DESERT BIGHORN COUNCIL TRANSACTIONS

VOLUME 38 1994

Desert Bighorn Council

DESERT BIGHORN COUNCIL 1994-1995

OFFICERS:

Chair:	Jim Guymon, Utah Division of Wildlife Resources, Moab
Vice-Chair:	Jim Karpowitz, Utah Division of Wildlife Resources, Moab
Secretary-Treasurer:	Charles Douglas, National Park Cooperative Studies Unit, University of Nevada, Las Vegas

TECHNICAL STAFF:

William R. Brigham (Chair), James R. DeForge, Amy S. Fisher, Mark C. Jorgensen, Raymond M. Lee, Richard A. Weaver, John D. Wehausen

COMMITTEE CHAIRS:

Nominations:	Jim Guymon
Program:	Jim Guymon
Arrangements:	Joe Cresto
Transactions:	Walter Boyce
Burro:	Vacant
Barbary Sheep:	Bruce Morrison
Historian:	Warren Kelley
Ewes:	Doris Weaver
Awards:	William R. Brigham

Desert Bighorn Council
1994 Transactions

A Compilation of Papers Presented and Submitted at the 38th Annual Meeting 6-8 April 1994, Moab, Utah

Walter M. Boyce, Editor, School of Veterinary Medicine, University of California, Davis, CA 95616

Paul R. Crosbie, Associate Editor, School of Veterinary Medicine, University of California, Davis, CA 95616

Raymond M. Lee, Associate Editor, Arizona Game and Fish Department, 2221 West Greenway Road, Phoenix, AZ 85023

Reviewers for the 1994 Desert Bighorn Council Transactions:
D. Armentrout, V. Bleich, T. Bunch, M. Cronin, C. Douglas, M. Festa-Bianchet, A. Fisher, J. Jaeger, M. Jorgensen, P. Krausman, R. Ramey, S. Torres, J. Wehausen

Illustrations by Pat Hansen.

TECHNICAL REPORTS

RANGE EXPANSION AND POPULATION GROWTH OF REINTRODUCED DESERT BIGHORN IN ZION NATIONAL PARK, UTAH

HENRY E. MCCUTCHEN, National Biological Survey, Northern Arizona University, P.O. Box 5614, Flagstaff, AZ 86011

JIM GUYMON, Utah Division of Wildlife Resources, P.O. Box 606, Cedar City, UT 84721-0606

STEPHEN KING, National Biological Survey, Northern Arizona University, P.O. Box 5614, Flagstaff, AZ 86011

Abstmct: In 1973, 12 desert bighorn sheep (*Ovis* canadensis nelsoni) were released into a 32 ha propagating enclosure at Zion National Park. In 1977, 13 bighorn were released into the park. The remaining 19 bighorn in the enclosure were released in 1978. At least 18 sheep had survived from the transplants when intensive monitoring of the herd ended in 1979. In 1992, because of a lack of knowledge on the status of this herd since 1979, 12 bighorn were captured in the park by helicopter net-gun and were radiocollared. Observation and radiotelemetry indicated that the population is about 67 animals and appears to be increasing. Fall ram:ewe:lamb:yearling ratios were 58:100:51:24. Since 1979, the herd has expanded its range from the rearing enclosure in the park about 12 km eastward to the park boundary and southward outside the park boundary for a distance of about 13 km. Range extent was about 36 km^2 in 1979, and this has expanded to about 170 km^2 in 1994. Although derived from pen-reared stock, the Zion herd seems to be prospering as well as other transplants in Utah.

Key words: reintroduction, transplant, desert bighorn, Zion National Park.
Desert Bighorn Council *Transactions 38:1-5.*

INTRODUCTION

In 1973, 12 desert bighorn sheep (*Ovis canadensis* nelsoni) from Lake Mead, Nevada were introduced into a 32 ha propagating enclosure in Zion National Park in a cooperative program between the Utah Division of Wildlife Resources (UDWR) and the National Park Service (NPS). The purpose of the project was to rear sufficient stock for transplanting into the park and in southwestern Utah (McCutchen 1975). This propagating enclosure method was successful in increasing the numbers of bighorn for transplanting. However, sinusitis caused by bot fly larvae (*Oestrus ovis*) was responsible for some mortalities in the captive bighorn (Bunch et al. 1978).

In January 1977, 13 bighorn (7 ewes, 2 rams and 4 lambs) were taken from the enclosure and released into Parunuweap Canyon, a remote area in the southeast section of the park, about 5 km from the rearing compound. Movements of these bighorn were followed by radiotelemetry. By December, 1977, only 4 remained in the wild. There had been 5 mortalities, and 4 ewes had returned to the enclosure (McCutchen 1979, 1982).

In spring of 1978, 19 bighorn (6 ewes, 3 yearling ewes, 3 yearling rams and 7 lambs) were released from the enclosure by lowering the fence. A ram that had escaped from the enclosure was also present in the area. Radiotelemetry indicated that ewes moved 5 to 6 km into the area southeast and east of the enclosure (McCutchen 1979, 1982). The herd mainly utilized slopes below the Navajo Formation and above the rearing enclosure in Zion Canyon, while a few animals utilized the higher slickrock country to the east. Rams and ewes also moved into Parunuweap Canyon which was on the contour to the southeast. Two yearling rams made a long-distance foray about 30 km to the west. One of these was killed by a poacher and the other disappeared (McCutchen 1979, 1982).

The intensive radio-monitoring effort was terminated in August, 1979. At that time, 11 animals from the second transplant group were known to be alive, and there were 5 lambs. The sighting of one ewe from the first transplant and a yearling ram raised the known population to 18. An additional ewe, her yearling offspring of unknown sex, and a 2 year old ram from the first release should also have been present in the area but were not observed after the second release. Causes of mortality of all

released animals included transplanting injuries (n=3), sinusitis (n=2) and mountain lion predation (n=5) (McCutchen 1982).

Between 1980 and 1991 there was no intensive monitoring, but individuals and small groups of bighorn were occasionally observed by park staff and visitors. The general opinion was that the population had declined and that success of this transplant was doubtful (Karpowitz and Guymon 1985).

In 1991, an increased number of sightings of bighorn in Zion National Park prompted interest in conducting a thorough helicopter survey of the area. A total of 36 bighorn were found by helicopter in the southeastern section of the park. Because of the surprising numbers seen, the NPS, in cooperation with UDWR, initiated a capture and radiotelemetry study. The purpose of this study was to determine population size, herd composition, distribution, and habitat use by the herd. This paper reports on the interim findings of this study.

The authors acknowledge the support of the NPS, UDWR, Dr. Robert Schiller, Vic Vieira, Larry van Slyke, Sherry Fedorchak, and Jan Hart.

STUDY AREA

Zion National Park is a 56,000 ha preserve in southwestern Utah. The climate is characterized by moderate winters, with an average low of 0°C, and hot summers, with an average high of 37°C. The average annual precipitation is 37 cm.

The park is located on the southern edge of the Markagunt plateau. Elevations range from 2700 m in the north to about 1100 m in the south. Thick beds of sedimentary rock in the area have been extensively dissected to form a maze of large canyons, smaller hanging canyons, mesas and buttes. The exposure of 300 to 800 m red and white sandstone cliffs of the Navajo Formation dominates the scene.

Above the cliffs of the Navajo Formation, at mid to upper elevations, is exposed sandstone "slickrock" containing ponderosa pine (*Pinus* pondemsa) and littleleaf mountain mahogany (*Cercocarpus* intricatus). Inner-canyon talus slopes below the cliffs of the Navajo Formation contain stands of singleleaf pinyon pine (*P. monophylla*), and juniper (*Juniperus osteosperma*) with shrub live oak (*Quer*-qus *turbinella*) and mountain mahogany (C. *montan*-us). Grass stands are varied, with mutton bluegrass (*Poa fendleriana*) found on cooler sites, and galleta (Hilana *jamesii*) and sand dropseed (*Sporobolus* cryptandrus) found on the warmer, dryer areas.

MATERIALS AND METHODS

In January, 1992, two bighorn ewes were captured in the park in Zion and Parunuweap Canyons by helicopter net-gun and equipped with radiocollars with mortality sensors (Telonics Inc., Mesa, Arizona). In November, 1992, an additional 10 bighorn (5 ewes, 5 rams) were captured in the same areas by helicopter and radiocollared.

The bighorn were radio-located several times a week by ground crews beginning in January, 1992. When possible, radiolocations were confirmed by visual observations. An intensive effort was undertaken from September 14, 1993, to February 17, 1994, to obtain a population estimate and data for this report. Plans are to continue this effort to September, 1994. Data were recorded on herd location, numbers, numbers marked and unmarked, age class composition, elevation, slope, aspect, geology and vegetation type. Monthly fixed-wing flights were made with a Cessna 182 to determine movements and distribution by radiotelemetry.

Radiolocations were recorded on standard base maps. Bighorn sightings and radiolocations of 1992, 1993, and 1994 were consolidated onto a single distribution map. Bighorn radiolocations and observations from 1977 to 1979 were obtained from the dissertation of McCutchen (1982) and consolidated for a distribution map. Fall sex and age ratios were consolidated from observations made from September 14, 1993, to November 30, 1993. A minimum population size was calculated using the Schnabel estimator method (White et al. 1982) using ratios of marked and unmarked animals from data obtained between September, 1993, and February, 1994.

RESULTS

A minimum population estimate of 67 $\pm$4 (95% confidence interval, SE = 1.9) was obtained using the Schnabel estimator (Fig. 1). Two additional population estimates were made by field personnel experienced in bighorn observation. During the helicopter capture operation of November, 1993, Kelly Barker of the UDWR estimated a population of 80 to 90 bighorn from counts he made during the flights (pers. commun., Zion National Park, November 7, 1992). Stephen King, who conducted the intensive ground radiotracking and observation session beginning in September 1993, estimated the population at 70 to 75 based upon individuals seen (pers. commun., Zion National Park, February 15, 1994).

Of 246 sheep observed between September 14, 1993 and November 30, 1993 (i.e., the fall season) the overall ram:ewe:lamb:yearling ratios were 58:100:51:24. Bighorn were radiolocated and observed throughout the southeastern section of the park and southward outside the park in the Canaan Mountain area, about 13 km south of the park boundary (Fig. 2). By February, 1994, only 7 of the original 12 radiocollars were still functioning. A ewe captured in January 1992 (#9) was found dead in Parunuweap Canyon in September, 1992. The cause of death could not be determined. Although radiocollars of two other ewes failed, the sheep were subsequently observed. Radio signals of two rams, last located south of the park, were not received after July and August, 1993. These rams have not been observed again. The radio of another ewe (#8) sent a mortality signal in November, 1993. The area where she was located required technical rock climbing equipment and skills and due to hazardous conditions complicated by ice and snow a trip to locate her was deferred. Unfixtunately, her signal ceased to be heard after February, 1994.

When the bighorn were originally released, sinusitis was present, and there was concern that it would continue unabated. Observations of bighorn since 1992 indicate that they are in good condition and have shown no signs of sinusitis.

DISCUSSION

The Zion herd has increased from a minimum of 18 in 1979 to approximately 67 in 1994 (Fig. 1). Simple extrapolation suggests that the population could reach approximately 100 by the year 2000, barring unexpected mortality factors such as drought, predation and disease. We believe that the population estimate we obtained using the Schnabel method is conservative. One of the assumptions regarding this mark/recapture model is that all individuals in the population have an equal chance of being observed (White et al. 1982). We had no way of testing this assumption in the field and were never certain of equal observability. Therefore, we believe that this estimate represents the minimum number of sheep that associated with the radiocollared animals.

The Zion fall 1993 ewe:lamb ratio of 100:53 indicates high lamb survival for the year and suggests an increasing trend when compared to Nevada bighorn, which are the closest populations to Zion. McQuivey (1978) found in Nevada fall surveys from 1969 to 1976 that ewe:lamb ratios varied between 100:18 and 100:48 with a statewide average of 100:33. McQuivey (1978) also found that a minimum fall ratio of 26 lambs per 100 ewes was necessary to maintain a stable population. The high Zion ewe:lamb ratios also compare favorably with recent surveys by the UDWR. In 1993, December surveys of the transplanted Escalante Desert and Arches herds showed ewe:lamb ratios of 100:41 and 100:47 respectively (Dec. 28, 1993, UDWR Memorandum by Norman McKee). The fall ram:ewe ratio of 58:100 found at Zion is comparable to that in Nevada, which showed a range of 53:100 to 70:100 and an average of 60:100 (McQuivey 1978).

The Zion herd has expanded its range southward and eastward from the original rearing enclosure (Fig. 2). After the releases of 1977 and 1978, bighorn concentrated their use in the vicinity of the Zion rearing enclosure in Zion Canyon and southeast in Parunuweap Canyon (McCutchen 1982). Several ewes and yearling rams utilized the slick rock country above Navajo Cliffs east of Zion Canyon, but use of this area by bighorn was lower than in canyons (Fig. 2). Size of the range utilized by bighorn was about 36 km^2.

Data from radiotracking from 1992 to 1994 indicates that bighorn ewes have expanded their range further southward from the rearing enclosure in Zion Canyon into Parunuweap Canyon and Shunes Creek on the south boundary of the park as well as into the higher slickrock country near the eastern park boundary. Additionally, rams have established ranges south of the park boundary for a distance of about 13 km in the vicinity of Canaan Mountain. The range utilized by bighorn in 1994 has expanded to about 172 km^2.

One area that bighorn used heavily in 1978-1979 and now use only lightly is the Zion Canyon area. The habitat appears to be suitable (Smith and Flinders 1992), but low bighorn use may relate to high visitor use. This potential problem needs further investigation. Another area containing bighorn habitat is the southern region of the park west of Zion Canyon. No radiocollared bighorn from the current study have moved into this area. Rams have been sighted here in past years, but there is no evidence that ewes have colonized this area.

