, 1977. This population is apparently still in the active dispersal stage, as there are many isolated reports of one to five animals throughout the Guadalupe Mountains. At least three established sub-populations have been located south of the Hondo Valley on ranch land and in the rough country of the Lincoln National Forest.

Barbary sheep have dispersed over 90 miles in about 20 years and presently occur as far south as El Paso Gap, within 5 miles of the Guadalupe Mountains National Park (Ogren 1958, Hughes, pers. comm.).

Ramsey (1968) delimited the distribution of Barbary sheep in Brewster, Culberson and Hudspeth counties of Trans-Pecos Texas. He found more than 50 animals in the former county and reported the latter two as having less than 50 head each. Since Ramsey's publication, we have evidence that Barbary sheep are established in Jeff Davis County. These four counties represent a major part of desert bighorn habitat in Texas. Regrettably, we have no information on the impact of Barbary sheep on desert bighorn habitat in Trans-Pecos Texas.

A measure of the wide dispersal and survival capability of Barbary sheep has been documented by records of animals sighted or shot some distance from mountainous country. Barrett (1967b) recorded dispersal of rams in California up to 40 miles from their release site but reported ewes moved less than ten miles. In New Mexico, one animal was shot illegally in the sand shinnery oak country some 65 miles East-North-East of Roswell, and another within 20 miles of Hobbs. These records represent movements of about 80 and 70 air miles respectively, from the closest rough country considered suitable habitat for Barbary sheep.

HOME RANGE AND INDIVIDUAL MOVEMENT

Ogren (1962, 1965) did not give any estimates on home range sizes for Barbary sheep, nor did he record any differences between winter and summer ranges. Barrett (1967a) discussed home range and movement of Barbary sheep in California herds, but data on individual home range requirements remained vague. We did not record any indication of stable herd structure in Palo Duro, nor did we find a "group home range" (Hampy and Simpson, in prep.).

Our research in Texas on wild-tranquilized, radio-collared animals has indicatd two distinct home ranges during the year: a small winter range and a large summer range (Hampy and Simpson, in prep.). Winter ranges covered about one square mile of canyon, while summer ranges increased the total area of the range by three to 19 times and included the winter range. The ranges of rams were larger than those of ewes.

During an early fall dispersal, animals moved from the centers of their winter range in different directions, up to a distance of 10.2 air miles. Some animals returned to their winter ranges shortly after this dispersal period; others remained beyond the limits of their previous seasonal ranges and appeared to have established a new winter range. This change in range was more noticeable in rams than ewes.

FEEDING HABITS

Ogren (1962) listed some species of plants eaten by Barbary sheep in eastern New Mexico based on rumen analysis. We have used both rumen analysis and fecal samples (Baumgartner and Martin 1939, Martin 1955) to identify plant species utilized by the Palo Duro sheep population. The list of plant species used by Barbary sheep in our study continues to grow each month and present indications are that most available vegetation is eaten by these animals.

Because our concern here is food competition with desert bighorn sheep, we reviewed previous work on bighorn food habits in southeastern New Mexico and compiled a list of plants known to be utilized in areas similar to those presently occupied by Barbary sheep (Davis and Taylor 1939, Halloran 1949, Halloran and Kennedy 1949, Kogutt 1976, Simpson and Leftwich 1976). Many genera have different, though similar, species which occur in the areas sampled, so only genera are listed in Table 1. We then checked those plants recorded as eaten by Barbary sheep by Ogren (1962) and in our Texas study at Palo Duro.

Of 49 desert bighorn food plants evaluated, 37 have been recorded so far as eaten by Barbary sheep (Table 1). Ogren (1962) reported 21 out of 49 as being eaten by Barbary sheep in New Mexico, and to date, we have recorded 27 being taken at Palo Duro, where several plants listed in Table 1 do not occur.

Ten plants were reported in the literature to be important in desert bighorn diets in southeastern New Mexico (Table 1). Comparing the use of these ten plants by Barbary sheep, we found all ten were eaten, and six represented important components of the Barbary sheep diet.

A quantitative comparison between the amount of grass, forbs, and browse in the diets of the New Mexico and Texas Barbary sheep (Fig. 1) showed close similarity in the proportions utilized

Table 1. Barbary sheep use of southeastern New Mexico desert bighorn food plants.

Common name	Genus	Bighorn in southeastern New Mexico a/ and Trans-Pecos Texas	Barbary sheep in New Mexico b/	Barbary sheep in Palo Duro Canyon c/
BROWSE:				
Oak	Quercus	X*	X*	X*
Mountain-mahogany	Cercocarpus	X*	X*	X*
Yucca	Yucca	X*	X*	X
Pricklypear	Opuntia	X	X	X
Cholla	Opuntia	X	X	
Saltbrush	Atriplex	X	X*	X
Apache-plume	Fullugia	X*	X*	
Mesquite	Prosopis	X*	X	X
Sage	Artemisia	X	X*	
Skunkbrush	Rhus	X		X
Sumac	Rhus	X		X
Juniper	Juniperus	X*		X
Catclaw	Acacia	X	X	
Silktassel	Garrya	X*	X	
Sotol	Dasylerion	X		
Snakeweed	Gutierrezia	X		
Horsebrush	Tetrademia	X		
Morman's Tea	Ephedra	X		X
Dalea	Dalea	X		X
Agave	Agave	X*	X	
Pinyon Pine	Pinus	X		
Willow	Salix	X	X	X
Maple	Acer	X		
Hackberry	Celtis	X		X
Elbowbrush	Forestiera	X		X
FORBS:				
Bladderpod	Lesquerrela	X*		X*
Wild onion	Allium	X		
Dayflower	Commelina	X		X
Starleaf	Choiysa	X		
Milkweed	Asclepias	X		X
Lippia	Lippa	X		
Virgin Bower	Clematis	X		
Mallow	Sphaeralcea	X		X
Ragweed	Ambrosia	X		X
Groundcherry	Physalis	X		X
Nightshade	Solanum	X	X*	X*
Aster	Helanthus	X	X	X
Horsetail	Equisetum	X	X	X
Penstemon	Penstemon	X	X*	
Spiderwort	Tradescantia	X	X	
Horsebrush	Parthenium	X	X	
Fendlerbush	Fendlera	X	X	
GRASSES:				
Needlegrass	Stipa	X		
Cottontop	Digitaria	X		
Gramagrass	Grama	X*	X*	X*
Greensprangle	Leptochloa	X		
Brome	Bromus	X		X
Threeawn	Aristida	X		X
Dropseed	Sporobolus	X		X

* Indicates major genera used by bighorn and Barbary sheep.

a/ Data from Davis and Taylor (1939); Halloran (1949); Halloran and Kennedy (1949); Kogutt (1976); Simpson and Leftwich (1976).

b/ Data from Ogren (1962, 1965); Ramsey and Anberegg (1972).

c/ Data from Palo Duro Aoudad Project — ongoing research

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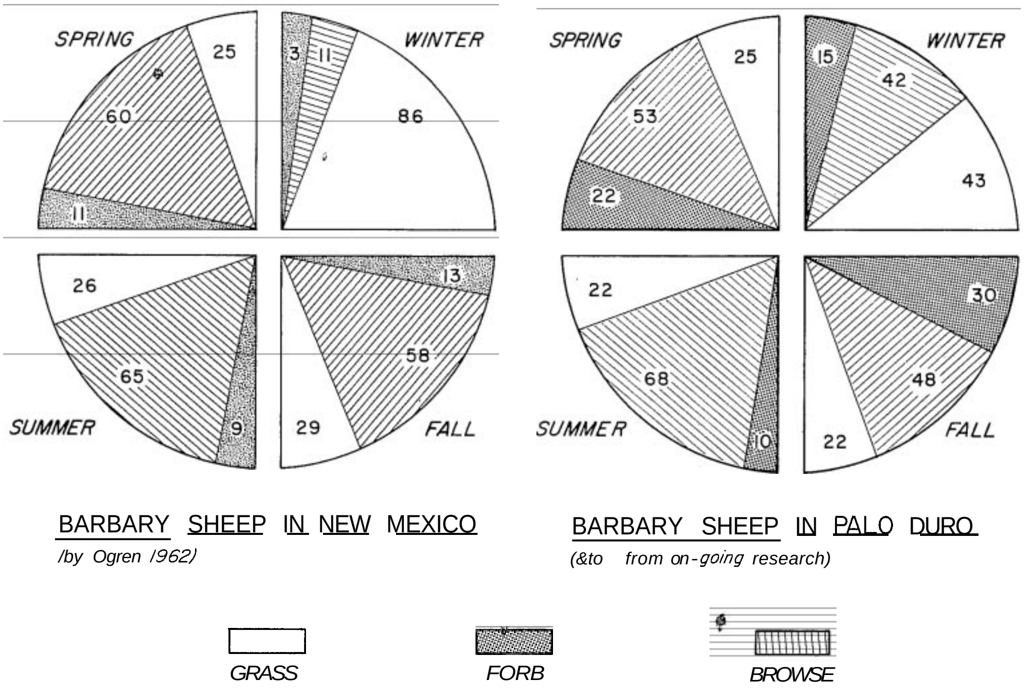

Figure 1. Proportional comparison of grass, forbs and browse eaten by Barbary sheep and Desert Bighorn sheep in New Mexico and Texas through four seasons.

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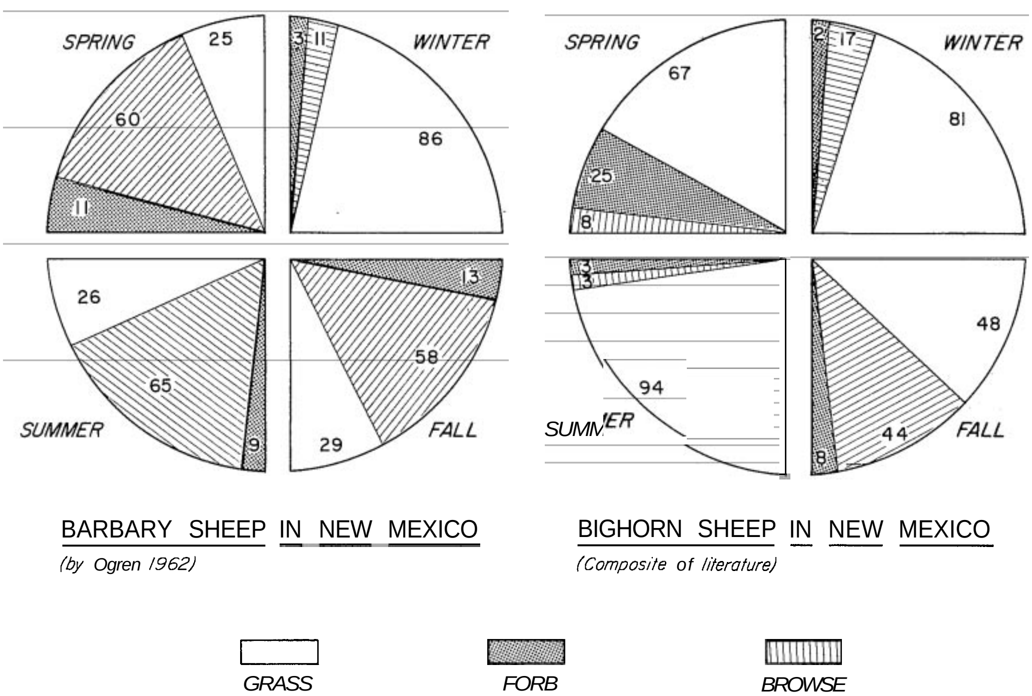

Figure 1. Proportional comparison of grass, forbs and browse eaten by Barbary sheep in New Mexico and Texas through four seasons.

during the Spring and Summer. In the Fall, the New Mexico animals used more browse and less forbs than the Palo Duro population; by winter, they were feeding predominantly on grasses, whereas the Texas animals were still utilizing a high percentage of browse. An overview of the food intake of Barbary sheep showed a definite predominance of browse throughout the year; the high incidence of browse in the diet of the Palo Duro animals probably reflects lack of available grasses rather than a preference for browse during this season.

The Barbary sheep diet recorded by Ogren (1962) probably represents a more realistic utilization of vegetation in typical desert bighorn habitat than data from the Palo Duro Canyon study. Comparison of seasonal composition of diets between Barbary sheep and desert bighorn sheep (Fig. 2) shows that bighorn eat a high proportion of grasses throughout the year, whereas Barbary sheep utilize more browse in Spring, Summer and Fall. Both species rely heavily on grasses in the winter in New Mexico. Figure 2 indicates that, in terms of food supply, the main period of competition would be during winter. As this is also a period of cold stress on both species, the interactive effects at this time may be compounded, to the detriment of the desert bighorn.

PARASITES AND DISEASE

Barbary sheep are remarkably disease-free according to Ogren (1965). Allen et al. (1956) reported low infestations of 13 different helminths but did not consider any to be pathologically significant. Gray et al. (1978) collected viscera from hunter-killed Barbary sheep and mule deer and recovered two nematodes and one cestode from the sheep. These parasites were also reported in Barbary sheep from New Mexico, although the number of parasitic species and levels of infection were much lower in Texas than those found in New Mexico animals.

Blood samples taken from animals harvested at Palo Duro were analyzed and positive seriological reactions were obtained for Infectious Bovine Rhinotracheitis and Bluetongue. In addition, several animals showed severe cases of Dermatophycosis, and most specimens examined showed small lesions indicating past infection. We are awaiting analysis of additional samples; further tests are being run at present.

In desert bighorn sheep, parasites such as ticks, tapeworms, pinworms, flukes, etc. have been reported from New Mexico (Allen and Kennedy 1952, Allen 1955). It seems unlikely that there would be any detrimental transmission between the two species. However, the disease Bluetongue could be a limiting factor to desert bighorn populations. There were four suspect and one positive Bluetongue titers obtained from our blood samples of Barbary sheep. Robinson et al. (1967) suggested that desert bighorn contract Bluetongue principally through contact with infected sheep at water sources. This could occur in the event that Barbary sheep/desert bighorn interface.

INTERSPECIFIC COMPETITION

Comparison of the success of various desert bighorn introductions to those of Barbary sheep in the two areas described above, leaves little doubt as to which would be the numerically dominant species in the event that the two animals become sympatric. Our accrued data on the population dynamincs of Barbary sheep suggest a productivity many times that of desert bighorn. While long range movement do occur in some bighorn populations for the most part, it is limited by the availability of suitable habitat. The rapid dispersal and colonization of virtualy any rough terrain by Barbary sheep clearly points to an ecologically aggressive species. This, and the fact that Barbary sheep are either already present or rapidly approaching existing desert bighorn habitat, holds a certainty that sympatry of the two species will be a fact in the near future.

The brief review of our limited knowledge of the biology of Barbary sheep speaks for itself regarding the competitive capability of this species. Biologists who are familiar with desert bighorn sheep must realize that Barbary sheep represent a real threat; one that can no longer be left on a back burner. All data collection takes time. We no longer have time to spare in implementing extensive research on Barbary sheep. If we start now, we will have at least a basic knowledge with which to make decisions when they become necessary. If we do not, crash programs to save the desert bighorn may well be ill-founded and ill-fated.

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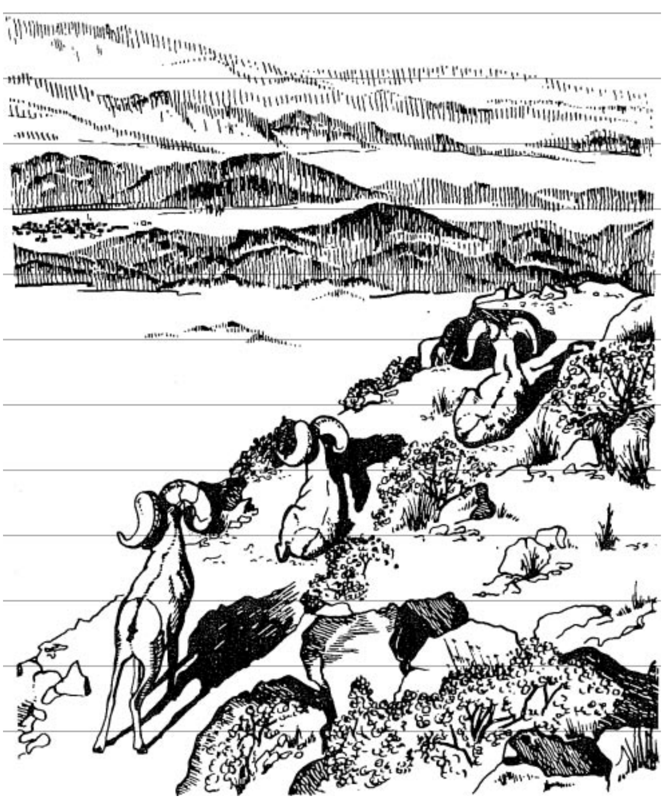

CAPTURE MYOPATHY IN DESERT BIGHORNS — LITERATURE REVIEW AND TREATMENT

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Abstract: Capture Myopathy (CM) has been identified as a source of mortality in capture operations utilizing etorphine as an immobilizer for desert bighorn sheep in Utah. A literature review illustrating the history, clinical and pathological abnormalities of CM is provided. Precautions and procedures for treatment of CM are discussed with emphasis on veterinary procedures, drugs and dosages.

Programs in wildlife management during recent years have resulted in increased handling of wild species by authorized agencies. In addition the public has become responsive to the activities of resource managers. Management and research activities that result in accidental mortality to wildlife receive almost immediate attention by the news media, general public and several self-serving, special interest groups. This publicity, which invariably is negative, threatens valuable and necessary wildlife management programs. Utah Division of Wildlife Resources has set a goal of "zero" mortality during capture operations. Since capture myopathy (CM) was suspected as being a source of mortality in the handling of desert bighorns, its occurrence needed to be verified and procedures for prevention and treatment needed to be developed.

METHODS

Capture Drugs. Utah Division of Wildlife Resources has been involved with the chemical capture (darts) followed by marking, instrumenting and the occasional transplanting of desert bighorn sheep since 1972. Etorphine (M-99) in dosages of 2.4 to 3.5 mg have been used to immobilize 71 free ranging bighorns to date. Occasionally a second dosage was administered if signs of immobilization were not apparent within six minutes after initial dart injection. In some instances acetylpromazine (6 mg) and/or atropine sulfate (1.2 to 2.4 mg) were used in combination with etorphine. In all instances diprenorphine (M-5050) in ratios of 2 mg, 2.2 mg, 2.4 mg and 2.5 mg of M-5050 per 1 mg of M-99 was used as the antagonist to reverse the effects of etorphine.

Procedure To Avoid CM. Each year capture operations were preceded by literature reviews and consultation with veterinarians and wildlife researchers familiar with chemical capture of wildlife. In 1977 CM was detected and a data-procedure form (Figure 1) was developed and strictly followed in order that non-veterinary personnel could respond to a bighorn's needs. By 1978 a decision to have a veterinarian on hand to treat each sheep had been made.

The first step to avoid CM in bighorns was to select animals that appeared healthy from the 1-½ to 7-½ year old age groups. Helicopter pursuits were directed at bighorns that tended to hide rather than flee. This reduced physical exhaustion and the potential for CM.

Once a sheep had been immobilized, oxygen was administered since etorphine reduced the rate of respiration. The eyes were flushed with distilled water to remove any foreign particles, treated with an eye ointment containing a cortisteroid and antibiotic and then blindfolded. Monitoring of rectal temperature, pulse and respiration (TPR) was initiated. After this, each sheep was either handled for immediate release or loaded into a helicopter and transported to a holding site for handling and overnight observation prior to being transplanted.

Attempts to reduce stress from audio disturbances were accomplished by placing an obstruction in the sheep's ears. In addition, the animals being held were kept in individual darkened crates away from any disturbance.

Bighorns were not transported from the capture site until their TPR stabilized. Note that a rapid increase in rectal temperature can be temporarily stopped with an intramuscular (I.M.) injection of 5 to 10 cc of Dipyrone. When stabilization of TPR could not be achieved the animal was given the antagonist and released. A partial dosage of the antagonist should never be administered during handling or moving of a sheep since an uncontrollable, rapid rise in temperature may result.

During handling, each bighorn was given an antibiotic (2.5 cc I.M. per 50 lb. of body weight of long lasting penicillin); Vitamins AD (2 cc I.M. per animal since a deficiency during winter is suspected); Vitamin B12 (5cc I.M. per animal to combat anoxic neuronal degeneration); and an intravenous (I.V.) injection of vitamin E-Selenium (1 cc per animal as a muscle restoring agent). All wounds were treated with an antiseptic and the ears were inspected for mites and treated with a miticide when necessary.

Bighorns that showed moderate signs of myopathy received in addition to the above treatment an electrolyte solution (250 to 500 cc I.V. normal electrolyte solution with 100 mEg—10 g/1—sodium bicarbonate) to combat acidosis. A short acting steroid (5 cc I.V. Dexamethasone followed up with 2 to 5 cc I.M. every 6 to 8 hours) for anti-shock and anti-inflammatory treatment was given. Dexamethasone will result in abortion during the last one-third of pregnancy. After an animal is able to stand, an oral, nutrient-electrolyte solution can be warmed and administered at six-hour intervals until release.

Bighorns that showed acute signs of myopathy received 500 to 1000 cc I.V. of the electrolyte solution. The initial dosage of the steroid was doubled (10 cc I.V. Dexamethasone). In instances where pulmonary edema was evident a diuretic (1 cc I.V. or 1.5 to 2.5 cc I.M. Furosemide) was given to lessen edematous tissue secretions through body excretion. It is recommended that calcium-dextrose (40-100 cc, slow I.V. or rapid subcutaneous) as a gluconate salt containing phorphorus and magnesium be given in acute cases.

Respiratory failure would have been treated with a respiratory stimulant (2 to 5 cc I.V. Doxapram Hydrochloride repeated in 7 to 10 minutes if only minimal response to first injection). An endrotracheal tube (13 mm wide x 400 mm long) could also have been used to facilitate manual ventilation. Heart stoppage would have resulted in use of epinephrine (0.75 to 1 cc I.V. or intracardial). Note that epinephrine is for true stoppage of the heart and is contra-indicated in cardiac fibrilation. Heart conditions are difficult to diagnose in the field.