There appears to be ample continuous bighorn habitat inside and outside the park to allow range expansion for the Zion herd. Smith and Flinders (1992) considered approximately 21 percent of the park (126.2 km^2), primarily in the southern quarter, as suitable habitat which could support a herd of

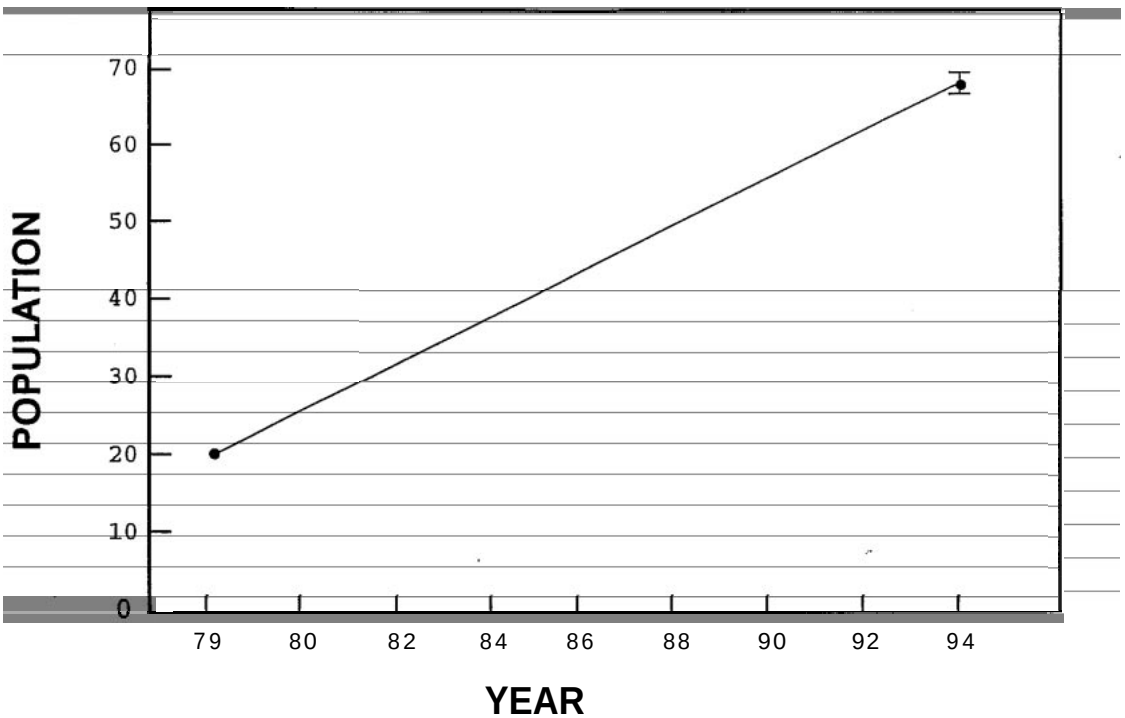


Figure 1. Population trendline of reintroduced desert bighorns, Zion National Park, Utah from two points (1979 and 1994 [$\bar{x} \pm 1$ SE]).

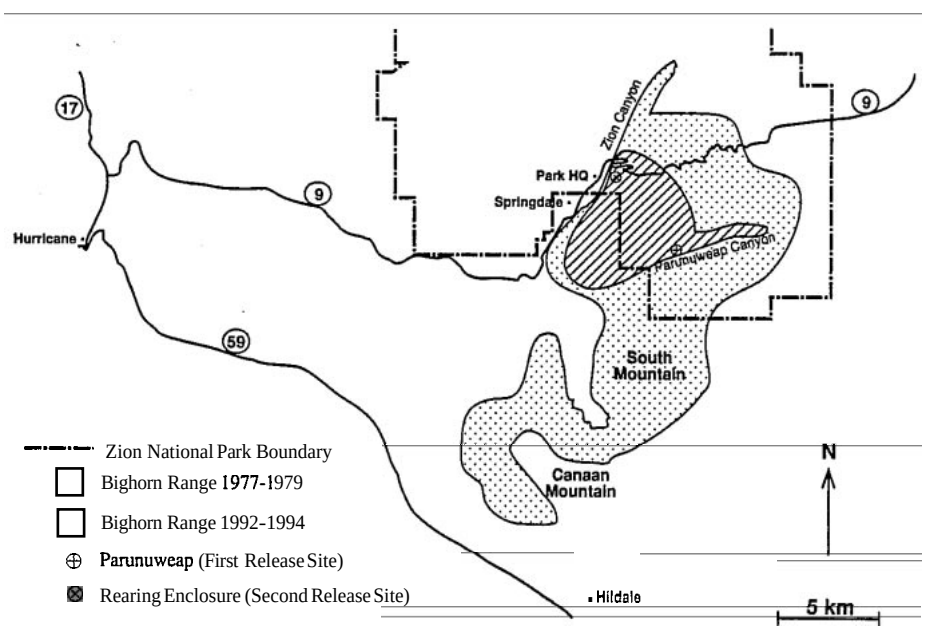


Figure 2. Ranges of desert bighorns, 1977-1979, 1992-1994, Zion National Park, Utah.

about 125 animals. We are currently assessing potential contiguous bighorn habitat outside the park. Our preliminary assessment indicates that the area south of the park boundary to the Canaan Mountain region, plus the area outside the park west to Interstate 15, contains at least as much bighorn habitat as the park. Thus, we estimate that the Zion area, including areas inside and outside the park, should be able to support 200-250 bighorn.

A lack of bighorn pioneering into suitable habitat to the west of Zion National Park could be remedied by the establishment of an additional transplanted herd here. However, a major concern is that small herds of domestic sheep are raised in paddocks on farms adjacent to state highway 9 within a kilometer of the southern park boundary. It must be assumed that the potential exists for transmission of their diseases to the desert bighorn. An additional concern for the Zion bighorn is that pink eye has caused mortalities in the Zion Canyon deer herd. The risk of potential transmission from deer to bighorn at the park is being investigated by Dr. Beth Williams, veterinarian for the NPS.

In summary, after a slow start, the Zion bighorn population has shown a considerable increase in numbers from the original transplant. The Zion herd has been the only pen-reared desert bighorn reintroduction in Utah. In the past, the NPS and the UDWR were concerned that possible inbreeding, disease, and other factors associated with pen-rearing would prevent the population from maintaining its viability. To date there is no evidence of any deleterious effects of pen rearing, and the population appears to be doing as well as other transplanted bighorn in the state.

LITERATURE CITED

Bunch, T.D., S.R. Paul, and H.E. McCutchen. 1978. Chronic sinusitis in the desert bighorn *(Ovis canadensis nelsoni*). Desert Bighorn Council Transactions 22:16-20.

Karpowitz, J.F. and J.C. Guymon. 1985. Utah's desert bighorn sheep status report, 1985. Desert Bighorn Council Transactions 29:40-41.

McCutchen, H.E. 1975. Desert bighorn restoration at Zion National Park, Utah. Desert Bighorn Council Transactions 27:19-27.

_____. 1979. Status of the Zion Desert Bighorn Reintroduction Project - 1978. Desert Bighorn Council Transactions 23:81.

_____. 1982. Behavioral ecology of reintroduced desert bighorns, Zion National Park, Utah. Ph.D. Thesis. Colorado State University, Fort Collins.

McQuivey, R.P. 1978. The desert bighorn sheep in Nevada. Nevada Department of Fish and Game Biological Bulletin Number 6. 81pp.

Smith, T.S. and J.T. Flinders. 1992. Evaluation of mountain sheep habitat in Zion National Park, Utah. Desert Bighorn Council Transactions 36:4-9.

White, G.C., D.R. Anderson, K.P. Burnham, and D.L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos National Laboratory, LA 8787-NERP, Los Alamos, NM 235pp.

HABITAT, VISIBILITY, HEART RATE, AND VIGILANCE OF BIGHORN SHEEP

CHARLES L. HAYES, School of Renewable Natural Resources, University of Arizona, Tucson, AZ 85721; Present address: Department of Veterinary Pathology, Microbiology, and Immunology, University of California, Davis, CA 95616

PAUL R. KRAUSMAN, School of Renewable Natural Resources, University of Arizona, Tucson, AZ 85721

MARK C. WALLACE, School of Renewable Natural Resources, University of Arizona, Tucson, AZ 85721; Present address: Department of Natural Resources Science, University of Rhode Island, Kingston, RI 02881

Abstract: Heart rate has been used as a physiological indicator of disturbance in bighorn sheep (*Ovis* canadensis). One reported cause of disturbance in bighorn sheep is the presence of visual obstructions. Increased vigilance and heart rate should occur as bighorn sheep become increasingly aroused. We quantified heart rate and vigilance for a female bighorn sheep and examined correlations with visibility slope, elevation, group size, and group vigilance for bighorn sheep in a 3.2 km^2 enclosure on the Desert National Wildlife Refuge (DNWR), Nevada. We also selected random points and compared visibility, slope, and elevation to locations used by bighorn sheep. Heart rate of the female varied with visibility ($P<0.0001$), slope ($P=0.006$), elevation ($P<0.0001$), and group size ($P<0.0001$). Vigilance of a given animal was significantly related to percent vigilance of the rest of the group. Random locations did not differ in visibility from locations used by bighorn sheep. Although visibility was a variable related to heart rate, it did not result in changes in behavior or habitat use in the scrub-dominated environment within the enclosure.

Key words: bighorn sheep, heart rate, Nevada, *Ovis canadensis*, vigilance, visibility
Desert Bighorn Council Transactions 38:6-11

INTRODUCTION

Visibility is a feature of habitat that has been shown to be important to bighorn sheep (Risenhoover and Bailey 1980). Increased foraging efficiency occurred with more open habitats in Colorado (Risenhoover and Bailey 1980), and bighorn sheep avoided habitats with low visibility (Risenhoover and Bailey 1985). MacArthur et al. (1979) also reported that heart rates increased for bighorn sheep in areas where visibility was low.

Our objective was to examine the heart rate of a female bighorn sheep in an enclosure that contained topographic features ranging from bajadas to rugged peaks. We quantified visibility to determine if it was correlated with a change in the heart rate, vigilance, or habitat use of bighorn sheep. We hypothesized that: 1) heart rate would increase as visibility decreased, 2) arousal could be predicted by percent of time vigilant, and 3) that the sheep would be less vigilant in secure cover and in large groups.

The United States Fish and Wildlife Service (USFWS), University of Arizona (UA), Nevada Department of Wildlife (NDOW), and the United States Air Force (USAF), cooperated in various aspects of this study. D.E. Brown, B. Zeller, M. and C. Goddard of USFWS, O.E. Maughan, L.R. Berner and M.J. Zine (UA), D. Delaney (deceased, NDOW), and R.C. Kull (USAF) provided ideas, support, and field assistance. S.G. Torres (California Department of Fish and Game) assisted with data analysis. The study was funded by the USAF. Use of animals in this study followed the United States Public Health Service and Animal Welfare Act guidelines and were enforced by the Institutional Animal Care and Use Committee (Protocol no. 89-01-50), UA, Tucson. We also followed guidelines established by the American Society of Mammalogists (1987).

STUDY AREA

All sheep in the study were observed within a 3.2 km^2 enclosure in the northeast comer of the DNWR, Nevada from January through March 1992. The mean high temperature was 13°C. Elevations ranged from 1,267 to 1,562 m (Krausman et al.

1992). Berner et al. (1992) identified 9 vegetation associations in the enclosure: main wash, west bajada, east bajada, west midslope, east midslope, west draw, east draw, ridge top, and blackbrush (*Coleogyne ramosissima*). Vegetation was typical of the Mojave desert scrub province (Bradley 1964).

METHODS

Nineteen bighorn sheep (*O.* c. nelsoni) were in the enclosure. Thirteen of the sheep (5 M, 8 F) were captured from the adjacent Sheep Range within DNWR. Six (5 M, 1 F) were yearlings born inside the enclosure. One adult female had a surgically-implanted heart rate transmitter (J. Stuart Enterprises, Oceanside, CA) that produced a radio pulse for each depolarization of the animal's ventricles (Kreeger et al. 1989). The radio pulse was received with a TR-2 receiver (Telonics, Inc., Mesa, AZ).

Sheep were located 2-3 times/day at random diurnal hours during January through March, 1992. Whenever possible, the group containing the animal with the heart rate transmitter (animal 4322) was observed at each random time. When we were unable to obtain heart rate and behavioral data from animal 4322, another animal was selected systematically from which we collected behavioral data. At each random time, behavioral data were recorded via scan sampling (Altmann 1974). Behavior and heart rate of animal 4322 or the behavior from the alternate animal were recorded for 15 seconds when first observed (Krausman et al. 1992), and the group was scanned by moving in an outward radius from the selected animal. We classified behavior as bedded, foraging, standing, walking, or running. We recorded the behavior that comprised most of the 15 second observation time. Habitat and vigilance (i.e., whether or not the animal was vigilant at any point during the 15 second observation period) were recorded for each animal during the scan sample. After the behavior of the entire group had been recorded, we recorded for 5 minutes the behavior, habitat use, vigilance, and heart rate (for animal 4322) for the selected animal at 30-second intervals. We measured visibility of the site where the selected animal was located following the method of Risenhoover and Bailey (1985). Visibility measurements were recorded when the exact site of the group could be reached without disturbing any animals inside the enclosure (i.e., 1-5 days after the observation was made).

We expressed heart rate as beats/15 second observation period. We used analysis of variance (ANOVA) to examine relationships between behavior and heart rate. We used multiple ANOVA procedures to examine differences in heart rate among vegetation associations, adjusting for the effects of behavior on heart rate (for animal 4322). We used stepwise multiple regression to determine the variables (i.e., visibility, slope, elevation, group size, percent of group vigilant) that were useful in developing the regression model for heart rate. We transformed all percent vigilance data using the arcsine-square root transformation to meet the assumptions of the linear regression model. We used dummy variables (bed, stand, forage, and walk) to account for variation in heart rate due to behavior. We used t-tests to compare visibility between random points and sites where sheep were observed.

We used ANOVA to examine the relationship among vegetation associations and percent of observations vigilant (transformed) for the selected animal only. We used stepwise multiple regression to build a model for predicting percent of observations vigilant for the focal animal.

We compared heart rates between observations when animal 4322 was vigilant versus non-vigilant using t-tests. We tested use versus availability of vegetation associations and slope classes using the G-test. We determined availability of associations and slope classes within the enclosure using a geographic information system (ARC/INFO).

RESULTS

We collected 1,026 observations of behavior from bighorn sheep at 70 locations where visibility was measured. Heart rate was measured during 543 observations. Heart rate varied significantly with behavior ($P<0.001$). Heart rate was significantly different among different associations ($P<0.001$; west bajada, 16.3 ± 1.8 [SD] beats/15 seconds, $n=11$; east bajada, 17.1 ± 0.6, $n=22$; west midslope, 18.1 ± 3.6, $n=188$; east midslope, 19.5 ± 3, $n=205$; west draw, 18.5 ± 2.1, $n=25$; east draw, 17.6 ± 3.2, $n=31$; ridge top, 16.7 ± 2.4, $n=61$). Heart rates recorded in west midslope were significantly different from those recorded on the ridge top, and those recorded on east midslopes were significantly different from all others except those recorded in west draws. Heart rate was not recorded for sheep in the main wash or blackbrush association. The multiple regression model accounted for 58% of all variation in the heart rate. Visibility,

slope, elevation, and group size all had a significant relationship ($P<0.05$) with heart rate (Table 1). Heart rates were positively correlated with slope and group size, and negatively correlated with visibility and elevation. The positive relationship between heart rate and slope may be a result of the increased metabolic demands of moving about steep and rugged terrain. To test this, we examined heart rates within behaviors (Table 2). For bedded observations, heart rate varied significantly with slope ($P<0.0001$), with highest heart rates found in slope classes 2 (11-35%), 1 (0-lo%), and 3 (36-60%), respectively. When foraging, there was a significant difference in heart rate with slope ($P=0.045$). However, in this case, the highest heart rates occurred in slope classes 5 (>80%) and 4 (61-80%). Percent of the group vigilant was not significantly related to heart rate. The multiple regression model for vigilance of the focal animal explained 80% of all variation even though only the percent of the group vigilant (transformed) had a significant (positive) relationship to focal animal vigilance. However, the heart rate was higher when the sheep was vigilant than non-vigilant ($P<0.001$).