Marking procedures were completed along with veterinary treatment. Data collection, marking and veterinary procedures required less than five minutes effort on each sheep, once it had been transported to a holding area.

RESULTS AND DISCUSSION

History of CM. A history of researchers' abilities to identify CM and the affected wildlife species began during 1955 with documentation of lesions in the striated muscles from a white-tailed deer (Hadlow 1955). It was not until 1964 that evidence of myopathy in wildlife again appeared in the literature (Fairlie 1964; Jarrett et al. 1964). Jarrett et al. (1964) described the condition as a muscular dystrophy in wild hunter's antelope from East Africa; Fairlie (1964) used the term myopathy to describe the condition he observed in a roebuck. CM was later identified in at least 20 specis of wild, African ungulates (Young 1966, Jarrett and Murray 1967, Mugera and Wandera 1967, Ebedes 1969, Basson 1971, Young and Bonkhorst 1971, Young 1972, Basson and Hofmeyr 1973, Hofmeyr et al. 1973, Hofmeyr 1974, Harthoorn et al. 1974, Harthoorn and Van Der Walt 1974, Harthoorn and Young 1974, Harthoorn et al. 1974, Harthoorn 1976, Gericke and Hofmeyr 1976) and in eight species of wild North American ungulates — bison, pronghorn, elk, moose, white-tailed deer, Rocky Mountain goats, Rocky Mountain bighorn sheep and desert bighorn sheep (Herbert and McCowan 1971, Hadlow 1973, Spraker 1975, Wobeser et al. 1976, Hudson et al. 1976, Chalmers and Barrett 1977, Haigh et al. 1977, Lewis et al. 1977, Spraker 1977). CM has also been identified in primates and birds (McConnell et al. 1974, Young 1967).

The clinical and pathological evidences of CM have been described by several researchers (Hadlow 1955, Fairlie 1964, Jarrett et al. 1964, Young 1966, Cardinet et al. 1967, Jarrett and Murray 1967, Mugera and Wandera 1967, Ebedes 1969, Basson et al. 1971, Herbert and McCowan 1971, Young and Bronkhorst 1971, Young 1972, Hadlow 1973, Harthoorn 1973, Hofmeyr et al. 1973, Basson and Hofmeyr 1973, Chalmers and Barrett 1974, Hadlow et al. 1974, Harthoorn and Van Der Walt 1974, Harthoorn and Young 1974, Harthoorn et al. 1974, Hofmeyr 1974, Gericke and Hofmeyr 1976, Harthoorn 1976, Wobeser et al. 1976, Chalmers and Barrett 1977, Haigh et al. 1977, Lewis et al. 1977, Spraker 1977). Generally speaking, clinical signs include a marked increase in rectal temperature, pulse rate and respiration which sometimes is accompanied with dyspnea (difficult or painful breathing). The animal is often oblivious to the presence of humans, and if able to stand shows signs of ataxia (an inability to coordinate voluntary muscle movements) and wanders in circles with an obvious torticollis, which manifests itself as twisted neck muscles and abnormal carriage of the head. The hooves show signs of being folded under the animal as if they were stiff and the animal attempts to walk on the dorsum of the hooves. These conditions are followed by recumbency, lethargy and paralytic symptoms which are most noted in the hindquarters. Depression, coma and death result if the animal is not treated. Myoglobinuria, recognizable as a brown urine, is common.

Pathological evidences of CM are predicated by a metabolic and/or respiratory acidosis (an acid condition of the body resulting from low bicarbonate reserves) along with a sharp increase in serum levels of creatine phosphokinase (S-CPK), glutamic-oxalacetic transaminase (S-GOT), lactate dehydrogenase (LDH) and blood urea nitrogen (BUN), which results in a reduction of blood pH well below 7.0. Gross skeletal musculature shows necrosis (death) of muscle fibers. Lesions in the large muscles of the hind limbs are obvious. Pulmonary edema (abnormal accumulation of fluid in cells of the lungs), nephrosis (kidney disease in which there is degeneration of the renal tubules, but no inflammation), hepatic necrosis (death of liver tissue), myocardial degeneration (death of muscle cells in the heart muscle), and anoxic neuronal degeneration (death of nerve cells due to lack of oxygen) are known to result from CM.

Response of Desert Bighorns to CM. All of the clinical symptoms and some of the pathological abnormalities that resulted from CM have been observed during capture operations for desert bighorn sheep in Utah. Gross lesions on the skeletal musculature in the hind limbs of desert bighorns were obvious in all animals that died from suspected CM. Pulmonary edema was noted in several bighorns. Examination and tests for blood gases, levels of S-CPK, S-GOT, LDH, and BUN along with other clinical and pathological work to identify CM will be initiated in Utah.

All Utah sheep showing signs of acute CM have expired. Animals that have shown only moderate signs of CM (two sheep) were treated and survived. Generally speaking, treatment of CM by other researchers has also only met with limited success.

Known mortality in Utah's desert bighorns from capture operations using etorphine as an immobilizer has been 17 of 71 sheep which amounts to 24 percent capture mortality. Seven of the mortalities (41 percent of the deaths) were due to injuries or disease that the animal sustained prior to or as a result of capture operations. Five mortalities (29.5 percent of the deaths) resulted from capture operations during 1975 that used the tranquilizer acetylpromazine in combination with etorphine. Mortalities that involve acetylpromazine represent 71 percent of the sheep in Utah injected with the tranquilizer. In retrospect all of these sheep showed clinical and/or pathological signs of CM.

To date other researchers have not experienced CM in desert bighorn sheep, even though tranquilizers have been used. Arizona Game and Fish has successfully used 15 mg of Azaperone (tranquilizer) in combination with 2.5 mg of etorphine to capture and transport desert bighorn sheep (personal communication, April 1978, Robert K. Weaver, Arizona Game and Fish). Texas Parks and Wildlife has also successfully used a tranquilizer to transport desert bighorn sheep. After capturing a bighorn with etorphine, 2 cc I.M. valium was injected. This dosage is reported to last about 4 to 6 hours and in some instances it has been repeated without any negative results (personal communication, April 1978, Jack Kilpatric, Texas Parks and Wildlife Department).

Analysis of results from desert bighorns immobilized with etorphine in Utah showed ($P < 0.025$) that the length of time the animal was under the influence of the drug was critical to its survivability. The mean time from dart injection until injection of the antagonist for bighorns that lived and bighorns that died was 39 ± 16 and 63 ± 17 minutes respectively. The 95 percent confidence interval for sheep that lived was 34 to 44 minutes; for sheep that died it was 53 to 74 minutes (Table 1).

It has been observed that bighorns that readily succumb to the immobilizing effect of etorphine are in the best condition after being administered the antagonist. Other studies in Utah (Winegardner et al. 1977) have shown that mean immobilization time for desert bighorns has been 3.8 minutes using 2.4 mg of etorphine. Some of those animals required 6 minutes for immobilization. Since rapid immobilization and the total immobilized time are such critical factors in the sheep's survivability, a substance that promotes rapid absorption of etorphine is needed.

SUMMARY AND RECOMMENDATIONS

The history, clinical and pathological abnormalities of capture myopathy are documented. In addition CM has been identified as a source of mortality when etorphine was used as an immobilizer on desert bighorn sheep in Utah. In order to approach a goal of "zero" mortality on capture operations, recommendations for prevention and treatment of CM have been developed and are displayed as a step by step sequence in Figure 1. The tranquilizer acetylpromazine should not be used in combination with etorphine because mortalities with symptomatology similar to acute CM may result. Mortality from CM in instances where no tranquilizer was used only equalled 7 percent.

Hyaluronidase is a drug that promotes rapid absorption of other drugs into an animal's system. It is recommended that 90 units (0.6 ml) of hyaluronidase be combined with 2.4 mg of etorphine and tested on desert bighorns. It is hbped that negative impacts from handling sheep can be reduced by shortening the immobilization period. Massive dosages of hyaluronidase (75,000 units) in animals has not caused any significant change in blood

Table 1. Chi Square comparison of survivability for 42 free ranging, desert bighorn sheep immobilized with etorphine between 1973 and 1978 during November, December, January and February in San Juan County, Utah.

	Time from dart Injection until injection with the antagonist –								
	21 - 30 minutes		31 - 40 minutes		41 - 50 minutes		51 or more minutes		
Results	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected	Total
Died	0	2.17	0	1.67	2	1.17	5	2.00	7
Lived	13	10.83	10	8.33	5	5.83	7	10.00	35
Total	13		10		7		12		42

Calculated Chi Square 10.71 and 3 degrees of freedom ($P < 0.025$)

– The time from dart injection until injection with the antagonist rqnged from 20 to 75 minutes in animals that lived and 45 to 94 minutes in animals that died.

pressure, respiration, body temperature, kidney function or any histological changes in body tissues.

Selective pursuits of young bighorns that prefer to hide rather than flee from the helicopter are demanded. Once immobilized, the antagonist should always be administered as soon as possible and no later than 44 minutes following dart injection. It is expected that one out of every 20 sheep will die if held under the influence of etorphine between 34 to 44 minutes. It should be noted that 19 out of 20 bighorns held under the influence of etorphine between 52 and 74 minutes should be expected to die.

Bighorns should not be transported from the capture site until TPR has been stabilized. When being held they should be placed in individual, darkened crates and in an area away from human activity and disturbance.

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Figure 1. Bighorn sheep capture and tagging procedures with safeguards for myopathy.
Data at Immobilization Site

1. Date ____________
   Vital signs (Temp.) (Pulse) (Resp.) (Time)

2. Location ____________
   At Capture
   Other

3. Sex and Age Male Female ____ Other

4. Drugs Used in Dart______mg______mg______mg

   (a) Dart Type and Size
   (b) ____darts discharged hits ______missed.
   (c) Time of dart injection____________
   (d) Time of immobilization____________
   (e) Lapsed time for immobilization (if longer than 6 minutes use another dart).

5. Protect animal's eyes from dirt. If necessary, clean with distilled water. Apply cortisteroid-antiobiotic ointment, then blindfold (leave on until animal is released or crated). With plastic gloves, remove any immobilizing darts and insert into dart box. Record life signs. Begin process to move animal to holding site or mark for release.

Data at Holding or Release Site

6.1 **Normal Situation–No Signs of Myopathy**

(a) Record life signs and set up nasal canulas with oxygen for animals immobilized with drugs.
(b) Place gauze balls in animals ears.
(c) Intramuscular injections (I.M.)
  (1) 5 cc antiobiotic (long acting penicillin 2.5 cc/50 lb. body weight).
  (2) 2 cc Vitamins AD
  (3) 5 cc Vitamin B12
(d) Intravenous injections (I.V.)
  (1) 1 cc E-Selenium (muscle restoring agent)
(e) Treat wounds with antiseptic

6.2 **Animals That Were Moderately Stressed and Show Some Signs of Myopathy**

(a) Initiate procedures in 6.1, except part (d).
(b) Prepare animal for intravenous catheter.
  (1) Shave jugular furrow—implant catheter (coat with heparin).
  (2) 250-500 cc electrolyte over 45-60 minutes. Give first one-half rapidly (100 mEg sodium bicarbonate——10 g/1—dissolved in normal electrolyte solution).
  (3) 1 cc E-Selenium
  (4) 5 cc Dexamethasone—follow up with 2-5 cc I.M. every 6-8 hours (short acting steroid for anti-shock and anti-inflammatory—females will abort in last one-third of pregnancy).
(c) When animal is able to stand, warm and give orally at six hour intervals 1 qt. nutrient-electrolyte solution.