There was no difference in visibility between the 70 locations where sheep were observed (ridge top, $n=7$, visibility=35%, mid-slopes, $n=47$, visibility=50%; draws, n=11, visibility=53%; bajadas, $n=5$, visibility=65%) and 30 random locations ($P=0.70$). The number of random points were a representative sample of points within the enclosure. There was no significant difference between availability and the distribution of random points with respect to habitat association ($P=0.23$) or slope ($P=0.15$). However, vigilance was significantly different among associations ($P<0.001$; west bajada, vigilance = 87 ± 3 [SD]%, $n=31$; east bajada, 62 ± 5, $n=58$; west midslope, 5455, $n=364$; east midslope, 54+5, $n=304$; west draw, 30 ± 5, $n=67$; east draw, 40 ± 5, $n=62$; ridge top, 83 ± 4, $n=113$).

DISCUSSION

MacArthur et al. (1979) stated that heart rate "is a sensitive physiological indicator of disturbance in unrestrained bighorn." As an example, they noted the significant increase in heart rate of bighorn who became increasingly aroused when they passed through stands of timber that they normally avoided. We hypothesized that increased arousal and heart rate would be negatively correlated with visibility. In this study, increased heart rate did correlate with decreased visibility. Increased heart rate also occurred with decreased elevation, increased slope, and larger group size. While the inverse relationship between heart rate and elevation could be explained by increased arousal and predator avoidance, the same is not true for the relationship between heart rate and slope. This could be explained by increased metabolic demands of foraging on steep slopes. When bedded, there should be no increased metabolic demands for steep terrain compared to more gentle slopes. The increased bedded heart rates in lower slope classes may be the result of some other process, such as increased alertness or stress when away from escape terrain, as suggested by MacArthur et al. (1979) and Risenhoover and Bailey (1985).

The increased heart rate observed with increasing group size may be a result of interactions among animals. Groups with a large number of individuals have greater potential interactions. Social interactions often involve active behaviors that would raise the heart rates of the individuals involved. We recorded 16 observations of animals running when no disturbance could be detected. Of these, 7 occurred while rutting activities were taking place, and 5 resulted from play behavior with ewes, lambs, and yearlings.

We found faster heart rates when the sheep was vigilant than when non-vigilant. We hypothesized that arousal of bighorn sheep could also be predicted by percent of time vigilant, and that sheep would be less vigilant when they were secure in high, steep, and open places, and in large groups. Animals will be less nervous and less likely to be alert when there is a larger number of group members alert and watching for predators or other disturbances (Berger 1978, Graham 1980, Risenhoover and Bailey 1981). Instead, we found a strong positive relationship between the vigilance of a particular animal and the vigilance of the rest of the group. None of the habitat features (i.e., visibility, slope, elevation) were significantly related to vigilance. Sheep appeared to rapidly respond to the attention posture of other conspecifics by becoming vigilant, as had been previously observed by Geist (1971).

Bighorn sheep in the enclosure selected certain vegetation associations and slopes above others. Concurrent changes in heart rate with use of the different habitat components suggest that sheep may feel more or less secure in different habitats. Visibility was a habitat feature significantly related to heart rate. While bighorn sheep may have been "less secure" in areas of lower visibility, this did

Table 1. Standaniized regression coefficients (r) and P-values for relationships among heart rate, visibility, slope, elevation, group size, and percent of group vigilant (transformed) in Desert National Wildlife Refuge, Nevada, 1992.

Variable	*r*	*P*
Visibility	-0.19	<0.0001
Slope	0.08	0.0057
Elevation	-0.18	<0.0001
Group size	0.27	<0.0001
% of group vigilant (transformed)	0.05	0.17

Table 2. Mean heart rates (HR) in beats/minute by slope class for a female bighorn sheep in Desert National Wildlife Refuge, Nevada, 1992.

	HR[a]				
	Slope class[b]				
Behavior	1	2	3	4	5
Bed					
$\bar{x}$	62.9ABC	65.8A	61.6B	54.9D	58.2CD
SD	3.1	2.8	7.7	3.1	5.2
n	11	34	70	11	35
Forage					
$\bar{x}$	77.4B	80.4AB	81.3B	85.6A	88.2A
SD	7.2	13.2	7.6	11.1	9.9
n	17	21	81	58	25

[a] Means with different letters differ ($P < 0.05$, Tukey HSD test) within behaviors.
[b] Slope class 1 = 0-10%, 2 = 11-35%, 3 = 35-60%, 4 = 60-80%, 5 = >80%.

not result in sheep being more vigilant. Nor was visibility different between random points and points used by bighorn sheep.

In the Mojave desert scrub, visibility is limited by topography (e.g., cliffs, boulders, steep slopes). In the enclosure, the only plants large enough to obstruct visibility were creosote bush (*Larrea* tridentata) and joshua trees (Yucca *brevifolia*). The type of topography that decreases visibility is the same type of terrain that comprises escape cover (Hansen 1980, Holl 1982). Therefore, avoidance of the areas of lowest visibility in this region would result in bighorn sheep being farther away from escape cover. Visibility was high in the enclosure compared to other habitats where visibility has been measured (i.e., K. L. Risenhoover, [Texas A&M Univ., pers. commun.] measured visibility in 7 habitats; 4 were <20%, 1 was <30%, and 2 >45%); it may not be as important to limiting bighorn sheep distribution within the enclosure.

MANAGEMENT IMPLICATIONS

Several authors have noted the importance of openness of terrain (Hansen 1980, Holl 1982, Risenhoover and Bailey 1985, Gionfriddo and Krausman 1986, Armentrout and Brigham 1988, Etchberger 1990). Attempted improvement of bighorn habitat through the reduction of visual obstructions has been achieved by clearing vegetation in Colorado (Risenhoover 1981) and burning vegetation in Arizona (deVos 1983, Etchberger 1990). However, in our enclosure other factors were more important in determining use of areas. Risenhoover and Bailey (1985) state that poor visibility resulted in the avoidance of habitats, but "once a threshold of visibility was exceeded, forage density became more important in determining habitat preference." Our entire study may lie above this threshold. This study area was representative of bighorn sheep habitats in the DNWR, a 6,000 km^2 refuge created in 1936 to preserve bighorn sheep and their habitats (Krausman et al. 1992). The vegetation association from DNWR not included within the study area was pinyon pine (*Pinus monophylla*) and juniper (Juniperus *osteosperma*). In this area and other higher-elevation bighorn sheep habitats that are dominated by trees and larger vegetation, visibility may be an important habitat feature. However, we did not demonstrate that the importance of visibility can be extrapolated to lower desert environments dominated by scrub vegetation.

LITERATURE CITED

Altmann, J. 1974. Observation study of behavior: sampling methods. Behaviour 49:227-267.

American Society of Mammalogists. 1987. Acceptable field methods in mammalogy: preliminary guidelines approved by the American Society of Mammalogists. Journal of Mammalogy 65 (4, Suppl.). 18pp.

Armentrout, D.J., and W.R. Brigham. 1988. Habitat suitability rating system for desert bighorn in the basin and range province. Bureau of Land Management Technical Note 384. 18pp.

Berger, J. 1978. Group size, foraging and anti-predator ploys: an analysis of bighorn sheep decisions. Behavioral Ecology and Sociobiology 4:91-100.

Berner, L.R. 1992. Habitat selection by mountain sheep in Mojave Desert Scrub. M.S. Thesis, University of Arizona, Tucson. 62pp.

Bradley, W.G. 1964. The vegetation of the Desert Game Range with special reference to desert bighorn. Desert Bighorn Council Transactions 8:43-67.

deVos, J.C., Jr. 1983. Desert bighorn sheep in the Pusch Ridge Wilderness Area. United States Department of Agriculture Forest Service, Contract No. R381151. 57pp.

Etchberger, R.C., P.R. Krausman, and R. Mazaika. 1990. Effects of fire on desert bighorn sheep habitat. Pages 53-57 in P.R. Krausman and N.S. Smith, eds. Managing wildlife in the southwest. Arizona Chapter of the Wildlife Society, Phoenix, Arizona

Geist, V. 1971. Mountain sheep: a study of behavior and evolution. University of Chicago Press, Chicago, Illinois. 383pp.

Gionfriddo, J.P., and P.R. Krausman. 1986. Summer habitat use by mountain sheep. Journal of Wildlife Management 50:331-336.

Graham, H. 1980. Impact of modem man. Pages 288-309 in G. Monson and L. Sumner, eds. The desert bighorn. University of Arizona Press, Tucson. 370pp.

Hansen, C.G. 1980. Habitat. Pages 320-335 in G. Monson and L. Sumner, eds. The desert bighorn. University of Ariina Press, Tucson. 370pp.

Holl, S.A. 1982. Evaluation of bighorn sheep habitat. Desert Bighorn Council Transactions 26:47-49.

Krausman, P.R., M.C. Wallace, M.J. Zine, L.R. Berner, C.L. Hayes, and D.W. DeYoung. 1993. The effects of low-altitude aircraft on mountain sheep heart rate and behavior. United States Air Force Technical Report AL/OE-TR-1993-0184. 134pp.

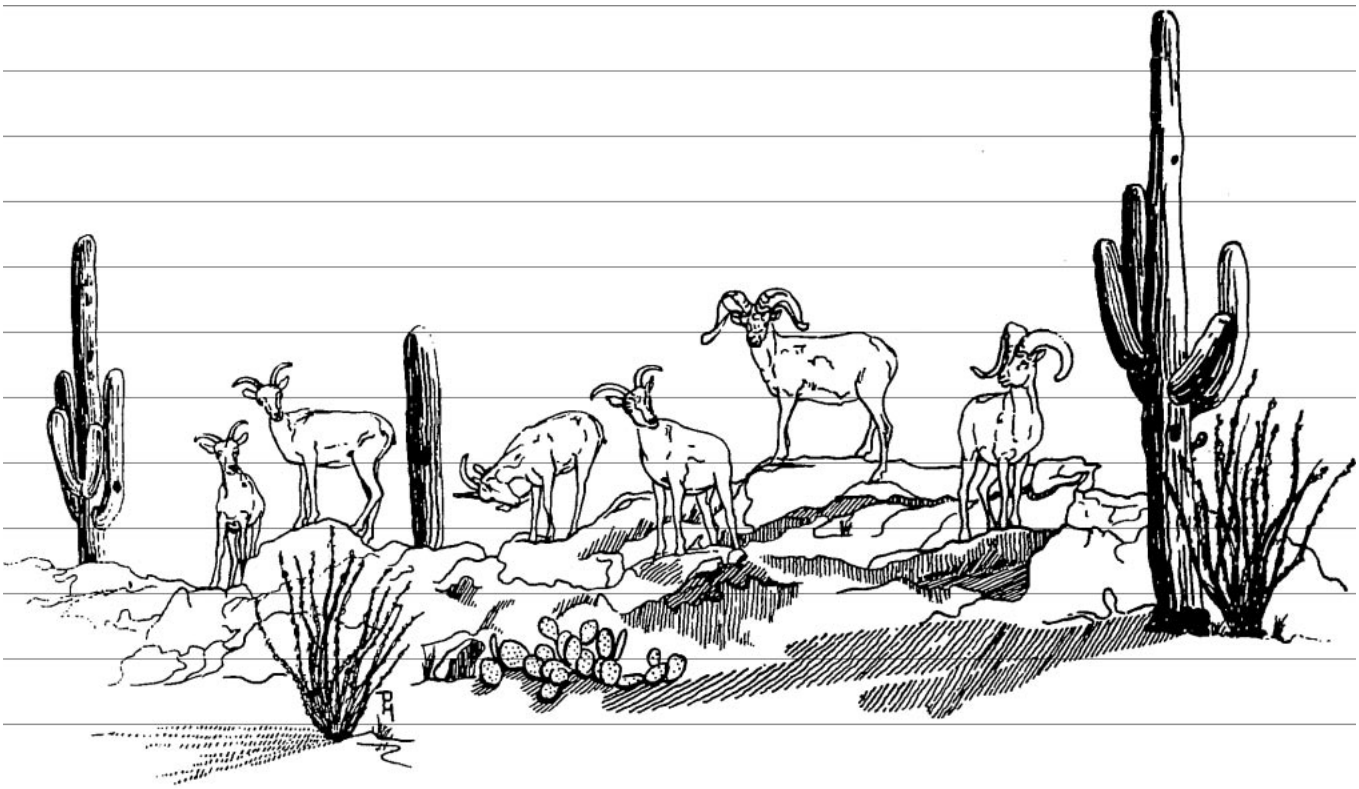
Kreeger, I.J., D. Monson, V.B. Kuechle, U.S. Seal, and J.R. Tester. 1989. Monitoring heart rate and body temperature in red foxes (*Vulpes vulpes*). Canadian Journal of Zoology 67:2455-2458.

MacArthur, R.A., R.H. Johnston, and V. Geist. 1979. Factors influencing heart rate in free-ranging bighorn sheep: a physiological approach to study wildlife harassment. Canadian Journal of Zoology 57:2010-2021.

Risenhoover, K.L. 1981. Winter ecology and behavior of bighorn sheep, Waterton Canyon, Colorado. M.S. Thesis, Colorado State University, Fort Collins. 124pp.

——, and J.A. Bailey. 1980. Visibility: an important habitat factor for an indigenous, low-elevation mountain herd in Colorado. Biennial Symposium of the Northern Wild Sheep and Goat Council 2:18-28.

——, and J.A. Bailey. 1985. Foraging ecology of mountain sheep: implications for habitat management. Journal of Wildlife Management 49:797-804.



A SECOND HELICOPTER SURVEY OF DESERT BIGHORN SHEEP IN SONORA, MEXICO

RAYMOND M. LEE, Arizona Game and Fish Department, 2221 West Greenway Road, Phoenix, AZ 85023

EDUARDO E. LOPEZ-SAAVEDRA, Centro Ecologico de Sonora, Apartado Postal No. 1497, Hermosillo, Sonora, Mexico 83000

Abstract: Using 16.3 hours of helicopter time, 17 mountain ranges in Sonora, Mexico were surveyed for desert bighorn sheep. A total of 132 groups was seen in 11 of the areas flown, resulting in 442 individual classifications. The ram:ewe:lamb:yearling ratios were 56:100:32:7. Observations per hour were 12.7 sheep per hour in the northern ranges; this rate increased to 42.7 sheep per hour in the inhabited ranges west and south of Caborca.

Desert Bighorn Council Transactions 38:12-13.

INTRODUCTION

Various efforts have been made to estimate the number of bighorn sheep in Sonora. Mendoza (1976) provided a population estimate of 935 animals. Prior to the present survey efforts it was felt that the Sonoran population probably did not exceed 1,000 animals, but it was not known whether the population might not be considerably below these estimates (unpublished report prepared for the Centro Ecologico de Sonora by C. Castillo, 1992). Helicopter surveys were initiated in Sonora in 1992 (Lee and Lopez-Saavedra 1993) and were continued this year to further evaluate the number and distribution of bighorn sheep in Sonora.

METHODS

Surveys were flown in the same manner and in the same helicopter as those in 1992 (Lee and Lopez-Saavedra 1993). Observers were provided by the Direccion General de Ecologia, the Centro Ecologico de Sonora, and the Subdelegacion Forestal y Fauna. Surveys were flown November 6 through November 10, 1993. Only the more rugged areas of each range were surveyed.

RESULTS AND DISCUSSION

The surveys resulted in the classification of 442 bighorn sheep with ram:ewe:lamb:yearling ratios of 56:100:32:7 (Table 1). Of the 17 ranges flown in 1993, 14 were different from those flown in 1992. A total of 365 of the 1993 observations were from areas not covered during 1992. This results in a two year total of 893 individual sheep observed, with desert bighorn sheep seen in 32 of the 42 ranges surveyed.

Observation rates varied considerably between the northern and southern mountain ranges. In the mountains north of Caborca, the mean observation rate was 12.7 animals per hour. In the mountains south of Caborca, the mean observation rate was 42.7 animals per hour. The 1992 surveys showed similar results with sheep per hour rates of 9.9 in the north and 37.3 in the south. By comparison, in Arizona in 1991 and 1992, average observation rates were 10.8 and 11.5 sheep per hour, respectively. This indicates the similarity between sheep population densities in Arizona and northern Sonora and shows the divergence which occurs in those ranges south of Caborca.

The combined classifications for both survey years results in ram:ewe:lamb:yearling ratios of 45:100:24:23. By comparison, Arizona's past 5 years ratios average 58:100:34:21. This may indicate the utilization of rams in Mexico at a rate which exceeds even that of the sport harvest program in Arizona.

Many sheep go unobserved during helicopter surveys (Miller et al. 1989). Recent survey work in Arizona indicates that 30-60% of the population is seen during a helicopter bighorn sheep survey (unpublished observations). Using these observation rates results in a population range between 1,488-2,977 animals for that portion of Sonora which has been surveyed. It should be noted that not all of the area of each mountain range and that not all of the sheep habitat in Sonora has been flown.

Table 1. Results of November 1993 helicopter survey of desert bighorn sheep in Sonora, Mexico

Mountain Range	Hours	Classification[a]	No. Sheep	No. Groups
1) Sierra Blanco	0.9	0-0-1-0-2-1-1-0	6	3
2) Sierra Pinacate	1.5	2-5-3-1-10-3-1-0	25	10
3) Sierra San Francisco	1.7	0-0-5-0-10-5-0-1	21	7
4) Sierra el Alamo	1.6	0-2-3-0-7-1-0-0	13	5
5) Cerro Basura	0.5	no observations	0	0
6) Sierra la Gloria	0.8	no observations	0	0
7) Cerro el Alamo	0.9	no observations	0	0
8) Sierra la Vibora	0.3	no observations	0	0
9) Sierra la Rajon	0.3	0-0-0-0-1-0-0-0	1	1
10) Sierra Santa Rosa	0.5	no observations	0	0
11) Sierra el Gavilan	0.2	no observations	0	0
12) Pico Johnson	1.0	1-1-2-2-24-9-1-0-4	44	14
13) Sierra Kun Kaak	2.9	8-16-30-14-123-34-3-4	232	63
14) Sierra Tiburon	0.8	0-0-1-0-4-0-1-0	6	3
15) Sierra Menor	1.0	2-6-9-2-24-9-3-0	55	11
16) Sierra los Lobos	0.2	1-0-0-0-2-1-0-0	4	3
17) Sierra los Mochos	0.9	0-1-5-1-17-8-1-0-3	34	12
Totals	16.3	14-31-59-20-224-71-11-5-7	442	132

[a]Classifications: Class I-II-III-IV Rams-Ewes-Lambs-Male Yearlings-Female Yearlings-Unclassified

LITERATURE CITED

Lee, R. and E. Lopez-Saavedra. 1993. Helicopter survey of desert bighorn sheep in Sonora, Mexico. Desert Bighorn Council Transactions 37:29-32.

Mendoza, J. 1976. The bighorn sheep of the state of Sonora. Desert Bighorn Council Transactions 20:25-26.

Miller, R., R. Remington, R. Lee, R. Van Den Berge and M. Haderlie. 1989. Efficiency of bighorn sheep helicopter surveys. Federal Aid Report W-53-M-39. Arizona Game and Fish Department, Phoenix, Arizona. 13 pp.

Remington, R. and G. Welsh. 1989. Surveying bighorn sheep. Pages 63-81 in R. Lee, ed. The desert bighorn sheep in Arizona. Arimna Game and Fish Department, Phoenix, Arizona. 265 pp.

COMMENTS AND STATUS REPORTS

A PRELIMINARY REPORT ON MOUNTAIN SHEEP ECOSYSTEM MANAGEMENT ON PUBLIC LANDS

DONALD J. ARMENTROUT, Bureau of Land Management, 6221 Box Springs Boulevard, Riverside, CA 92507

RAYMOND J. BOYD, Bureau of Land Management, Service Center, SC-210, Denver, CO 80225

Desert Bighorn Council Tmnsactions *38:14-15.*

In 1986 the Bureau of Land Management (BLM) published The *Rangewide* Plan for Managing Habitat of Desert Bighorn Sheep on Public Lands (United States Department of Interior 1986). This Rangewide Plan consolidated desert bighorn objectives from the BLM's district level into rangewide objectives. Desert bighorn were defined within three subspecies: *Ovis canadensis* nelsoni, O. c. *cremnobates*, and 0. c. *mexicana*.

In 1991, the BLM reviewed The Rangewide Plan. This review indicated that though many information needs identified in 1986 were being met, some of the original objectives were inconsistent with the ecosystem and metapopulation mandates. Also, 3 other species or subspecies of mountain sheep were not included as required by the BLM's Fish and Wildlife 2000 Strategy. Because of these deficiencies, the BLM began developing a plan for mountain sheep ecosystem management on public lands that will include 4 species or subspecies found on public lands: desert bighorn sheep (all are considered as *O.* c. nelsoni in the new plan), Dall sheep (*Ovis* dalli dalli), Rocky Mountain bighorn sheep (*O.* c. *canadensis*), and California bighorn sheep (*O.* c. *californiana*). To determine current mountain sheep distribution, population levels, and management needs, a questionnaire was developed (available on request from authors) and sent to each Fish and Game agency and each BLM office where at least 1 of the 4 subspecies of mountain sheep occur. The questionnaire emphasized an ecosystem approach by asking questions such as total habitat in a biological unit irrespective of land ownership and overall population. To date, the BLM has had a 95 percent response. Results of the questionnaire will be provided to each member of the Interagency Plan Development Committee who will draft The Mountain Sheep Ecosystem Management Plan.

An estimated 17,500,000 acres (7,082,250 ha) of desert bighorn habitat occur in 6 western states, of which BLM administers 65%. Approximately 13,143,000 acres (5,319,000 ha) are currently occupied, and 1,532,000 acres (620,000 ha) of suitable habitat are unoccupied. An estimated 2,826,000 acres (1,143,680 ha) of historic habitat (16% of the total habitat) are no longer suitable for desert sheep. All but an estimated 100,000 acres (40,470 ha) may be recoverable by actions such as removing domestic sheep. The exact amount of habitat recoverable and actions required will be determined under implementation of the plan.

The Rangewide Plan estimated 10,000 desert bighorn sheep in 1985. Estimates for 1993 yielded a median of 12,858 with a projected median population by the year 2000 of 17,623 animals with a potential carrying capacity for a median population of 43,195.

Baseline soil and vegetation inventories have been completed on 6,850,000 acres (2,772,195 ha) with 4,373,000 acres (1,769,753 ha) still to be inventoried. A projected $1,743,190 is needed to complete these inventories by the year 2000. Vegetation trend monitoring has been established on 2,256,000 acres (913,000 ha) with 8,343,000 acres (3,376,412 ha) remaining to be put into a monitoring system. The estimated cost per year for the increased monitoring effort is $644,000.

Between 1985 and 1993, the BLM spent $4,049,-855 completing enhancement projects. Maintenance costs for existing projects includes $3,127,445 for 401 water developments, $160,000 for 5,000 acres

(2,024 ha) of vegetation manipulation, and $18,000 for 12 livestock exclosures. New projects needed include 228 water developments at a projected cost of $2,113,783, 44,920 acres (18,179 ha) of vegetation manipulation for $811,041, and 9 additional livestock exclosures at a cost of $9,000. Only 3 of 90 respondents reported that they had completely implemented activity plans. An activity plan is written for a specific habitat area and defines specific actions to be taken to manage the habitat.

To facilitate effective ecosystem management, land exchanges and acquisitions are needed for 387 parcels or 1,316,955 acres (532,972 ha) at an estimated cost of $15,403,805. Easements for access to mountain sheep habitat are needed for 48 areas covering 824 miles (1,326 km) of access at an estimated cost of $880,000.

Information needs identified in The Rangewide Plan (e.g., disease and genetics, nutritional requirements, impacts of feral and domestic livestock, habitat evaluation techniques, and habitat improvement techniques) are still being identified. Some progress has been made in genetic analysis which indicates there is 1 subspecies of desert bighorn sheep (Ramey 1991). Impacts of domestic sheep have been addressed by BLM guidelines that recommend separation between bighorn and domestic sheep (USDI 1992).

Discussions such as those during the Desert Bighorn Council 1992 Annual Meeting (Krausman et al. 1992) and within the Interagency Plan Development Committee indicate that if the BLM is to move forward into ecosystem and metapopulation management our definition of viable populations must be adjusted. The Rangewide Plan defined a viable population as having 100 $\pm$ 20 individuals and being self-sustaining with minimal demographic or genetic intervention over the long term. For the current effort the definition is: "viable populations or metapopulations are those having a 99% probability of surviving for a time of persistence of approximately **30** years despite the foreseeable effects of demographic, environmental and genetic events and natural catastrophes" (Marcot and Murphy 1992).

To successfully implement metapopulation and ecosystem management in The Mountain Sheep Ecosystem Management plan wildlife biologists, land managers, and agencies involved in wild sheep management must integrate the three "C"s of wildlife management in their work. *Consultation* is required when dealing with threatened and endangered species issues to insure that what we do in one part of an ecosystem does not negatively impact another part. *Coordination* must extend beyond single projects, plans, or studies to insure effective long-term management. *Coopemtion* is making all the pieces of the puzzle come together through team effort. Practicing the three "C"s will facilitate the implementation of this and other plans to benefit desert bighorn sheep.

LITERATURE CITED

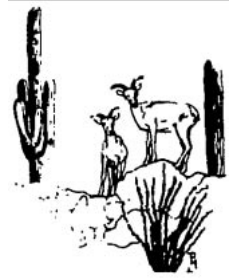
Krausman, P.R., J. Bailey, V. Bleich, D. Armentrout and R.R. Ramey. 1992. Panel: what is minimum viable population size? Desert Bighorn Council Transactions 36:68-74.

Marcot, B.G. and D.D. Murphy. 1992. Population viability analysis and management. Transactions of the Conference on Biodiversity in Managed Landscapes: Theory and Practice. July, 1992 (In press).

Ramey, R. R. II. 1991. Genetics and conservation of North American mountain sheep: Implications for management on BLM lands. Report to the Bureau of Land Management Service Center, Denver Federal Center, Building 50, Denver, Colorado. 25pp.

USDI, Bureau of Land Management. 1986. Rangewide plan for managing habitat of desert bighorn sheep on public lands. Washington, D.C. 41pp.

------, 1992. Guidelines for domestic sheep management in bighorn sheep habitats. Instruction Memorandum No. 92-239. Bureau of Land Management. Washington, D.C. 4pp.



STATUS OF BIGHORN SHEEP IN ARIZONA, 1993

RAYMOND M. LEE, Arizona Game and Fish Department, 2221 West Greenway Road, Phoenix, AZ 85023

Desert Bighorn Council Transactions *38:16-17.*

POPULATIONS

Estimates of Arizona's desert bighorn sheep (*Ovis* canadensis *mexicana* and O. *c. nelsoni*) indicate a growing population of approximately 6,000 animals. The 1993 desert bighorn sheep helicopter surveys produced 1,995 observations in 231 hours (8.6 sheep/hour). Survey results yield ratios of 66 rams: 100 ewes: 25 lambs: 15 yearlings.

The Rocky Mountain bighorn sheep (*O.* c. canadensis) population, estimated at 500 animals, continues to expand both in numbers and range. This population was supplemented with 21 animals from Colorado this winter. The 22.4 hours of helicopter surveys resulted in a record observation of 351 animals. These survey results produce ratios of 53 rams: 100 ewes: 49 lambs: 14 yearlings.

Since 1980, a mean of 74 sheep have been transplanted annually, with a mean of fewer than 2 mortalities. In 1993, 96 bighorn sheep were successfully captured and transplanted to 5 release sites. These transplant efforts included a desert bighorn for Rocky Mountain bighorn trade with Colorado.

RESEARCH

The Arizona Game and Fish Department (AGFD) is currently involved in several sheep research and management projects. These include survey methodology and efficiency tests, movement and mortality studies with Rocky Mountain sheep, development of a bighorn sheep management program for Sonora, Mexico, and development of an inter-state bighorn sheep management complex between Arizona and Utah.

HABITAT IMPROVEMENTS

The AGFD, primarily in cooperation with the Bureau of Land Management and the Arizona Desert Bighorn Sheep Society (ADBSS), develops about 10 bighorn sheep waters annually. These water projects may vary from simple tinaja modifications to extensive artificial water collection and storage systems. The AGFD tries to develop the most cost effective, environmentally sensitive, maintenance free waters possible - a very difficult task.