6.3 **Animals That Show Acute Signs of Myopathy**

(a) Initiate all procedures in 6.2, except part (d)
  (1) Amount of electrolyte solution described in 6.2 (b) (2) should be increased to 1000 cc and administer over 60-90 minutes. Give first one-half rapidly.
  (2) Calcium-Dextrose (40-100 cc, slow I.V. or rapid subcutaneous) as a gluconate salt containing phosphorus and magnesium.
  (3) Amount of Dexamethasone should be increased to 10 cc and given to all animals. Follow up treatment with 2-5 cc I.M. every 6-8 hours.
(b) Pulmonary Edema—fluid in lung
  (1) 1 cc I.V. or 1.5-2.5 cc I.M. Furosemide (diuretic—lessens edematous tissue secretions through body excretions).
(c) High temperature (105°F.+)
  (1) 5 to 10 cc I.M. Dipyrone.
(d) Respiratory failure
  (1) 2-5 cc I.V. Doxapram Hydrochloride (respiratory stimulant), repeat in 7-10 minutes if minimal response.
  (2) Insert endotracheal tube (13 mm wide x 400 mm long) and begin manual ventilation with oxygen.
(e) Heart stoppage
  (1) .75-1 cc Epinephrine I.V. or intracardial in true stoppage of heart. Note, this is contraindicated in cardiac fibrilation—life or death emergency only.

7. Presence or non-presence of ear scabies (Yes ___ no___).
   (a) Treat with miticide (3 drops on finger rubbed in each ear)

8. Tag each ear and attach collar
   (a) Ear tag No.__________
   (b) Collar color________ Tag No.________
   (c) Radio frequency________

9. Total time under influence of M-99__________ (do not exceed 44 minutes)

10. Inject antagonist I.M. (recommend 1 mg of M-50-50: 1 mg of M-99. Do not exceed 2 mg M-50-50:1 mg of M-99).
   (a) Amount of M-50-50________mg.
   (b) Time of injection________
   (c) Time animal regains mobility________(10 minutes after initial injection of antagonist if mobility is not achieved, inject additional M-50-50).
     (1) Amount of additional M-50-50________mg.
     (2) Time animal regains mobility________(if initial injection of antagonist, initiate treatment 6.3 6.3 for capture myopathy.

11. Leave animal in darkened crate at an undisturbed area.

12. Remove rubber gloves and discard in safe place.

13. REMARKS: (a) Note any other comments relating to this animal.
(b) If time and equipment are available
(1) Weight__________estimated scale
(2) Boone and Crockett Score

DESERT BIGHORN HABITAT MANAGEMENT PLAN, BLACK MOUNTAINS, ARIZONA

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Abstract. In 1976, an intensive inventory and analysis of desert bighorn habitat was made in the Black Mountains in north-western Arizona. Based on data collected and other available information, crucial and important bighorn habitats were identified. Habitat and habitat-related problems, both existing and potential, were identified. Management alternatives for the solution of these problems were developed for inclusion in the Black Mountain Habitat Management Plan (HMP).

The Black Mountain HMP provides direction for managing wildlife habitat within the Black Mountain Planning Unit through habitat improvement and maintenance. The primary goal of the HMP is to increase and/ or maintain present wildlife populations and species composition for consumptive and non-consumptive recreational use. Many wildlife species were con,; sidered in the HMP, with desert bighorn sheep *(Ovis* canadensis *nelsoni)* being the primary wildlife species.

This plan was developed cooperatively under the Sikes Act between Arizona Game and Fish Department (AG&FD) and BLM. AG&FD personnel involved included George Welsh, Wildlife Manager, Region III and Don Belknap, Development Supervisor, State Office. Both of these men played a major role in the development of habitat management recommendations. Other persons having input included Mike Walker, M.S. student, ASU and Don Seibert, Arizona State Biologist, BLM.

The plan is still in the development stages, and final approval by the Directors of AG&FD and Arizona BLM are needed prior to implementation. All HMP recommendations presented may be subject to modification prior to being approved.

HABITAT AREA

The Black Mountain HMP Area is located in the western portion of Mohave County in northwestern Arizona. The area is some 80 miles long and 25 miles wide at its widest point. There are 801,000 acres of which 538,000 acres (67%) are administered by BLM and 263,000 acres (33%) are state private. The HMP area includes the Black Mountain Range, a rugged range typical of the southwest, characterized by steep rocky slopes and narrow steep canyons. The southeastern portion of the range consists of large extensive mesas with steep talus slopes. The range protrudes sharply out of the desert floor and is surrounded by broad alluvial plains. Elevation in the unit ranges from 500 to 5400.

The vegetation in the HMP area is predominately Mohave Desert shrub type, represented by several different plant communities (Lowe 1964). The northernmost portion of the range supports vegetation typical of the Great Basin Desert, whereas the southern portions support vegetation typical of the Sonoran Desert. The climate is arid with precipitation ranging from 4 inches to 10 inches per year. Water is the critical element in this desert ecosystem and is only available seasonally in many areas.

Desert bighorn are the major big game species and have been hunted for more than 20 years. The bighorn population has increased over the past 20 years and is estimated at 200 + 40. Bighorn move on and off the Lake Mead Recreation Area to the north, changing the number of bighorn using the area at any one time.

INVENTORY AND ANALYSIS

Prior to the development of the HMP, an intensive inventory and analysis of bighorn habitat was made. A full analysis of the bighorn situation in the Black Mountains was made based on 6 months of ground and helicopter surveys, available literature and personal contacts. Crucial habitat such as lambing grounds, summer concentrations, water sources, movement areas (migration areas) and other important habitat such as ram use areas, were identified. Habitat and habitat related problems, both existing and potential were also identified.

A Habitat Evaluation of bighorn habitat was also made based on several criteria including: (1) topography i.e., slope, regularity, rockiness (2) distance from permanent water; (3) present bighorn use and type of use; and (4) human disturbance i.e., roads, mining and other land uses. Bighorn habitat was classified in terms of high, medium and low-value habitat. These are relative values and general in nature. An area classified as low does not mean it is of no value to bighorn.

Results indicate there are approximately 244,500 acres of bighorn habitat of which only 77,000 acres (31%) was rated as high. The major problems included lack of water, competition wih domestic livestock and feral burros and those conflicts associated with man i.e., mining and land development. Based on the inventory and analysis, habitat recommendations were developed for the HMP.

HABITAT MANAGEMENT PLAN

The objectives of the HMP are to implement habitat protection and development programs for the conservation and rehabilitation of wildlife resources consistent with BLM multiple-use management objectives. Management methods used to obtain these objectives come under the headings of habitat development and improvement, livestock management, burro management, recreation management, land acquistion, classification and withdrawal and wildlife inventories and studies.

Habitat Development and Improvement. Lack of water is the single most limiting factor for desert bighorn (Weaver 1975). This results from poor distribution of water or the lack of permanence. Permanent water sources properly spaced can improve bighorn habitat by increasing their distribution. Because bighorn concentrate within a mile or two of permanent water during the dry summer months, the forage within this radius will determine range carrying capacity. Improved water distribution can increase this carrying capacity.

The Black Mountain HMP proposes dependable water every four miles in favorable habitat and closer in crucial lambing areas. Sixteen new waters will be developed throughout the range and 19 existing waters will be improved. Water developments include both natural tank developments and apron type catchments. Natural tanks were recommended whenever the area lent itself to this type of development. Development of existing waters consisted of spring improvements designed to increase storage capacity and/or improve water quality. Three water sources have been developed in cooperation with the Arizona Desert Bighorn Society.

Several bighorn have died as a result of entanglements in fences within the planning unit and adjacent areas. Fences in two areas were identified as existing or potential hazards and were recommended for modification to allow safe access by bighorn. Future fence construction will be discouraged. Those fences that are constructed will be built to proper specifications to protect bighorn.

Livestock Management. Much of the bighorn range is grazed by livestock on a yearlong or seasonal basis except for the southern portion of the range where forage has been reserved for wildlife. HMP recommendations have been made seperately for perennial and ephemeral ranges because of differences in BLM authority.

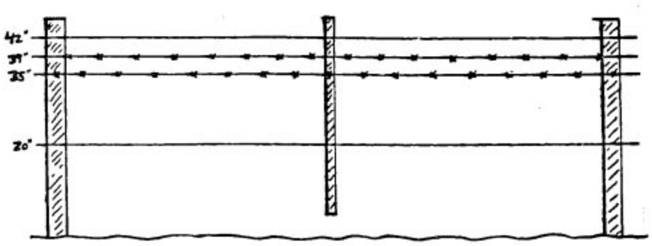
1. **Perennial Ranges.** Allotment management plans (grazing systems) have been developed on six allotments. Implementation will be based on range condition. Allocation of forage for a reasonable number of bighorn has been made. In addition, no new livestock waters will be developed in bighorn habiat to increase livestock distribution which would create more intense competition with bighorn. If, at a future date, livestock grazing is found to have an adverse impact on bighorn, elimination of livestock grazing will be considered.

2. **Ephemeral Ranges.** Ephemeral range classification occurs on five allotments. Recommendations were made to close two of these areas to livestock grazing and manage the remainder in accordance with BLM regulations. This includes the elimination of grazing within 2½ mile radius of crucial bighorn waters where bighorn generally congregate. Proper forage allocation will be made before any ephemeral grazing permtis are issued.

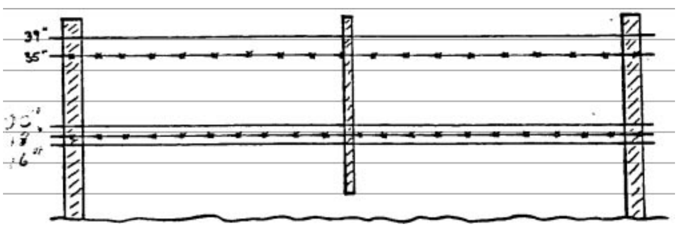
Burro Management. The feral burro is the bighorn's most serious competition in the Black Mountains. High concentrations of burros occur in several areas and pose a serious threat to the bighorn's existence. The present estimated burro population is over a thousand animals. The population is also estimated to be increasing at 23% per year (Walker, M.S.). This burro population level is adversely affecting bighorn habitat. An earlier BLM management decision was made to reduce the burro population to 200. These 200 burros would be distributed throughout the unit. This reduction is needed but 200 burros is still too high. Distributing burros throughout this area is unrealistic from a maintenance standpoint. The HMP recommends that burros be eliminated from all crucial habitat and allow a small number in three areas, where no serious conflict would occur.