HARVEST

Bighorn sheep permits remain the most sought after hunting permits in Arizona. There was a record total of 4,946 applicants (3,763 resident and 1,183 non-resident applicants) for the 97 regular season permits. This represents nearly 51 hunters applying for each permit, with individual unit odds varying from as low as 12:1 to 326:1, depending on the unit's accessibility and harvest history.

As a result of this year's survey, permits for the 1994 season were increased from 97 to a record 110. Two additional permits will again be issued to raise funds for bighorn sheep management programs. Aravaipa Canyon, after several years with no permits, will be increased to 2 permits. Game management units 16A, 28, and 32 will be opened to desert bighorn sheep hunting for the first time in 1994. All 3 of these units have populations which were transplanted in the 1980's. This brings the total number of units being hunted in Arizona with transplanted populations to 12, with 26 permits being offered.

During the 1993 hunting season, all 99 hunters participated, harvesting 92 rams for a 93% success rate. The 1993 season produced 37 animals (40% of the harvest) qualifying for the Arizona Trophy Book (min. score of 162 Boone and Crockett points). Of these rams, 17 (18%) scored >170 points, with 7 scoring above 180 points. During the last 5 years, these trophy harvest percentages have averaged 38% and 19%, respectively. The average age of the harvested animals was 7.3 years.

For 10 years, the AGFD and the ADBSS have entered into an agreement whereby the ADBSS auctions 1 permit (at the Foundation for North American Wild Sheep convention) and raffles another to raise funds for bighorn sheep management projects. Since the program started in 1984, $1,509,860 has been raised from the 20 permits ($743,000 from the auction tags and $766,860 from the raffle tags). In 1993, the 2 special permits produced over $400,000; including a record auction bid of $303,000. In 1994, the auction permit was

sold for $243,000. The success of Arizona's bighorn sheep management program is dependent upon the funds derived from these permits.

STATUS OF BIGHORN SHEEP IN CALIFORNIA, 1993

STEVEN G. TORRES, California Department of Fish and Game, 1416 Ninth Street, Sacramento, CA 95814

VERNON C. BLEICH, California Department of Fish and Game, 407 West Line Street, Bishop, CA 93514

JOHN D. WEHAUSEN, White Mountain Research Station, 3000 East Line Street, Bishop, CA 93514

Desert Bighorn Council Transactions 38:17-28.

POPULATIONS

The California Department of Fish and Game's (CDFG) Mountain Sheep Management Program maintains an inventory of the distribution of bighorn sheep in California. This assessment of bighorn sheep populations has been conducted as part of a long-term management plan for mountain sheep in California, and is intended to update previously published inventories by Wehausen et al. (1987) and Weaver (1989). The current and historical distribution of bighorn sheep in California is detailed on Fig. 1. This map was prepared by transferring all published accounts of bighorn sheep to a United States Geological Survey (1:1,000,000 scale) map. The distribution information was then digitally transferred to a Geographic Information System (GIS) database where county and highway boundaries were referenced. The areas or polygons highlighted on the map follow topographic features of the mountain masses and define known areas used by bighorn sheep. In some cases, these areas may represent more than one population with varying degrees of interchange or isolation. U.S. Highway 395 and Interstate Highways 10, 15, and 40 are illustrated on the map and separate most of the referenced metapopulations. A detailed inventory of these population polygons is provided in Table 1. This data will be modified as updated survey and historical accounts are received. Specific references that document the historical distribution can be found in Wehausen et al. (1987).

We have grouped the populations of bighorn sheep in California into metapopulations, or systems of populations (Hanski and Gilpin 1991), that best represent logical regions for managing for the long-term viability of this species (see Fig. 2, Table 1). This regional approach recognizes the importance of inter-mountain areas that allow movement and exchange of individuals between populations, the recolonization of vacant habitats, and the interagency coordination of land management (Bleich et al. 1990). Indeed, Bailey (1994) emphasized the importance of large scale management of bighorn sheep populations, defined by ecotypes, throughout North America. Our definition of regional populations considers not only vegetative and geographic boundaries, but also man-made barriers that define distributions and which have resulted in the fragmentation of habitat.

Although a metapopulation approach is an important biological principle for management and long-term survival of bighorn sheep populations, it is equally important as a management concept that prioritizes regional coordination for bighorn sheep population and habitat management. For example, data regarding extinction and recolonization are limited, and we therefore have incomplete biological justification for considering some regions as true metapopulations as defined by Levins (1970). Nevertheless, given the need for regional management of bighorn sheep populations, we have defined the metapopulations based on our best understanding of the regions. Several investigations have postulated the importance of population size and genetic diversity to the long-term viability of bighorn sheep populations (Berger 1990, Schwartz et al. 1988). Although population size is an important parameter, the maintenance of genetic diversity and the ability to recolonize vacant areas are equally important.

Given the need to understand the status and dynamics of regional populations of bighorn sheep, we have categorized the populations by size class

Table 1. Extant and extirpated populations of bighorn sheep in California (1994).

METAPOPULATION	POPULATION	POPULATION STATUS	POPULATION SIZE CLASS
Peninsular Ranges	Pinto/Inkopah (S. of I-8)	N	<25
	Jacumba/Inkopah	N	25-50
	Laguna	E	0
	Tierra Blanca	E	0
	Fish Creek	E	0
	Vallecito	N	25-50
	N. Anza Borrego	N	151-200
	Santa Rosa	N	101-150
	San Jacinto	N	25-50
San Gabriel	San Gabriel	N	>300 (400-600)
Western Transverse Range	San Rafael	R	25-50
	Caliente Pk.	E	0
Sonoran	Chocolate (Gunnery)	N	151-200
	Chocolate (Colorado R.)	N	151-200
	Orocopia/Mecca Hills	N	101-150
	Chuckwalla	A	25-50
	Cargo Muchacho	E	0
	Palo Verde	E	0
South Mojave	Newberry	N	25-50
	Ord	E	<25
	Rodman	E	0
	Bullion	R	<25
	Sheephole	A	51-100
	San Gorgonio	N	101-150
	N. San Bernardino	N	<25
	Little San Bernardino	N	101-150
	Queen	N	25-50
	Pinto	E	0
	Eagle	N	51-100
	Coxcomb	N	<25
	Granite/Palen	N	<25
	McCoy	E	0
	Little Maria	E	0
	Big Maria	E	0
	Riverside	E	0
	Iron	E	0
	Turtle	N	101-150
	Whipple	R	51-100

METAPOPULATION	POPULATION	POPULATION STATUS	POPULATION SIZE CLASS
	Old Woman	N	51-100
	Chernehuevi	N	<25
	Sacramento	N	<25
	Clipper	N	25-50
	Marble	N	101-150
Central Mojave	Cady	N	25-50
	North Bristol	R	25-50
	Old Dad/Kelso/Marl	N	201-300
	Granite	N	<25
	Providence	N	25-50
	Wood/Hackberry	N	51-100
	New York	N	<25
	Castle/Hart/Piute	N	<25
	Dead	N	25-50
Central North Mojave	Clark	N	101-150
	Kingston/Mesquite	N	101-150
	Nopah	N	51-100
	Soda	E	0
	Avawatz	N	25-50
North Mojave	Granite/Quail	E	0
	Owlshead	E	0
	Black	N	51-100
	Funeral	N	25-50
	Grapevine	N	25-50
	Eagle Crags	R	<25
	Argus/Slate	R	51-100
	Coso	E	0
	S. Panamint	N	101-150
	Tucki	N	25-50
	Panamint Butte/Hunter	N	51-100
	Tin	N	51-100
	Dry Mountain/Last Chance	N	51-100
	Inyo	N	51-100
	Deep Springs	E	0
	N. White	N	201-300
	S. White	R	<25
Very Southern Sierra Nevada	Cache Pk.	E	0
	Chimney Pk.	E	0
Southern Sierra Nevada	Great Western Divide	E	0

METAPOPULATION	POPULATION	POPULATION STATUS	POPULATION SIZE CLASS
	Olancha Pk.	E	0
	Mt. Langley	R	51-100
	Mt. Williamson	N	25-50
	Mt. Baxter	N	101-150
	Taboose	E	0
	Mt. Tom	E	0
	Wheeler Ridge	R	25-50
Central Sierra Nevada	Convict/McGee Cr.	E	0
	Lee Vining/Bloody	R	51-100
	Sonora Pass	E	0
	Sweetwater	E	0
Northeastern California	Truckee River	E	0
	Skedaddle/Smoke Cr.	E	0
	Warner	E	0
	Lava Beds/Mt. Dome	E	0
	Mt. Shasta	E	0
	Goosenest	E	0
	Bogus	E	0

N = native A = augmented R = reintroduced E = extirpated

Table 2. Bighorn sheep population size class profile and summary by metapopulation (1994).

Metapopulation	0	<25	25-50	51-100	101-150	151-200	201-300	>300
Peninsular Ranges	3	0	3	0	1	1	0	0
San Gabriel	0	0	0	0	0	0	0	1
Western Transverse Range	1	1	0	0	0	0	0	0
Sonoran	2	0	1	0	1	2	0	0
South Mojave	7	7	3	4	4	0	0	0
Central Mojave	0	3	4	1	0	0	1	0
Central North Mojave	1	1	0	1	2	0	0	0
North Mojave	4	2	3	6	1	0	1	0
Very Southern Sierra	2	0	0	0	0	0	0	0
Southern Sierra Nevada	4	0	2	1	1	0	0	0
Central Sierra Nevada	3	0	0	1	0	0	0	0
Northeastern California	7	0	0	0	0	0	0	0
Total	34	14	16	14	10	3	2	1

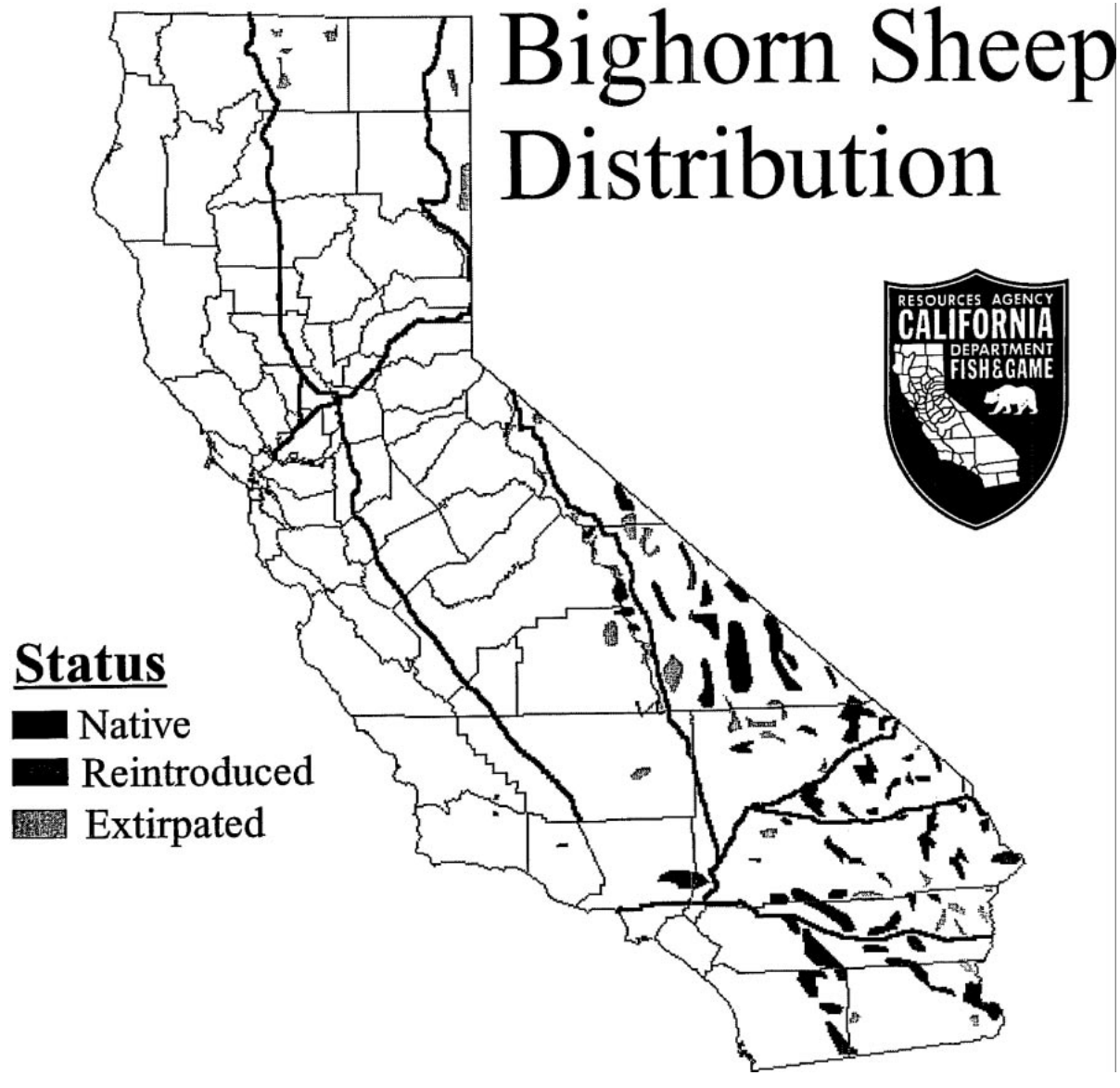


Figure 1. Current and historical distribution of bighorn sheep populations in California.

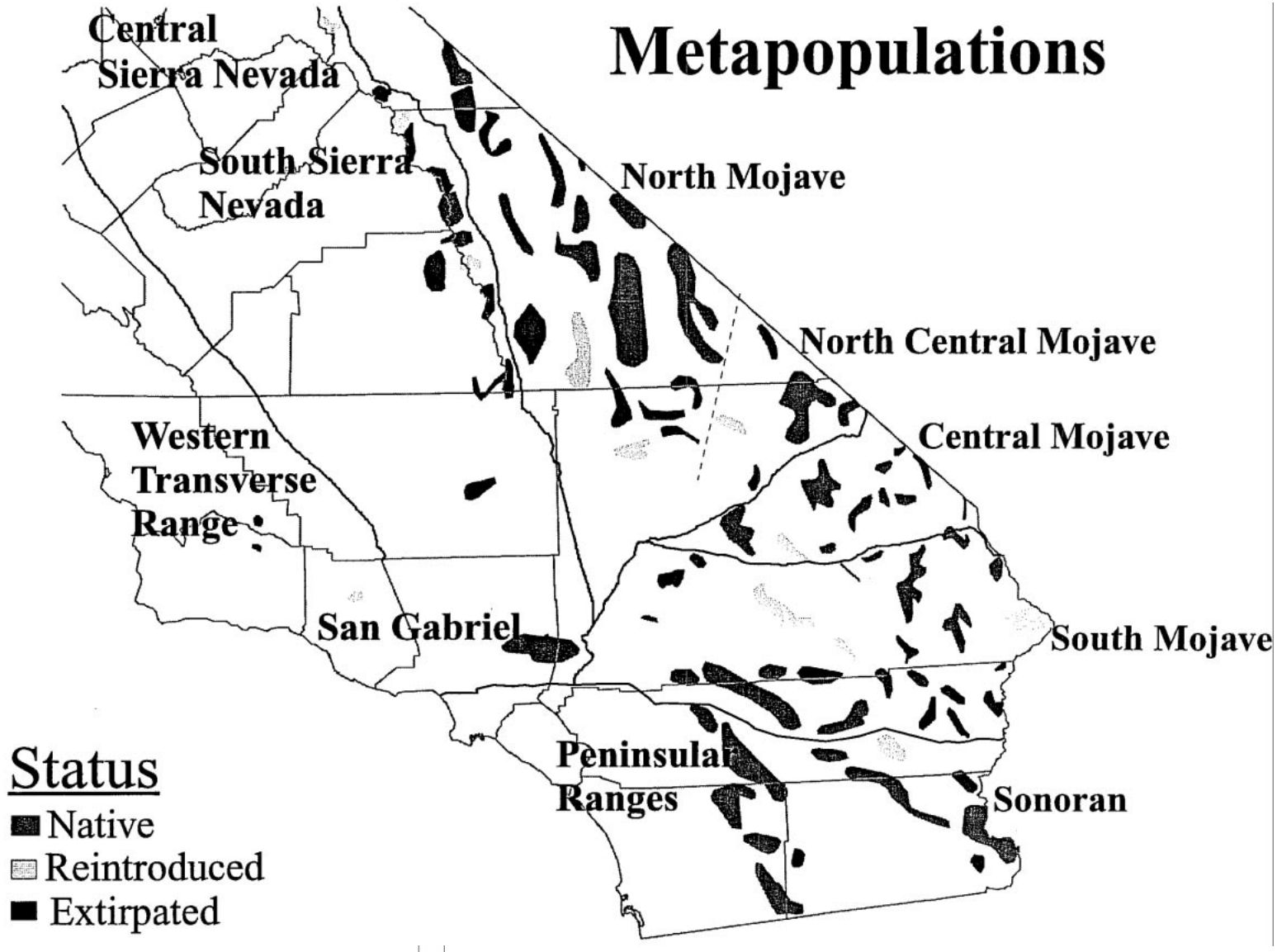


Figure 2. Current and historical distribution of bighorn sheep metapopulations in California.

(Table 1). We utilized historical and current data from ground, waterhole, and aerial surveys to categorize these populations. Although the population estimates are of varying precision, we believe the size classes are large enough to provide an accurate and conservative assessment. Our defined metapopulations are summarized by size classes in Table 2, and population estimates are subsequently computed by totaling the high, low, and median interval estimates (Table 3). This type of inventory should provide an index for documenting regional population changes over time, and help evaluate the success or failure of management actions at a meaningful level. Further, this approach may help identify the 'missing pieces of the puzzle' for optimizing future reintroduction and management efforts to ensure population viability.

Although the traditionally defined subspecies are questionable (Ramey 1993, Wehausen and Ramey 1993), CDFG traditionally has reported the population estimates for Nelson (Ovis canadensis *nelsoni*), Peninsular (*O.* c. cremnobates), and California (*O.* c. *californiana*) bighorn sheep, because the latter 2 of these remain State listed as Threatened (Table 4). The population estimate for Peninsular bighorn simply corresponds with the Peninsular Ranges metapopulation total, while that for California bighorn is for the Sierra Nevada. The total statewide estimate of bighorn sheep is approximately 4,633 animals, consisting of 3,854 Nelson, 426 Peninsular, and 353 California bighorn sheep. All populations of Nelson bighorn, with the exception of those found in areas open to hunting, are fully protected by state law.

RESEARCH

The CDFG continues to cooperate with several universities and agencies in support of bighorn sheep research and management in California. The CDFG conducted several bighorn sheep capture, sample, and survey efforts in 1993. These efforts occurred as part of ongoing research on bighorn populations in: Lee Vining Canyon (Mono County); Old Dad/Kelso Peak, Granite, Marble, Clark, and Old Woman Mountains (San Bernardino County); Kingston Mountains (Inyo County); Eagle, San Jacinto, and San Bernardino Mountains (Riverside County); Santa Rosa Mountains and Anza Borrego Desert State Park (Riverside and San Diego Counties); San Gabriel Mountains (Los Angeles County); and East Chocolate Mountains (Imperial County).

Additionally, the focus of some of the 1993 survey efforts was to assess past bighorn reintroduction and augmentation projects in the following mountain ranges: Lee Vining Canyon (Mono County); Argus Mountains (Inyo County); Avawatz Mountains and Eagle Crags (San Bernardino County); and San Rafael Peak/Cobblestone Mountain (Ventura County). Preliminary assessment of these surveys indicate that the population restoration projects in Lee Vining Canyon, Argus, and Avawatz Mountains appear successful. However, the Eagle Crags and San Rafael Peak/Cobblestone Mountain survey results do not indicate successful population establishment, with less than 25 individuals estimated in each herd. Further analysis of these past CDFG reintroduction projects is warranted.

Field work emphasizing the demography and habitat-use of bighorn sheep in the East Chocolate Mountains (Imperial County) was completed in 1993. Andrews (1994) has prepared a detailed report summarizing these data and provides recommendations for continued monitoring, removal of individuals for translocation projects and recreational harvest, and habitat management. This study was in cooperation with the University of Rhode Island.

A study of the demography, distribution, and movements of bighorn sheep in the Kingston and Clark Mountain Ranges (San Bernardino and Inyo Counties) has been completed and a preliminary report regarding the demography has been prepared (Jaeger and Wehausen 1993). A more complete report is pending. This study is in cooperation with the University of Nevada, Las Vegas.

The Peninsular Bighorn Sheep Population Health and Demography Study completed the planned capture efforts in 1993, and monitoring is planned to continue for the next 3 years. To date, 100 bighorn sheep have been captured, sampled, and fitted with radio collars. The distribution of collars includes: 22 (2 M, 20 F) in Carrizo Canyon; 22 (3 M, 19 F) in Palm/Tubb Canyon; 10 (1 M, 9 F) in Coyote Canyon; 13 (3 M, 10 F) in the Vallecito Mountains; and 33 (8 M, 25 F) in the Santa Rosa Mountains. Data assessing population size, recruitment, cause-specific mortality, and distribution are now being provided from areas throughout the Peninsular Ranges. This study is contracted with the University of California, Davis, in cooperation with the California Department of Parks and Recreation (CDPR).

In 1993, the CDFG Bighorn Sheep Management Program funded a study to address the spatial relationships between habitat and behavior of bighorn sheep in the Peninsular Ranges. This

Table 3. Bighont sheep population estimates by metapopulation (1994).

Metapopulation	Low	Median	High
Peninsular Ranges	327	426	524
San Gabriel	400	500	600
Western Tranverse Range	1	13	24
Sonoran	426	514	600
South Mojave	690	1006	1318
Central Mojave	355	514	672
Central North Mojave	254	340	424
North Mojave	685	967	1248
Southern Sierra Nevada	202	277	350
Central Sierra Nevada	51	76	100
Total	3391	4633	5860

Table 4. Bighorn sheep population estimates by subspecies (1994).

Subspecies	Low	Median	High
Peninsular	327	426	524
California	253	353	450
Nelson	2811	3854	4886
Total	3391	4633	5860

Table 5. Summary of Nelson bighorn sheep tag allocations, harvest, applications, and revenue from 1987-1994 in California.

Year	# Tags Allocated	# Rams Harvested	#Applicants	Fund-raising Revenue	Application & License Revenue	Revenue Total
1987	9	9	4,066	$ 70,000.00	$ 21,930.00	$ 91,930.00
1988	9	7	3,385	$ 59,000.00	$ 18,525.00	$ 77,525.00
1989	9	9	3,185	$ 40,000.00	$ 17,525.00	$ 57,525.00
1990	6	6	2,591	$ 37,000.00	$ 13,955.00	$ 50,955.00
1991	8	7	2,834	$ 42,000.00	$ 15,570.00	$ 57,570.00
1992	12	12	3,798	$ 61,000.00	$ 22,464.50	$ 83,464.50
1993	11	9	4,318	$100,000.00	$ 25,082.00	$125,082.00
1994	14	-	4,692	$162,000.00	$ 28,422.00	$190,422.00
Totals	78	59	-	$571,000.00	$163,473.50	$734,473.50

research is in collaboration with the Anza Borrego project, and will provide a detailed analysis of the relationship between habitat and the distribution of bighorn sheep. This project is contracted with the University of California, Riverside, Geography Program.

Long-term demographic studies continue in 8 Mojave Desert and Sierra Nevada populations through a contract with the University of California, Los Angeles, White Mountain Research Station. In addition to continued research focusing on demography and distribution of these bighorn sheep populations, analyses evaluating the efficiency of helicopter surveys also are being prepared. This collaboration will also continue research on bighorn morphometrics and future population modeling.

Monitoring of the bighorn sheep population in the Eagle Mountains was initiated in 1993. This effort is in response to a landfill project, approved in 1992 by the Riverside County Board of Supervisors, that may impact the distribution of Nelson bighorn sheep by altering existing water sources. The monitoring program will be continued for 5 years in cooperation with the University of Nevada, Las Vegas.

The annual San Gabriel Mountains Nelson bighorn sheep aerial survey was not conducted in 1993. Problems with locating bighorn sheep from the ground monitoring effort have forced CDFG to reevaluate the current survey program. Historical survey data are being reviewed, and new observation posts are being evaluated to improve the resulting population estimate. Future survey work will be in cooperation with the United States Forest Service (USFS), Society for the Conservation of Bighorn Sheep (SCBS), and local conservationists.

A study prospectus for a monitoring program of bighorn sheep in the southeastern San Bernardino Mountains has been prepared, and the capture, sampling and radio-collaring of bighorn sheep was initiated in 1993. The primary objective for this monitoring effort includes establishing baseline demographic and distributional data for this population. Future research will emphasize hypotheses that help address future management options such as the removal of individuals for translocation projects and recreational harvest, and habitat management.

In summary, 117 bighorn sheep were captured and sampled for CDFG research and monitoring projects in 1993. Fifty-nine Nelson bighorn sheep (38 female, 21 male) in 5 populations, and 57 bighorn sheep (46 females, 11 males) in the Peninsular Ranges were captured and sampled for CDFG-funded health and demographic studies. One California bighorn ewe was captured and sampled in April, 1993 from the Lee Vining population in the Sierra Nevada.

HABITAT IMPROVEMENTS

The CDFG, in cooperation with volunteers from the Volunteer Desert Water and Wildlife Survey (VDWWS), constructed 1 artificial catchment to benefit bighorn sheep in the Little San Bernardino Mountains of Riverside County. In addition, 162 maintenance inspections were made on bighorn sheep guzzlers and springs. Members of the VDWWS contributed 4,750 hours of labor and 126,790 vehicle kilometers to the CDFG while accomplishing these tasks. The CDFG Region 5 habitat development crew additionally contributed 3,500 hours and 40,260 vehicle kilometers toward bighorn sheep projects. All development and maintenance work occurred cooperatively with the Bureau of Land Management (BLM).

HARVEST (1987-1994)

Since bighorn sheep hunting was authorized by the California Legislature in 1987, 7 hunting seasons have been held (Table 5). To date, the total allocation of 64 tags has resulted in the harvest of 59 adult rams within the 3 hunt zones (Marble Mountains, Old Dad/Kelso Peak, and Clark/Kingston Mountains, Fig. 3) for an overall success rate of 92.2%. Animals shot during annual hunts have ranged from 4 to ≥13 years of age, and 18 (31%) have qualified for the Boone and Crockett Records Book based on their "green" scores. Hunters in 1993194 did not experience any disruptions from protesters.

For the fifth consecutive year, the CDFG prepared an environmental document that detailed the anticipated environmental effects of hunting bighorn sheep. This document, through the State Resources Secretary, is intended to comply with the mandates of the California Environmental Quality Act. In the 1994 document the CDFG proposed to add a new hunt zone in the East Chocolate Mountains (Zone 4), and to issue 14 tags for the 1994195 hunting season as follows: 2 at the Marble Mountains (Zone 1), 4 at the Old Dad/Kelso Mountains (Zone 2), 3 at the Clark/Kingston Mountain Ranges (Zone 3), 3 at the East Chocolate Mountains (Zone 4), 1 open-zone fund-raising tag that is valid in any hunt zone, and 1 East Chocolate Mountains fund-raising tag. State law limits the number of tags issued to

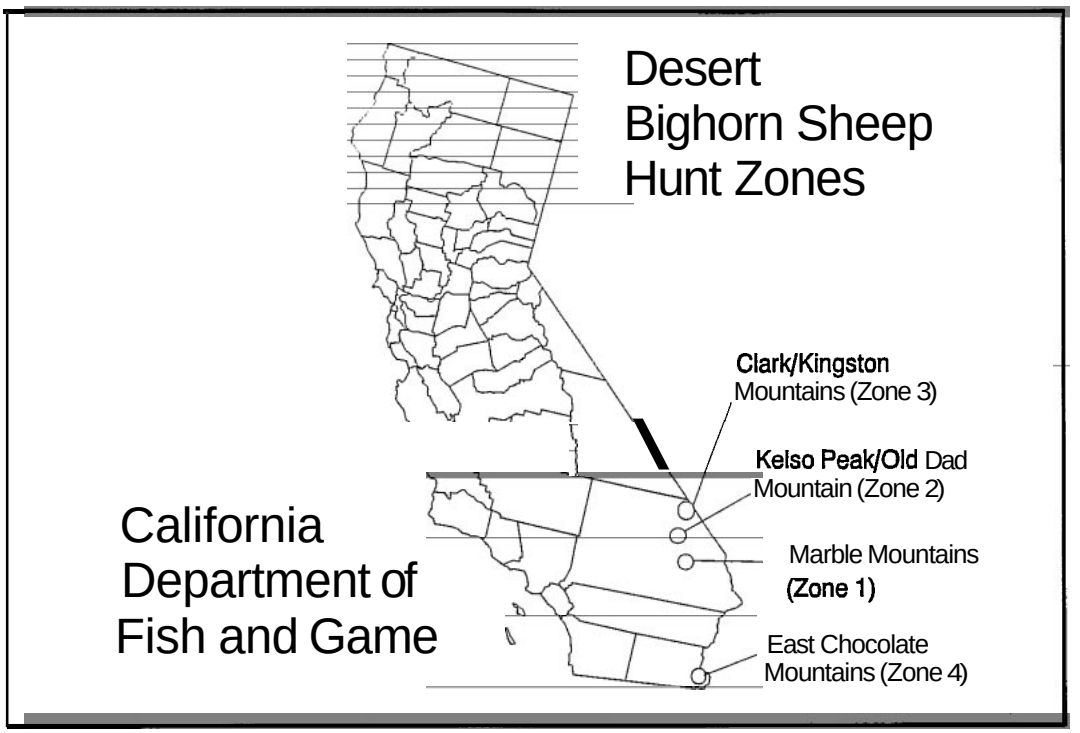


Figure 3. Locations of **1994** Nelson Bighorn Sheep Hunt Zones.