Burro reduction by established BLM method (round-up and burro adoption) is slow and expensive. Because of this, reduction of burros in the Black Mountains could take years. To help reduce competition between bighorn and burros, recommendations were made to fence crucial bighorn water to exclude burros. This would force burros to seek water elsewhere, eliminating competition with bighorn during crucial summer months. These fences would only be needed until burros were eliminated.

One water was fenced-following those specifications of Helvie (1971).This design failed to keep burros out so a new design is now being tested (Figure 1). Two springs have been fenced with this new design and will be monitored for its effectiveness.



ORIGINAL DESIGN



NEW DESIGN

Figure 1. Diagram of the original Helvie design of bighorn fence, and a modified type being tested in the Black Mountains, Arizona.

Recreation Management. Recreation use in the planning unit was not identified as being a major problem at the present time, but does pose a very serious threat. Six areas were designated as "restricted use areas" which include crucial bighorn habitat where bighorn should be managed as the priority resource. Recommendations were made to limit off-road vehicles to existing roads, washes and trails within these areas. If recreation activities become heavy at a future date, regulation of use will be needed, particularly during the lambing season.

Land Acquisition. Areas of the Black Mountains are mixed private, state and federal ownership. This mixed ownership sometimes does not allow for complete management. Some 56 parcels of land (approximately 30,000 acres) were recommended for acquisition.

Corridors and Communication Sites. Bighorn habitat has been disturbed in several areas by powerlines, pipelines, highways and communication sites. It was recommended that all future construction projects of this type be confined to those areas already disturbed by projects. This will prevent any new habitat disturbance.

Roads. The HMP recommends that no new roads be constructed within the "resticted use areas". The only exception would be those roads used for the construction and maintenance of wildlife waters. These would be minimal roads and would be closed to public use.

Mining. Mining has a great impact on bighorn habitat because activities related to mineral exploration reduce and eliminate habitat which takes decades to return to its natural state. Most mining activities generally occur in some of the best bighorn habitat and can have serious conflicts.

The original recommendation concerning mining was to withdraw 132,000 (Restricted Use Areas) acres from mineral entry. This recommendation conflicts with an existing BLM planning decision and the possibility of such a recommendation becoming reality is very slim. The regulation of mineral exploration to minimize habitat destruction and insure adequate rehabilitation and mitigating measures is the next best alternative. It will take an act of Congress to create such laws and regulations.

Wildlife Inventories and Studies. Data are still lacking on desert bighorn populations and habitat in the Black Mountains. More data are vital to insure proper management of bighorn habitat.

There is presently an annual bighorn survey conducted every spring by the Arizona Game and Fish Department. A second survey will be conducted in the fall of each year. The purpose will be to collect additional data on bighorn numbers and seasonal use areas, gain comparison (to spring survey) data as to use, dispersion, group size, and numbers for different times of the year, and continue to locate new water sources for future development.

A study on bighorn-burro competition by Arizona State University began in July 1976, and terminated on September **30,** 1977. This type of study is needed on a long-term basis and will be initiated again and expanded to include the following major objectives: life history research to determine seasonal distribution, home range, movements and major conflicts affecting bighorn populations and their habitat.

IMPLEMENTATION AND COST

As mentioned previously, the Black Mountains Habitat Management Plan is still in the developmental stages. Once recommendations have been accepted by BLM Management and AG&FD, these recommendations then become management decisions that can then be implemented under the Sikes Act funds.

Implementation of water developments and fence projects have been set up on a three-year schedule. Cost of these projects is estimated at $97,325. Studies and inventories are to begin the first year of implementation. Estimated cost of bighorn inventories studies for the first three years if $165,750. The fall bighorn survey will continue each year thereafter and the bighorn study may also be extended. Livestock and burro management recommendations will be implemented as funds become available, and will not be funded by Sikes Act monies.

Other elements of the plan may also take years to implement, if they are approved. Mineral withdrawals and mining regulations and off-road vehicle regulations may require new laws and regulations. Land acquisition is a slow and costly operation and may take years and may require major Impact Statements.

Update of the Black Mountain HMP by AG&FD and BLM will be on a continual basis, all elements of the plan will be subject to annual review. Modifications will be made as new data becomes available and changes are deemed necessary. The HMP is not the complete and final answer to all of the bighorn's needs, but it is a definite beginning and should be recognized as such. Continued good management based on sound data will help to insure the future success of the Black Mountains bighorn population.

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ZION DESERT BIGHORN REINTRODUCTION 1977: PROJECT STATUS AND ACTIVITIES OF RELEASED ANIMALS

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Abstract. In Zion National Park, Utah, 13 of the 20 bighorns were removed from the 80-acre, holding-propagating enclosure and transplanted eight miles away. Four of the released animals were radio-collared. The movements and activities of the released bighorns are described. The influence of mountain lion movements and predation upon the 'bighorns are noted. Changes in the project plan are discussed.

INTRODUCTION

In 1973, 12 desert bighorn sheep (*Ovis* canadensis nelsoni) from Nevada were released into an 80-acre, holding-propagating enclosure in Zion National Park, Utah. The goal of the project has been to propagate and restore the subspecies in areas of the Park and southwestern Utah where it has been extirpated. The project is a cooperative effort between the National Park Service, U.S. Department of the Interior, the Utah State Division of Wildlife Resources, the Nevada State Department of Fish and Game and the Zion Natural History Association.

By the end of 1976, the enclosure contained 20 bighorns. It became apparent that this number was in excess of the carrying capacity of the enclosure. In late January and early February of 1977, 13 bighorn were trapped and transported by helicopter to a release site in the Park about eight miles away from the propagating enclosure. In an effort to habituate them to the release area, they were held in a temporary, 10-acre enclosure. Three losses occurred in this enclosure. One loss occurred from disease, one occurred from an accident and the third occurred apparently from predation.

After a month had elapsed, the 10 remaining bighorn were released into the wild. The details of the trapping, transporting and releasing the sheep have been reported previously (McCutchen, H., 1976, The Zion Bighorn Restoration Project, 1976, Desert Bighorn Council Trans., pp. 9-11). In addition to ear and collar marking, four radio collars (Telonics, Inc., 120 South Mesa Drive, Mesa, Arizona) were installed on selected animals so that their movements could be monitored more easily. This report describes the movements and behavior of the released bighorns and reviews the project events that have occurred over the past year.

Acknowledgment for project support is given to Park Superintendent Robert C. Heyder; Donald A. Smith, Director of the Utah State Division of Wildlife Resources; Glen K. Griffith, Director of the Nevada State Department of Fish and Game; and to the Zion Natural History Association. Acknowledgment is also given to the other personnel involved in the project this past year, including numerous National Park Service employees; Floyd Coles, Jim Guymon, Rodney John and Gary McKell of the Utah State Division of Wildlife Resources; and Tom Bunch and Steve Paul of Utah State University.

DISCUSSION

Description of the Bighorn Release Area. The release site was located adjacent to the East Fork of the Virgin River in Parunuweap Canyon, about eight miles southeast of the Zion Canyon propagating enclosure (Figure 1). The canyon bottom contains a riparian forest of Fremont cottonwood (Populus *fremontii)*, boxelder (Acer negundo) and willows (Salix spp.). Adjacent to the river are flood plains up to several hundred feet wide, which contain four-wing saltbush (Atriplex canescens), cheatgrass (Bromus tectorum) and dropseeds (Sporobolis spp.). The elevation is about 4,000 feet.

Adjacent to the river and flood plains are talus slopes, covered generally with pinyon *(Pinus* monophylla) and juniper (Juniperus utahensis) woodland and associated herbaceous species, including galletta *(Hilaria* jamesii) and needle-and-thread (Stipa comata). The talus slopes extend upward at a steep angle to about the 5,000-foot elevation, where they meet the base of the cliffs of the Navajo Sandstone Formation. The cliffs of this formation are nearly vertical and in many areas are over 1,000 feet high. These cliffs dominate the landscape and form a barrier to upward migration. Access to the top is limited to a few locations where the cliff is broken.

Above the cliffs at elevations of about 6,000 feet, the Navajo Formation becomes a land of broken slickrock containing exposed sandstone ridges and domes and canyons. Much of the area is bare rock, but there are scattered, open stands of pinyon-juniper, ponderosa pine *(Pinus* ponderosa), littleleaf mountain mahogany (Cercocarpus intricatus) and sagebrush (Artemesia tridenta).

Among the more common grasses are muttongrass (Poa fendleriana), blue gramma *(Bouteloua* gracilis) and Indian ricegrass (Oryzopsis hymenoides). Water is available from the rivers, from numerous springs at the base of the Navajo Formation and from seeps and potholes in the slickrock country. All of the area is historic bighorn range.

Social Organization of Release Bighorns. It was believed that there would be less likelihood of a herd breakup if a family group of animals were used for the release. This belief was supported by previous observations within the enclosure that suggested that there were strong leadership and family group ties. The 13 bighorns chosen for the release contained a known family group consisting of an older ewe (No. 4), which had been trapped in the wild in Nevada, her ram lamb, her 2%-year-old female, pen-reared offspring (No. 13) and her ram lamb. Ewe No. 4 was the most dominant ewe within the Zion enclosure and exhibited leadership behavior. The other bighorns, consisting of two rams, five ewes and two ram lambs, were chosen because they generally had exhibited a high degree of association with ewe No. 4.

Movements and Behavior of Released Animals. All of the released bighorns were marked with ear tags or colored collars. In addition, two ewes (Nos. 4 and 19) and the two rams (Nos. 15 and 18) were fitted with radio collars.

After the release from the Parunuweap enclosure on February 27, 1977, an intensive effort was made to determine the behavior and movements of the bighorn through radio tracking and observation. Very little movement or home range data were obtained from the non-radioed animals. However, the four radio-collared bighorn provided insight into what occurred (Figure 1).

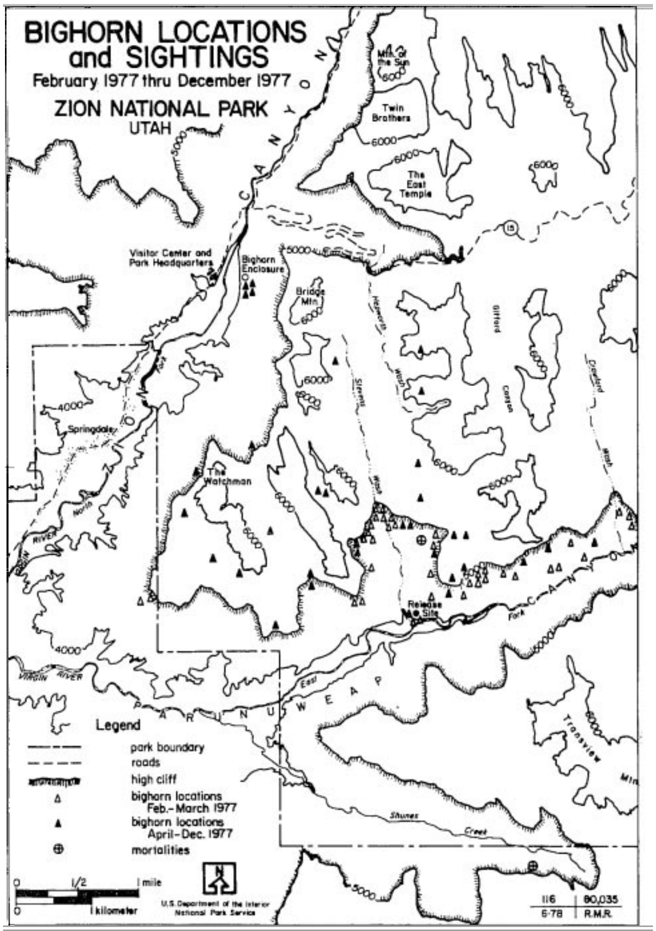

Figure 1. Locations and sightings of released bighorns, Zion National Park, Utah.