≤15% of the mature rams (1 2 years) estimated in each hunt zone during annual CDFG surveys. For hunting purposes, legal rams are those possessing ≥¾ curl. State law also limits the number of fund-raising tags to ≤15% of the total number of allocated tags.

The open-zone fund-raising tag sold for $110,000 at the February 1994 convention of the Foundation for North American Wild Sheep, an increase of $10,000 (10%) over the price paid for the 1993 auction tag (Table 5). The East Chocolate Mountains fund-raising tag sold for $52,000 at the March 1994 banquet of the Golden Gate Chapter of the Rocky Mountain Elk Foundation. Total fund-raising revenue for 1994 was $162,000. State law requires that these funds be dedicated solely to the management of bighorn sheep.

Torres et al. (1993) reported their analysis of hunter harvest of bighorn sheep in California. These authors suggested that consideration of hunter effort may further enhance the usefulness of the ram score and age harvest data as an additional management tool for interpreting demographic changes over time. Although our additional analyses revealed that hunter effort was similar between hunt zones, it was also extremely variable (coefficient of variation = 53 & 80% in hunt zones 1 and 2, respectively). Accordingly, our Boone and Crockett "green score" per day hunted (Score/hunter days) were also highly variable. Therefore, no statistical tests comparing effort or score/effort measures between hunt zones were statistically significant ($P<.05$), and all had low statistical power to detect any true differences. In summary, hunter effort and successful ram harvest represents an event that is probably influenced by a wide variety of interacting factors. These factors include hunter skill, physical ability, selectiveness, number in hunting party, and presence or absence of guide service.

PROBLEMS/OPPORTUNITIES

The CDFG continues to review and respond to legislation (California Desert Protection Act, S. 21) that would designate lands in the California Desert as wilderness, and would establish Death Valley, Joshua Tree, and East Mojave National Parks.

Various amendments to this legislation continue to be proposed in both the House of Representatives and Senate. Proposals to amend this legislation to provide for access, maintenance and implementation of habitat projects, and the continuance of hunting, remain undecided.

The Sierra Nevada Bighorn Sheep Interagency Advisory Group (SNBSIAG) held its annual meeting at Lee Vining in October, 1993. Participating agencies included the CDFG, National Park Service (NPS), BLM, USFS, and the University of California. Primary topics emphasized the need for updated distribution and demographic data for all populations of Sierra Nevada bighorn sheep. A population monitoring effort in Lee Vining Canyon reported that this herd has increased to at least 80-90 animals. However, a report of the Sand Mountain herd (Mt. Baxter) indicates a potential population decline or shift in range-use.

The CDFG Bighorn Sheep Program continues to participate in regional habitat management planning for the 4 southeastern California metapopulations of Nelson bighorn sheep. However, this planning process is being complicated and delayed pending legislation (S. 21) that may dramatically change land management authority and responsibilities among federal agencies. These regional cooperative management efforts to ensure the health of bighorn sheep metapopulations remain a high priority for the CDFG. The CDFG is proposing a regional inventory program to evaluate the population status of the bighorn sheep populations/subpopulations within the Sonoran metapopulation (Riverside and Imperial Counties). This survey and inventory effort will include participation from the CDFG, BLM, Department of Defense (Chocolate Mountains Aerial Gunnery Range), CDPR (Picacho State Recreation Area), and the United States Fish and Wildlife Service (USFWS; Imperial National Wildlife Refuge). Specifically, this proposed monitoring will be initiated in the Orocopia and West Chocolate Mountains. Survey and monitoring efforts will also be resumed in the Chuckawalla Mountains, and continued in the East Chocolate Mountains.

The USFWS has not rendered a decision regarding their proposal to list the Peninsular Ranges population of desert bighorn sheep as endangered (May 8, 1992 Federal Register, Vol 57, 90:19837-19843). However, the CDFG continues to participate in an interagency task force (coordinated by the BLM) to develop a habitat management and population recovery program for bighorn sheep in the Peninsular Ranges.

In July 1993, representatives from the CDFG met with the BLM to discuss the potential for a bighorn sheep reintroduction in the Amadee/Skedaddle Mountains of northeastern California. Agency team members concluded that although the resource area has habitat capable of supporting bighorn sheep, range condition, water availability, and domestic sheep grazing may limit the success of a reintroduction effort. Singularly, domestic sheep grazing is a serious conflict that currently precludes reintroduction efforts.

LITERATURE CITED

Andrews, N. 1994. Demography and habitat use of desert-dwelling mountain sheep in the East Chocolate Mountains, Imperial County, California. M.S. Thesis, Univ. Rhode Island. 134pp.

Bailey, J. 1994. Status of major ecotypes of bighorn sheep in the United States. In prep.

Berger, J. 1990. Persistence of different sized populations: An empirical assessment of rapid extinctions in bighorn sheep. Conservation Biology 4:91-98.

Bleich, V.C., J.D. Wehausen, and S.A. Holl. 1990. Desert-dwelling mountain sheep: Conservation implications of a naturally fragmented distribution. Conservation Biology 4:383-390.

Hanski, I., and M. Gilpin. 1991. Metapopulation dynamics: brief history and conceptual domain. Biological Journal of the Linnean Society 42:3-16.

Jaeger, J.R. and J.D. Wehausen. 1993. Distribution, movements, and demography of mountain sheep in the Kingston and Clark Mountain Ranges of California: A preliminary report on demography. California Department of Fish and Game, Sacramento, Interagency Agreement FG2248-WM. 20pp.

Levins, R. 1970. Extinction. Pages 77-107 *in* M. Gerstenhaber ed., Some mathematical problems in biology. Providence, R.I., American Mathematical Society.

Ramey, R.R. II. 1993. Evolutionary genetics of North. American mountain sheep. Ph.D. Thesis, Cornell University, Ithaca, New York. 250pp.

Schwartz, O.A., V.C. Bleich, and S.A. Holl. 1986. Genetics and the conservation of mountain sheep *Ovis canadensis nelsoni*. Biological Conservation 37:179-190.

Torres, S.G., V.C. Bleich, and A. Pauli. 1993. An analysis of hunter harvest of mountain sheep in California, 1987-1992. Desert Bighorn Council Transactions 37:47-52.

Wehausen, J.D., V.C. Bleich, and R.A. Weaver. 1987. Mountain sheep in California: A historical perspective on 108 years of full protection. Western Section Wildlife Society Transactions 23:65-74.

Wehausen, J.D. and R.R. Ramey II. 1993. A morphometric reevaluation of the peninsular bighorn subspecies. Desert Bighorn Council Transactions 37:1-10.

Weaver, R.A. 1989. Status of bighorn sheep in California - 1989. The Sheepherder, January 1989:20-23.

STATUS OF BIGHORN SHEEP IN COLORADO, 1993

VAN K. GRAHAM, Colorado Division of Wildlife, 711 Independent Avenue, Grand Junction, CO 81505

Desert Bighorn Council *Transaction 38:28-31.*

POPULATIONS

Colorado desert bighorn sheep managers are cautiously optimistic that populations are at their highest levels since reintroductions began in 1979. Population indicators such as lambing success, harvest results, field observations, and sex/age classification counts all indicate increased populations. The population, distributed among 5 herds, is currently estimated to be 475 sheep (Table 1). Population estimates are based on the above indicators as well as computer simulation models for each herd using the POP-I1 population program developed by Bartholow (1992). The transplant and other management efforts of the Colorado Division of Wildlife (CDOW) prior to 1993 were summarized previously in the DBC Transactions (Lytle 1993). Since that time, one additional transplant of 21 sheep (*Ovis canadensis nelsoni*) from the Black Mountains of Arizona was made in Roubideau Canyon during the summer of 1993.

The apparently successful reintroduction of desert bighorn sheep in Colorado has somewhat decreased, but not eliminated, the need for transplants, and CDOW has begun to focus on long-term management of herds. The goals of Colorado's desert bighorn sheep management program are presented in the Colorado Desert Bighorn Sheep Management Plan (1989), which was cooperatively prepared by the Grand Junction and Montrose Resource Areas of the Bureau of Land Management (BLM) and the Northwest and Southwest Regions of the CDOW. The goals are to: 1) facilitate the restoration of desert bighorn sheep into historic range of south west Colorado on BLM administered public lands in cooperation with the CDOW and private landowners; 2) improve and maintain habitat for population goals of 500 bighorn sheep by 1995 and 1,200 by the early 21st century; 3) reintroduce 200 bighorns into 3 areas: Palisades/Sewemup Mesa (near Gateway, Colorado), the Dolores River Habitat Units (in the vicinity of Slick Rock, Colorado), and on Black Ridge (west of Grand Junction, Colorado); and 4) manage desert bighorn sheep habitat using the guidelines developed in the resource management plan.

With the exception of the PalisadesISewemup Mesa locality, all sites (Fig. 1) outlined in the desert bighorn management plan have had at least 1 transplant. The Grand Junction Resource Area of the BLM is currently developing a draft environmental assessment for the reintroduction of desert sheep at this site. The CDOW is actively seeking desert bighorn sheep to fulfill transplant requirements at 3 sites. These sites are on Black Ridge in Knowles Canyon; on the Middle Dolores herd site; and at the Palisades/Sewemup Mesa site.

During 1993, the CDOW submitted an application for a grant from the Foundation for North American Wild Sheep (FNAWS). These monies will be used to fund trap/transplant programs for the first time from within Colorado herds. If funding is approved, attempts will be made to trap sheep in Dominguez Canyon and transplant them to Black Ridge. The objective is to expand desert sheep range into Knowles Canyon near the Utah border just south of the Colorado River. Excellent desert sheep habitat appears to exist there. The present

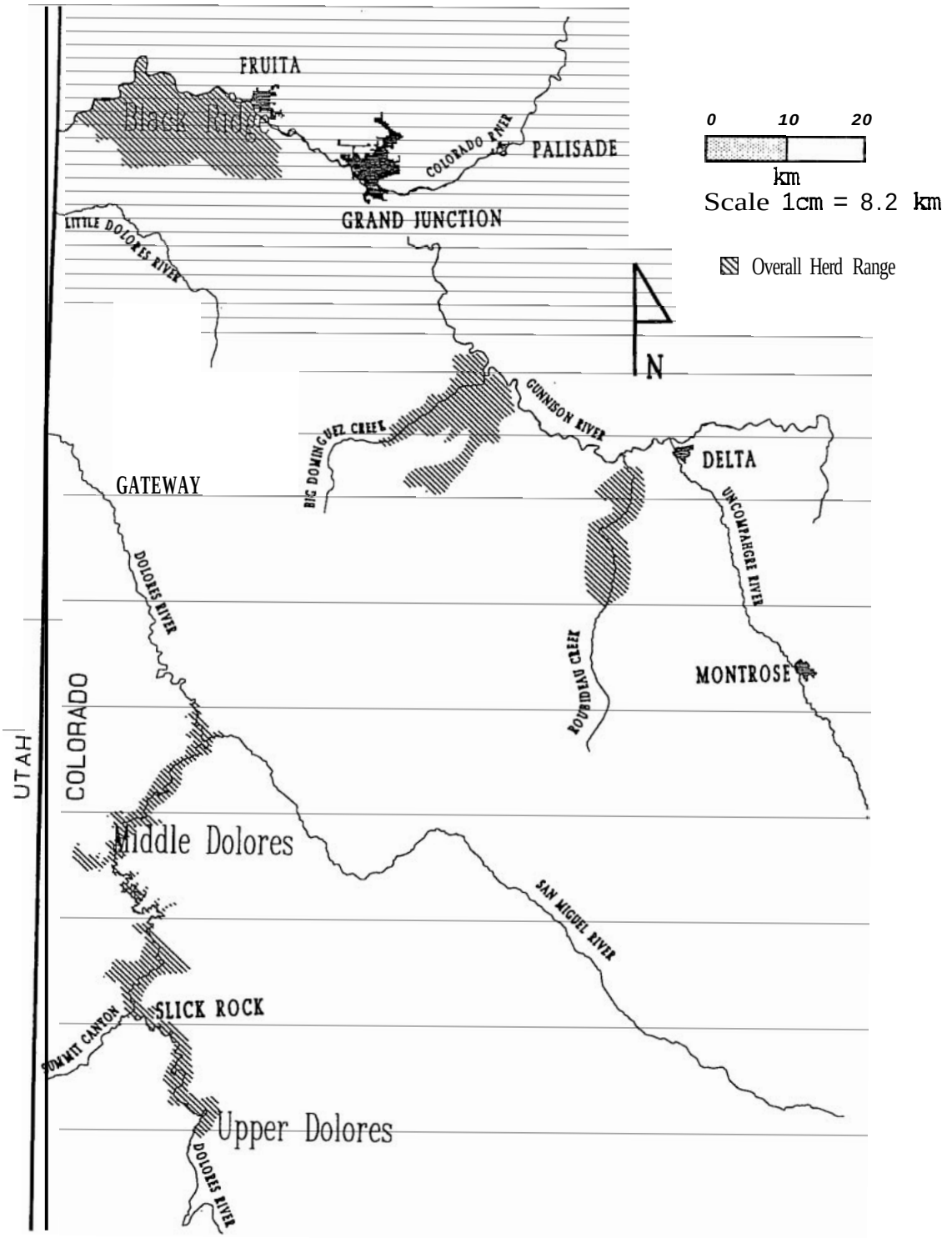


Figure 1. Location of 5 desert bighorn sheep herds in western Colorado, 1993.

Table 1. Desert bighorn sheep herds and estimated population size in Colorado, 1993.