1. Ewe No. 19 (Radio-collared). This ewe was about 1¾ years old at release time. On the first day of the release, No. 19 along with another ewe and an unrelated lamb became separated from the others. It appeared that the bighorn had difficulty in following each other in the pinyon-juniper woodland. The three animals moved upriver and eastward from the release enclosure for a distance of about one mile. They halted their travel in a small side canyon and remained there for about three days. A week later, No. 19 and her companions were located and observed with most of the other releasees in the vicinity of the release enclosure. From March to mid-April she was radiolocated and observed in companionship with a single yearling. She utilized various areas on the talus slopes upriver from the release site up to a distance of about two miles. During this time, she did not appear to actively seek association with the other bighorns, although they were utilizing areas about one mile away.

In mid-April, she moved out of her previous range and was observed alone about one mile downriver below the Navajo cliff west of the release enclosure. At this time, the other radio-collared bighorn had already found routes up to the higher slickrock country above the 5,000-foot elevation. In late April, her weak and intermittent radio signal was picked up in Zion Canyon; it could not be located in Parunuweap Canyon. It was evident that she had discovered a route up into the slickrock area above the Navajo cliff overlooking Zion Canyon. On May 2, she was unexpectedly radio-fixed and observed in the Zion enclosure area. She had not only returned to the area but had somehow worked her way back into the enclosure. She had her lamb about a week later.

2. Ewe No. 4 (Radio-collared). This was the older, more dominant ewe. On the first day of the release, No. 4 led the other ewes and lambs out of the release enclosure. As she moved rapidly through a pinyon-juniper woodland, her lamb and another ewe followed her, but the rest of the bighorn became separated from her. She moved about ¾ mile upriver east of the enclosure and gained elevation for about 1,000 feet until she was stopped by the Navajo Formation. By the next day, February 28, 1977, she had moved west into lower Stevens Wash, a large side canyon north of the release enclosure. On March 8, she was radio-located and observed with her two companions feeding on the supplemental feed in the release enclosure. Most of the released bighorns had regrouped and were present here also. During the remainder of March and until mid-April, she was radio-located and sighted with her lamb and several ewes within one mile of the enclosure. She preferred to utilize the area on the upper talus slope near the base of the Navajo cliff.

Late in April, the signal indicated that she had discovered a route up to the slickrock country above the 5,000-foot contour line and northwest of the release enclosure. Because of the rugged terrain, she was difficult to radio-locate on foot. In late May, she was radio-located by helicopter and sighted with a new lamb in the slickrock habitat aout two miles north of the release site. From late May until early April, the signals and sightings indicated that she made several short trips with her lamb into lower Stevens Wash but always returned to the higher slickrock habitat which she preferred. Her signal was not located after August 2, and it was assumed that the transmitter had failed. She has not been observed to date.

3. Ram No. 15 (Radio-collared). No. 15, a 2%-year-old ram, was the first to leave the enclosure on the release day of February 27. He moved alone about one mile upriver eastward, gaining elevation until he was stopped by the Navajo cliff. On March 1, he was radio-located several hundred yards from a ewe group at the head of lower Stevens Wash about one mile north of the release enclosure. The signals indicated that the yearling ram (No. 18) was associated with him also. A week later, he and radio-collared ram No. 18 were radio-located, but not sighted, together over two miles downriver to the west of the release enclosure. It was apparent that the ram movements were of a greater magnitude and more rapid than those of the ewes. In mid-March, he was located again in lower Stevens Wash. By early April, he and the younger ram had moved up into the slickrock habitat (above the 5,000-foot contour line) north of the release enclosure. He was radio-located here from the air several times in April and May.

In late May, he again was located in lower Stevens Wash near the release enclosure. He remained in this vicinity for several weeks then began to migrate west. In mid-June, he was located in Zion Canyon about one mile south of the propagating enclosure; however, he did not return to the propagating enclosure. During this time, the Parunuweap Canyon area was being traversed on foot by radio-tracking parties. Mountain lion (Felis concolor) tracks were observed along the river in Parunuweap Canyon and in Stevens Wash, and it was surmised that No. 15 had moved out of the area because of the lion. In early July, No. 15's signal was located back in lower Stevens Wash. After several days of receiving his signal from the same location without being able to observe him, an intensive search was initiated. His carcass was discovered in a riparian thicket below the Navajo cliff. The physical evidence at the site indicated that he had been killed by a mountain lion. Apparently, he had ventured into the thicket of oak (*Quercus* spp.) and grapevine (*Vitis* spp.) to obtain a drink of water from a streamlet and had been attacked.

4. Ram No. 18 (Radio-collared). This ram was 1¾ years old at the time of the release on February 27, 1977. On the day of the release, he left the enclosure for a few hours with a ewe his age, but returned with her for the night. On the second day, he left the enclosure and eventually began to associate with ram No. 15. During March, he moved from one to two miles up and downriver from the release site with the older ram. During the first part of April, they found their way up into the slickrock country. In early May, he was radio-located from the air in the slickrock about 1½ miles northwest of the release site. In mid-May, another flight was made over the area and he could not be located, although the other radio-collared animals were. In May and June, several other flights were made, but again he was not located. It was assumed that his radio had malfunctioned.

On November 30, a prolonged flight was made outward from the release site in an attempt to locate ewe No. 4. Unexpectedly, No. 18's signal was located during this flight in a deep box canyon, south of the Park boundary. His carcass was located on the ground below the Navajo cliff in an oak-grapevine thicket along a game trail to water. He had been dead for a long time. The position of the carcass and the manner in which it had been eaten upon resembled that of ram No. 15. It appeared most likely that ram No. 18 had been killed by a lion also.

5. The Other Released Bighorns. In hindsight, more sheep should have been radio-collared. The non-telemetered animals seldom were observed, leaving uncertainty about their well-being. On July 21, 1977, two ewes which had been released in Parunuweap (Nos. 13 and 21) were observed outside the Zion enclosure with their large, robust, wild-born lambs, pacing up and down the fence trying to get back in. After a couple of days, they found their way into the enclosure. On August 4, another Parunuweap releasee (ewe No. 17) returned to the Zion enclosure. She was alone. Apparently, she had lost the lamb she was known to have had in the wild. These returnees have remained in the enclosure to date.

One ewe and two ram lambs have not been seen since they were released.

A Review of Bighorn Movements and Activities. For the first month and a half after the release, the bighorn ranged about two miles up and downriver from the release enclosure. They preferred the upper talus slopes adjacent to the cliffs of the Navajo Formation, and they traveled along this contour at about the 5,000-foot elevation level. There was a loose herd association but breakups and recombinations occurred. The rams moved over greater distances and more rapidly than did the ewes. Rams were first to move into the slickrock country at the 6,000-foot elevation with its exposed, rocky ridges and deep canyons.

About a month and a half after the release, in mid-April, groups began to break up and the animals moved up into the slickrock habitat. Apparently, ewes were beginning to seek seclusion and proper habitat to lamb in. The slickrock country was much more open than the lower canyon talus slopes. It had good stands of herbaceous vegetation and numerous watering areas, due to late spring rains. From mid-April until late July, bighorn preferred the slickrock area but would make occasional trips down to the lower areas below the Navajo Formation. In mid-May the rams separated from each other. For some unknown reason, the yearling ram (No. 18) made the exodus across the river into another canyon system. He did not return.

The observations suggested that using a family group and associated animals for the release did not prevent long-term herd breakup and scattering. Some long-term association was observed, however, when ewe Nos. 13 and 21 returned to the Zion enclosure together. Returning from the Parunuweap area back to the Zion enclosure occurred two months after the release for one ewe and five months after for three others. It is noteworthy that the returning ewes were pen-reared, whereas the two ewes that remained in the wild were from the original wild-trapped stock. It could be that the wild-trapped ewes were less habituated than the pen-reared ewes to the human activity in Zion Canyon and thus, avoided it.

From the radio-tracking and observation effort, it appeared that the returning bighorns did not show any strong or obvious homing activity after the release. Instead, it appeared that the Zion enclosure area was encountered by accident during the home range expansion and development process of the bighorn after the release and that the sight of the enclosure herd served to attract them. It is interesting also that ram No. 15 did not return to the Zion enclosure when he moved into Zion Canyon in June, 1977. This may be explained, in part, by his lack of interest in the ewes at this time.

After the release and before the ram mortalities, there was evidence from radio-locations and fresh mountain lion tracks that bighorn and lions were interacting to some unknown degree. Differential predator vulnerability between the two rams and the ewes was observed. There was evidence also, although not fully quantified, that both sheep and lion use of the slickrock country was higher than in the lower canyon areas. Bighorn-mountain lion relationships are difficult to explain at present.

A Summary of the Release Effort. The release of desert bighorn sheep into the wild at Zion National Park did not go as well as was expected but could have been worse. Of the 13 animals transported to the Parunuweap release site, three died before the release. Of the remainder that were released into the wild, the two rams were apparently killed by lions, and four of the six ewes returned to the Zion propagating enclosure. Two ewes and two yearling rams, plus at least two lambs born in the wild are unaccounted for at the present time.

On the positive side, enough animals were removed from the overcrowded Zion propagating enclosure to reduce intraspecific competition sufficiently to allow lambs to grow into healthy, vigorous animals. This was a welcome change from the problems of the year before when 20 animals were in the enclosure and most of the lambs suffered from a variety of illnesses. Also, the returning ewes gave some insight into the ability of pen-reared bighorns to be released into new range and not only survive but rear lambs successfully in a fairly hostile environment. Hopefully, these ewes will provide a cadre of animals that can impart their experience and home range knowledge to other pen-reared bighorns when they are all released into the Park in the near future.

An Assessment of the Small Release Enclosure Technique. It is difficult to assess the value of using a small, temporary release enclosure to habituate the animals to an area for a short time before release. Use of a temporary enclosure would vary depending on timing, finances and circumstances. At Zion the bighorns were retained in the 10-acre release enclosure for nearly a month and they could have been held somewhat longer if a mountain lion had not visited the area. Two of the three losses may have been avoided if more stringent measures had been applied to reduce the chance of a predator visiting the area.

One of its main values in the Zion operation was that it served as a holding pen until all of the animals could be transported there. It was observed that when the animals were given their freedom, the younger, pen-reared bighorns were reluctant to leave it. It was apparent that the herd had an affinity for the release enclosure for at least one week after the release, perhaps because of the supplemental feed that was available. Also, for about one and one-half to two months after the release, the bighorn remained in the general vicinity of the release site. It is possible, however, that if the herd had been released directly into the wild, they would have remained close to the site if the habitat components had been adequate. More experimentation and comparison of this type of technique in relation to other release techniques is needed in order to determine its value.

Enclosure Population Status. After the removal of 13 bighorn from the Zion enclosure in February, 1977, seven remained. These consisted of a two-year-old ram, a yearling ram, a ram lamb and four ewes. In April, three lambs were born in the enclosure. In early May, ewe No. 19 homed to the enclosure from the Parunuweap release site and lambed, which increased the population to 12. In July and August, three additional ewes from the Parunuweap release, plus two lambs, homed to the Zion enclosure, bringing the population to 17. Between October and November, 1977, the older ram and two mature ewes with sinusitis were trapped and transferred to Utah State University where they died. In March, 1978, the yearling ram apparently died of pneumonia. At present, the population consists of 13 bighorns — one ram, six ewes and six lambs (three male and three female). It is anticipated that the population will increase to 19 after lambing this spring.

Disease in the Zion Enclosure. Ever since the bighorn were introduced into the Zion enclosure, there has been a gradual mortality of the older animals. During 1974 and 1975, four rams died. One ram, which had been acting sick for some time, died from a broken shoulder received in fighting; one yearling's skull was broken in a fight; one ram died from unknown causes. The fourth ram was captured in a debilitated condition. He had several large abscesses in the frontal region of his skull. He died during treatment. The cause of his death was diagnosed by a veterinarian as a severe case of sinusitis, probably caused by injuries received from fighting. At the time, it was believed that mortality was initially caused by intraspecific competition and stress.

In 1976, a two-year-old ram was found with the sinusitis infection. He was captured and treated by a veterinarian and released back into the enclosure. He appeared to respond favorably to the treatment. In January and February, 1977, most of the bighorn were captured, examined and either released back into the Zion enclosure or transported to the Parunuweap release enclosure. Two ewes exhibited head and horn infections. One old ewe, who was transported to Parunuweap, was held in a small pen there and treated with antibiotics; she subsequently died. Another younger ewe was held several days for treatment and then returned to the Zion enclosure. She appeared to respond to the treatment and later in the year, reared a healthy lamb. In October, it was observed that the infection was getting worse in this ewe. She was captured and transported to Utah State University at Logan where Drs. Tom Bunch and Steve Paul treated her and investigated the etiology of her disease. Unfortunately, the ewe was too debilitated to respond to treatment and died.

In November, 1977, two other bighorn with the disease were also captured and transported to Utah State University. The ewe soon died. However, the ram responded favorably to treatment for several months, and then died. From these animals, it was found that the apparent cause of the disease was parasitism by bot fly larvae *(Oestrus ovis)*. It appeared that the bot fly larvae created an irritation in the sinuses and horn cores, which resulted in a severe bacterial infection, bone necrosis and ultimately death.

To determine the extent of the disease, the skulls of other bighorn that died within the Zion enclosure were sectioned and examined. Most of these skulls exhibited evidence of the disease.

In February, 1978, an additional ewe with the infection was captured and transported to Utah State University for treatment. She responded favorably to the treatment and was returned to the Zion enclosure in good condition. The details of this disease in the Zion herd are reported on by Drs. Bunch and Paul in a separate paper in these transactions.

It was originally believed that intraspecific competition and stress were causative agents toward enclosure mortality. This does not now appear to be the case. Most of the mortalities have been related to bot fly infestations. The relationships of this parasitism to stress and intraspecific competition within the enclosure are not clearly understood.

A Revision of the Bighorn Restoration Program, Recent Project Activities and Plans. In November, 1977, the National Park Service met with the Utah State Division of Wildlife Resources to discuss the history and future of the Zion project. It was agreed that because of the problems experienced during the first release into Parunuweap Canyon and because of mortalities caused by the disease of the animals in captivity, it would be best to release the remaining captive bighorn in the Park as soon as feasible. It was believed that the additional numbers released would provide the best chance for a viable herd in the wild.

A new cooperative agreement was developed. The original cooperative agreement stated that as soon as the bighorn in the Zion enclosure had increased sufficiently, about 12 would be released into the Park and a second 12 would be released by the State of Utah in an area of its choice. The new cooperative agreement indicated that all bighorn in the Zion enclosure would be released. When the wild population increases to over 50 animals, the Utah State Division of Wildlife Resources will remove about 20 animals for transplant purposes.

On February 24, 1978, the Utah State Division of Wildlife Resources in cooperation with the National Park Service and Utah State University trapped 11 of the 14 bighorns in the Zion enclosure with a drop net. The animals were examined for disease and parasites and nine were radio-collared. Then they were all released back into the enclosure. Presently, there is a satisfactory amount of green vegetation within the enclosure as a result of the drought-breaking precipitation of the past winter. With this relief, the plan is to retain the bighorn in the Zion enclosure this spring until about a month after lambing. Then the fence will be removed, giving the animals their freedom.

NOTES ON A GROUP OF PENINSULAR BIGHORN

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Abstract. In 1976, a total of 47 sheep were sighted during 21 days of observation on peninsular bighorn found in the Pinyon and Vallecito Mountains of southern California. Sex and age classifications were established for all sheep sighted. A minimum population level of 23 bighorn was determined for the area. The ram/ewe/yearling/lamb ratio for the minimum population was 40/100/10/40. This was the first attempt at establishing a population level for bighorn in this area.

Investigations of peninsular bighorn sheep *(Ovis canadensis cremnobates)* in the Anza-Borrego Desert State Park have been concerned primarily with populations located in the San Ysidro-Santa Rosa Mountains and the In-Ko-Pah-Jacumba Mountains. Jorgensen and Turner (1973, 1974) and Turner and Jorgensen (1975) have defined population levels, range limits, distribution and general habitat quality in these areas. Much of the information on population levels was derived from annual waterhole counts, conducted during the summer months when bighorn were forced to concentrate around available water sources. The interference by humans on daily bighorn activity was at a minimum during these months.

The least understood and least investigated group of peninsular bighorn in the Anza-Borrego Park are those animals found in the Pinyon and Vallecito Mountains. Four sheep observed by Jorgensen and Turner (1963) and scattered reports from hikers are the only recorded observations of bighorn in the area. Park rangers who patrol less than one-half of the Pinyon-Vallecito area have noted only an occasional set of tracks. Turner and Jorgensen (1975) estimated 30 animals for these mountains, based on tracks, beds and sightings. No annual waterhole count has been attempted on this group of bighorn.

The only known dependable water source for the Pinyon and Vallecito Mountains is the Blue Point Spring Project, a man-made structure of large metal collecting tanks and a drinker box. There is no recorded evidence of sheep ever using this source since its construction in 1971.

This paper reports on bighorn sightings in the Pinyon and Vallecito Mountains and presents a determination of a minimum population size.

MATERIALS AND METHODS

Between 9 August 1976 and 30 October 1976, a total of 21 days was spent in the Pinyon and Vallecito Mountains of Anza-Borrego Desert State Park to record as many bighorn sightings as possible. Each observation day normally began at 0700 and lasted until approximately one hour after sundown.

The study area included the Pinyon Mountains from Mine Canyon to the western edge of Harper Flat, and the Vallecito Mountains from Harper Canyon to Pinyon Canyon. The part of the Vallecito Mountains not covered included the eastern edge of Harper Flat and Whale Peak. Because of the size of the study area (ca. 45.1 sq. mi.), only those general locations where bighorn were previously sighted were monitored. All observation points were between 549 and 975 meters in elevation and thus allowed a 360° view of the surrounding area.

A pair of 7x50 Pentax binoculars and a 20x80x zoom Mayflower telescope were used for observing bighorns. Individual bighorn, recognized through individual body and horn characteristics (horn chips, pelage scars, etc.), were recorded according to sex and age class. Since age classes for ewes are difficult to determine, females were classified as adults, yearlings, or lambs. Rams, aged by horn ring (Geist 1966), were separated into age groups of 6+ yrs., 2-5 yrs., yearlings, and lambs. Identification was performed at sufficiently close range (<180 m) to insure a minimum of error.

RESULTS

A summary of accumulated sightings (all animals observed) and the minimum population derived from those observations are presented in Table 1. Bighorn were observed on seven of 21 observation days. A total of 47 bighorn sightings were made from which 23 individuals were identified. These 23 bighorn are considered a minimum population level for the Pinyon and Vallecito Mountains. The ram/ewe/yearling/lamb ratio from data in Table 1 is 40/100/10/40.

Table 1. Sex and age group classification for accumulated sightings and the minimum population.

	6 yr.+ Rams	2-5 yr. Rams	Yr. Rams	Lamb Rams	Adult Ewes	Yr. Ewes	Lamb Ewes	Unid. Lambs	Total
Accumulated Sightings	9	12	0	3	19	1	1	2	47
Minimum Population	4	4	0	3	10	1	1	0	23

DISCUSSION

As stated earlier, there is virtually no available free water during the summer months in the Pinyon-Vallecito area. Since Blue Spring has apparently received little or no use by bighorn, it is unknown how sheep are meeting their water requirements. A natural rock tank, located **ca.** 150 m from the Blue Spring drinker, was cleared of debris and began collecting some runoff from summer rains in 1976. Bighorn immediately began using this water source. However, the limited capacity provides water for less than two weeks after rainfall, due to summer heat. Another natural rock tank on Harper Flat in the Pinyon-Vallecito area seldom contains water and is an unreliable source.

Preliminary data suggests a markedly different daily activity pattern for bighorn in the Pinyon-Vallecito area compared to bighorn in the In-Ko-Pah-Jacumba Mountains. Olech (1978) noted that bighorn in the In-Ko-Pah-Jacumba Mountains are active at waterholes and surrounding areas from 0600 to 1600 hours from June through mid-September. In contrast, bighorn in the Pinyon-Vallecito area were observed to bed down by mid-morning (under rock out-croppings, juniper trees, etc.) and remain inactive throughout the day until approximately 1645; then, the majority of animals would move to northeast facing slopes and begin to forage.

Since 1971, annual waterhole counts on the north and south populations of bighorn in Anza-Borrega Desert State Park have produced an average lamb:ewe ratio of 18:100 (R = 2:100-40:100) (Park files). During the past four years, the greatest lamb mortality in the northern and southern populations occurred during June and July (unpublished data). Although the present study's sample size was small, it was surprising to note a lamb:ewe ratio of 40:100 in the Pinyon and Vallecito Mountains. Five lambs were sighted after 1 September, 1976 in the Pinyon and Vallecito Mountains. Thus it is probable that lamb survival in the Pinyon and Vallecito area remains higher than in other areas of the park.

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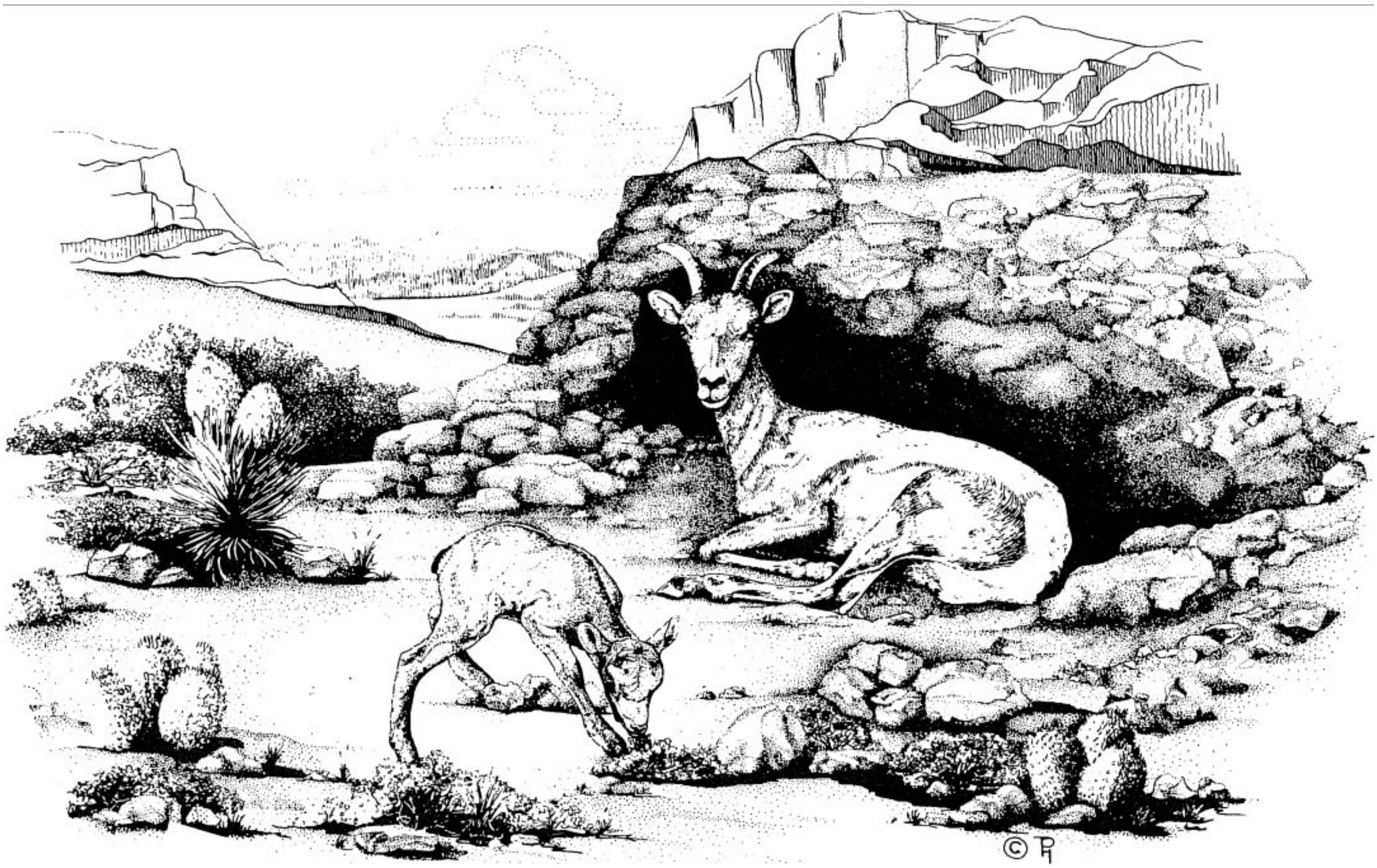

ON ESTIMATING BURRO NUMBERS: A MORE RELIABLE METHOD

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Abstract. The technique of marking and recounting feral burros was used in three localities in Arizona to gain reliable estimates on burro densities. Data indicate that direct air counts, at best, only reveal 30 to 35 percent of the total burro population because of the difficulty in spotting burros due to the rugged terrain they occupy.

Information on time, manpower, and other costs is included for a 15,360 ha (60 sections) area in the Black Mountains, Mohave County, Arizona.

INTRODUCTION

Passage of the Wild Free Roaming Horse and Burro Act (PL 92-195) in 1971 has resulted in concerted efforts to gain estimates of burro ***(Equus asinus)*** numbers on public lands for making management decisions. In general, population estimates have been made from direct counts conducted either from the air or ground. Burro density estimates made from ground or air have exceeded population estimates made from the method reported in this paper by a magnitude of 10 (Grand Canyon National Park; formerly Grand Canyon National Monument) or have underestimated the density by a magnitude of 3 (Alamo Lake area, Arizona). ***Errors of this magnitude cannot be tolerated by the managing agencies when management decisions are being made!*** These wide disparities will eventually raise doubts in the minds of the public about the credibility of the agency when more reliable estimates become available.

This paper presents the methodology for making burro population estimates by marking, counting, and applying a ratio-estimator formula to estimate population size. If time and money permit, subsequent counts can be conducted, and use of a second formula allows statistical confidence to be determined for the population estimate.

MARKING PROCEDURE AND POPULATION ESTIMATES

A CO_2-charged pistol capable of expelling oil-base paint pellets was used in the marking process. Burros were marked either on the left rib cage or the flank. Orange paint was used because of the polychromism displayed in burros. Marks became difficult to distinguish approximately 10 days after marking and were virtually indistinguishable after 20 days.

Marking was conducted from a three- or five-passenger helicopter with the door removed. The area to be censused was flown in a grid pattern with the distance between parallel lines being 0.4 to 0.8 km depending on terrain. Altitude ranged from 300 to 800 m depending on the vantage over the terrain.

The grid pattern was flown until burros were sighted. A count was taken on the group and then the pilot flew alongside and about 8 to 10 m from the animal selected for marking purposes. All sexes and age classes were marked using this procedure. In general, all animals in a group could be marked. The grid pattern was continued once all individuals in a group were marked.

Subsequent counts of marked and unmarked animals were conducted within five to nine days after marking. The five-day period allowed the very weak social bonds to recombine and the animals to resume their normal behavior.

In the counting process, the same grid pattern was flown at approximately the same elevation as in marking. Burros were examined from as close as 50 m to insure presence of absence of paint marks, and a tally was kept by the observer.

Marking was most efficient and best population estimates were obtained in summer months when burros were concentrated around water sources. Early morning and late afternoon were the best times to mark since cooler air reduces stress on the animals and allows for better lift for the helicopter.

An unbiased estimator of N when n is not predetermined (Bailey 1951, 1952) is as follows:

$$N = \frac{M\ (n+1)}{m+1}$$

which has a standard error of:

$$S.E. = \sqrt{\frac{M^2\ (n+1)\ (n-m)}{(m+1)^2\ (m+2)}}$$

Because of monetary constraints we were unable to conduct multiple counts, but if they were conducted, then Schumacher's method (Schumacher and Eschmeyer 1943) would provide a more reliable estimate. The formula is as follows:

$$\hat{N} = \frac{\Sigma\ M_i^2\ n_i}{\Sigma\ M_i n_i}$$

the S.E. for $1/N = \sqrt{\frac{\Sigma(m_i^2/n_i) - (\Sigma M_i n_i)^2/\Sigma M_i^2 n_i}{j-1}}$

from which confidence limit can be calculated for N.

In the above equations:

M_i = the number of individuals marked prior to the i^{th} sampling occasion.

n_i = the number of individuals on the i^{th} occasion.

m_i = the number of marked individuals counted on the i^{th} occasion.

j = the number of recount samples.

N = population estimate.

DISCUSSION

The constraints under which ratio estimators can be used to obtain unbiased population estimates frequently disallow full confidence in the technique. The technique requires the following criteria: 1) the probability of counting an unmarked animal is equal to that of a marked one; 2) no births, immigrants or emigrants occur in the area between marking and counting; and 3) no marks are lost.

With the use of this technique in censusing burros the above criteria are met as well as a biologist could expect in field conditions. Marked animals are no easier to see than those without marks, since burros are always spotted from the air prior to getting close enough to see the marks. The rapidity of the mark-count procedure is such that data bias from births, immigrants, or emigrants is insignificant. Further, by conducting the counts in the summer months the animals are closely associated with available water, thereby reducing the probability of any movement bias.

The biology of burros is such that they are an ideal species on which to derive population estimates through the use of a ratio estimator. The constant exchange of individuals in herds (Moehlman 1974; Woodward 1976; Morgart and Ohmart 1977; Seegmiller and Ohmart ms; and Walker and Ohmart 1978), the open habitat which they occupy, and their body size, escape behavior (run and not hide) and patchy distribution over their habitat all combine to allow relative ease of marking and recounting.

General costs can be derived from the population estimate done in the Black Mountains, Arizona. An area of 15,360 ha (60 sections) was surveyed for burros in a grid-fashion and 95 burros were marked in seven hours of flight time. Costs for marking were $33 per 256 ha (one section). Counting consumed 7 more hours, to yield a total cost of $3,960 for the population estimate. These cost figures exclude the time of the marker and the observer but include the helicopter pilot, his helper, and fuel.

During the marking and recount process some insight was gained into the question, "What percentage of burros are spotted in aerial counts not using marked animals?" If the senior author is an average spotter and marked all the burros that were sighted, subsequent counts indicate his spotting ability ranged from 30 to 35 percent of the total population. Even the best spotter would probably not see more than about 40 percent of the total unless he flew every drainage, since burros usually stand and watch as you fly over and generally reside in broken and rolling terrain. However, flying every drainage would result in costs greatly exceeding those necessary to mark and count. Direct count estimates are also highly questionable, as has been demonstrated in the past.

CONCLUSIONS

Public concern has resulted in the close scrutiny of agencies responsible for the preservation and management of natural resources. Poorly designed methods of obtaining animal population estimates are not acceptable and are being tested in courts. To avoid these consequences, agencies responsible for the management of natural resources must use the best techniques available.

The mark-recount technique, combined with a ratio estimator, currently provides the most reliable data for estimating burro populations. Consequently, when proposed management decisions necessitate an Environmental Impact Statement or 102 Statement, the agency undertaking the action should possess data that are defensible in court. The method described above fulfills that need.

Costs and time involved in marking-recount estimates probably do not greatly exceed those of direct aerial counts. In the long run they may be much less than if the agency is faulted for unacceptable population estimates.

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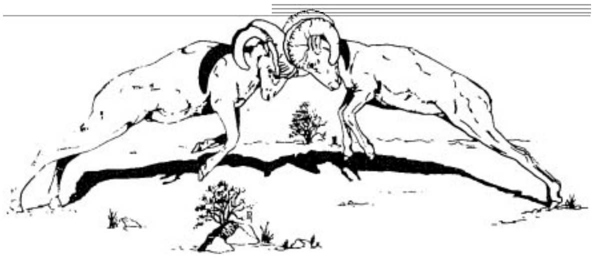

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1965 John P. Russo, Arizona Game and Fish Department, Phoenix, Arizona
1966 Charles Hansen, U.S. Bureau Sport Fisheries and Wildlife, Las Vegas, Nevada
1968 Steve James, Jr., Fraternity of the Desert Bighorn, Las Vegas, Nevada
1969 M. Clair Aldoux, U.S. Bureau Sport Fisheries and Wildlife, Fallon, Nevada
1974 The Arizona Desert Bighorn Sheep Society, Inc.
1978 Fauna-Silvestre, Mexico City, Mexico

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1968 Nevada Operations Office, Atomic Energy Commission, Las Vegas, Nevada
1969 Pat Hansen, Bighorn Illustrator Specialist, Death Valley, California
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