Herd Location	Estimated Population Size
Black Ridge	125
Dominguez Canyon	125
Upper Dolores River	125
Middle Dolores River	40
Roubideau Canyon	40
Total	475

Black Ridge sheep are reluctant to pioneer into this area, and this reluctance may be due to a lack of suitable movement corridors. However, it appears more likely that animals in this population may be poor pioneers because of social bonding that has favored the use of range established after the original transplant (Risenhoover et al. 1988).

Although desert sheep reintroduction in Colorado appears to have been successful, factors limiting population growth and expansion of these herds are not well known. Mountain lion (Felis concolor) predation has been documented in several instances and was thought to be a factor limiting growth of the Dominguez Canyon population. Don Masden, a biologist with the CDOW-Southwest Region, attributed 2 (out of 41 transplanted sheep) sheep mortalities in Dominguez Canyon to lions. Additionally, four other sheep carcasses located in this area were suspected to have been killed by lions, but due to scavenging, the mode of death could not be determined. A lion kill has also been documented in the Black Ridge sheep herd. During the 1993 desert bighorn hunting season, an experienced sheep hunter reported finding a young ram carcass that appeared to have been killed by a lion. Lion tracks were observed at the kill site as well as bite marks that indicated a lion had attacked the ram.

The impact that diseases have had on the populations is not well known. Extensive, all-age die-offs or large scale outbreaks of disease have not been seen. However, field observations indicate the presence of isolated examples of diseases in the populations. Contagious ecthyma was discovered in the Dominguez herd in 1992 by a desert sheep hunter who observed and photographed several infected sheep and harvested a ram that had a minor infection. This disease has not manifested itself recently. One ewe skull found on Black Ridge in the late 1980s showed extensive evidence of chronic sinusitis and the animal presumably succumbed to this disease. No other evidence of disease has been documented. Lamb production appears to be good. As an example, in the Dominguez herd the ewe:-lamb ratio was 100:44 in 1992 and 100:66 in 1993.

In early December 1993, the CDOW captured 6 bighorn sheep approximately 44 km northeast of Grand Junction. The sheep were captured from a small isolated population which inhabits the Battlement Mesa area near Collbran, Colorado. These 40-60 sheep are the remnants of a larger herd that once ranged over a considerably larger area. Over the years, significant controversy among wildlife managers has revolved around the possibility that these sheep might be desert bighorn rather than Rocky Mountain bighorn. Monson (1980) stated that a small herd of desert bighorn existed on Battlement Mesa. William Rutherford, a former CDOW Researcher, was their source for this information. Subsequently, Rutherford has stated that there was a misunderstanding in his conversations with Hatch Graham, a contributing author, and that Rutherford only speculated that these sheep might be desert bighorn. Their small physical size, low elevation range, and west-central Colorado location along the Colorado River corridor lent credence to the conjecture that these sheep may have been a remnant population of desert sheep. Blood and/or tissue samples were collected from each sheep that was captured. Rob Ramey, a bighorn sheep researcher from Cornell University, conducted the analysis of each sample during January 1994 to determine the genetic composition. His findings conclude that these sheep are Rocky Mountain and not desert bighorn sheep.

RESEARCH

Presently, no research projects are being conducted on any desert bighorn herds in Colorado. Population monitoring has been limited due to budget constraints, particularly in the past few years. While CDOW receives funding for management of Rocky Mountain bighorn sheep through hunting license auction and raffle funds, no such authorization has been granted for desert sheep.

HARVEST

Hunting of desert bighorn sheep has been authorized by the Colorado Wildlik Commission in 3 desert bighorn sheep management units for the 1994 season. These units are S56 (Black Ridge herd), S62 (Dominguez Canyon herd), and S64 (Upper Dolores herd). A total of 6 licenses will be issued - 2 in each unit. There is high public interest for hunting desert bighorn sheep in Colorado. In 1993, there were 346 applicants for 6 ram licenses. No ewe licenses have been issued since hunting was begun in 1988. Hunter success and apparent satisfaction have been excellent. Hunting success has been 100% for all years since 1988. Hunting has been limited to rams, 1/2 curl or larger. Sheep harvested during the 1992 and 1993 hunting seasons had an average of 5.7 growth rings. Average horn length for these sheep was 75 cm.

LITERATURE CITED

Bartholow, J., 1992. POP-I1 System Documentation, Fossil Creek Software, IBM-PC Version 7.00, Ft. Collins, Colorado, August, 1992. 50pp.

Lytle, T., J. Ellenberger, and J. Olterman. 1993. Status of bighorn sheep in Colorado, 1992. Desert Bighorn Council Transactions 37:52-53.

McVean, D. 1989. Goals. Page i in Colorado desert bighorn sheep management plan, Bureau of Land Management and Colorado Division of Wildlife. 21pp.

Monson, G. 1980. Distribution and abundance. Pages 48-49 in G. Monson and L. Sumner, eds. The desert bighorn. University of Arizona Press, Tucson, Arizona. 370pp.

Risenhoover, K.L., J.A. Bailey, and L.A. Wakelyn. 1988. Assessing the Rocky Mountain bighorn sheep management problem. Wildlife Society Bulletin 16:346-352.

STATUS OF DESERT BIGHORN SHEEP IN NEVADA, 1993

PATRICK J. CUMMINGS, Nevada Division of Wildlife, 4747 West Vegas Drive ,Las Vegas, NV 89108

CRAIG STEVENSON, Nevada Division of Wildlik, 4747 West Vegas Drive, Las Vegas, NV 89108

Desert Bighorn Council Transactions 38:31-33.

POPULATIONS

There are three subspecies of bighorn sheep (*Ovis* canadensis) in Nevada: Rocky Mountain bighorn (*O.* c. canadensis), California bighorn (*O.* c. *californiana*), and desert bighorn (*O.* c. nelsoni). Desert bighorn inhabit 48 mountain ranges in the central and southern portions of Nevada. This report summarizes desert mountain sheep status and bighorn program activities carried out within Nevada during 1993. Fall helicopter surveys conducted on 26 mountain ranges enabled the classification of 2,265 bighorn sheep (57 rams and 40 lambs per 100 ewes). Based on these surveys, the estimate of desert bighorn sheep in Nevada is 5,294. The 1993 population estimate reflects a 10.6% statewide increase in bighorn numbers above the 1992 population estimate. Some populations of bighorn sheep declined as a result of recent successive years of drought. Water developments, to varying extents, have served to attenuate the severity of reduced water availability endured by some populations of bighorn during drought years. Water developments have also been, and will continue to be, essential elements in efforts to re-establish mountain sheep into historic ranges. During the latter half of 1993, measurable precipitation was below average. Modest increases in some bighorn populations in

1992 and *1993* may have been offset due to below average precipitation during the latter half of *1993.*

During October, *1993,* a total of *151* desert bighorn sheep were captured in three mountain ranges: River, Muddy, and Mormon. The transplant phase involved *2* re-introductions and *4* augmentations in six mountain ranges. Bighorn captures were accomplished through the use of *2* techniques, drop net and net-gun. Twenty-four desert sheep were captured through the former method, and *127* were captured through the latter method. Fifty-five desert bighorn were captured in the River Mountains. A reintroduction was made in the Spotted Range *(n=25).* Augmentations were accomplished in the Toiyabe Range *(n=9)* and Gabbs Valley Range *(n=3).* Animals were marked and released back into the River Mountains during the summer dropnet operation *(n=16),* and ewes were given to the Hogle Zoo *(n=2).* Fifty-five mountain sheep were captured in the Muddy Mountains. Populations were augmented in the Gabbs Valley Range *(n=17),* Specter Range *(n=20),* and Bare Mountain *(n=18).* Forty-one bighorn sheep were captured in the Mormon Mountains. A reintroduction was achieved within the Pine Grove Hills *(n=21),* and an augmentation was conducted in the Egan Range *(n=20).* Since *1969,945* desert bighorn sheep have been transplanted to *27* mountain ranges in Nevada. In addition, *190* desert bighorn from Nevada have been transplanted to Colorado *(n=93),* Texas *(n=67)* and Utah *(n=30).* Nevada Department of Wildlife (NDOW) has approved plans to transplant desert bighorn sheep into additional mountain ranges within Nevada. Bighorn capture and transplant operations are scheduled to occur during October *1994.*

HABITAT IMPROVEMENTS

In *1993,* water catchments were constructed on Bare Mountain *(n=1)* and the Gabbs Valley Range *(n=1).* Collection aprons were repaired or added to existing projects on Bare Mountain *(n=1),* the Spotted Range *(n= 2),* and the Mormon Mountains *(n=1).* Additional tanks were added to projects in the Spotted Range *(n=2).* Existing fiberglass tanks were replaced with poly tanks to expand capacities in the Hiko Range *(n=3).* The combined water storage capacity added during *1993* equates to 109,53*1* liters.

There are now *104* water developments in Nevada for desert bighorn sheep with a combined storage capacity of *1,782,437* liters. These projects are funded all or in part by Nevada Bighorns Unlimited (Reno, Fallon and Elko chapters), the Fraternity of the Desert Bighorn (Las Vegas), and the Foundation for North American Wild Sheep (FNAWS). Catchment construction and maintenance is accomplished largely by volunteers from these organizations. Projects were constructed in cooperation with the Bureau of Land Management (BLM), U.S. Fish and Wildlife Service, and NDOW.

There are currently *4* water developments scheduled for construction in *1994, 2* near Las Vegas and *2* near Fallon. These projects will be constructed by volunteers. Funds for most of the materials and helicopter time are donated by volunteers. The pace at which desert bighorn water developments have been constructed in Nevada has slowed considerably during *1993* and *1994.* At issue is the compatibility of water developments with wilderness study areas (WSA) and impending wilderness classification. While only *14%* of the Las Vegas BLM District is classified as WSA, approximately *75%* of those areas consist of current and historical desert bighorn sheep habitat. The qualities of remoteness, rugged terrain, and limited access, which qualified those areas for wilderness consideration, constitute key habitat for desert bighorn sheep. Currently, the Interior Board of Land Appeals is reviewing appeals on the Muddy Mountain #6 Water Development and the Meadow Valley-Arrow Canyon-Delmar Bighorn Sheep Habitat Management Plan.

HARVEST

The desire to hunt desert bighorn rams remains high in Nevada. During the *1993* season, *125* desert bighorn sheep tags were available. There were 2,43*1* resident applications for *111* tags *(22:1* odds), and *1,149* non-resident applications for *12* tags (96:1 odds). Two special bid tags were also allotted for this hunt. Of the *123* resident and non-resident tags, *35 (28%)* were allotted to areas with bighorn populations established through transplants. No new units were opened during the *1993* hunt. In *1993, 104* rams were harvested, a hunter success rate of *83%,* which was *2%* higher than the *1992* success rate and slightly higher than the five year average *(78%).* The average age of the rams harvested was *6.4* years old. Eight rams exceeded the Boone and Crockett minimum score of *168* points. The largest ram was harvested in the Mormon Mountains and scored $178^{6/8}$ points.

In May *1994,* NDOW will furnish recommendations for *1994* desert bighorn harvest quotas to the Board of Wildlife Commissioners. The recom-

mended number of tags and areas to be hunted closely parallel the bighorn hunts in 1993. Twenty-nine units will be recommended for bighorn harvest in 1994, including a new unit, the Last Chance Range, established by transplants in 1988 and 1989 (n=24 and n=25, respectively). The estimated population in this range is 121 bighorn. Two harvest permits were auctioned for Nevada desert bighorns in 1994: one at the FNAWS Convention in San Antonio, Texas, and the second at the Nevada Bighorns Unlimited (Reno Chapter) banquet. Funds raised from the tags totalled $146,500.

STATUS OF DESERT BIGHORN SHEEP IN NEW MEXICO, 1993

AMY S. FISHER, New Mexico Department of Game and Fish, P.O. Box 25112, Santa Fe, NM 87504

Desert Bighorn Council *Transactions* 38:33-34.

POPULATIONS

In 1993, 315 desert bighorn sheep (*Ovis canadensis* mexicana) were estimated to be in New Mexico based on fall surveys. All 6 populations are ≤100 (Table 1). Population trends between 1988-93 (derived from previous DBC status reports) indicate that all populations are stable to increasing.

In October 1993, 19 bighorn (9 ewes, 10 rams) were captured with the helicopter net-gun method at the New Mexico Department of Game and Fish (NMGF) Red Rock Wildlife Area and subsequently released into the Peloncillo (n=11) and Ladron mountains (n=8). Cooperators included the Bureau of Land Management (BLM) and U.S. Fish and Wildlife Service (USFWS). Ewes were fitted with color-coded collars and pit-tags were embedded into the horn sheath of rams to help identify illegal kills. These transplants supplemented established populations, replaced rams lost to illegal harvest in the Ladron Mountains (Fisher 1993), and reduced the number of rams in the captive facility.

To date, 137 desert bighorn have been transplanted in New Mexico, 111 from the Red Rock Wildlife Area and 26 from Arizona. The Red Rock Wildlife Area was designated a Watchable Wildlife site in 1993 (MacCarter 1993) to provide educational viewing of the captive desert bighorn herd and other wildlife.

RESEARCH

As part of the on-going investigation into the relationship between desert bighorn and psoroptic mites (Psoroptes spp.), 11 San Andres bighorn were captured with the helicopter net-gun method in October 1993 in cooperation with the USFWS, White Sands Missile Range (WSMR), and the New Mexico Chapter Foundation for North American Wild Sheep (NM-FNAWS). San Andres bighorn were last examined in 1989 (Clark and Jessup 1992). Objectives of the capture were to assess health status and to radiocollar as many sheep as possible for demographic monitoring. Standard handling and sampling procedures were followed (Clark and Jessup 1992). Bighorn were also inoculated with a sustained release ivermectin formulation that would confer immunity for 90 days. Permanent immunity was not possible because only 1/3 of the population (n=11) was captured and the potential role of deer as an alternate host for bighorn psoroptic mites is unknown.

All bighorn captured were clinically and/or serologically positive for scabies. Ten of the 11 captured sheep had completely occluded ear canals with underlying secondary infections. One ram was heavily infected with scabies extending down the neck, foreleg and flank. Eight of the sheep had been previously captured; the severity of infestation had improved in 3 sheep captured in 1993 compared to previous captures, whereas condition worsened in 5 others. No pattern of acquired immunity to scabies is evident.

The San Andres population numbered about 200 sheep until a psoroptic scabies epizootic decimated the herd in 1978 (Sandoval 1980). Thirty bighorn were counted in an aerial survey conducted in November 1993. The position of NMGF is that recovering the San Andres bighorn is integral to restoring desert bighorn in New Mexico because: 1) the San Andres is the largest contiguous habitat in the state (Dunn 1991); and, 2) we are reluctant to transplant sheep to ranges adjacent to the San Andres due to the potential for spreading scabies.

Table 1. Size of desert bighorn herds in New Mexico, 1993.

	Estimated Population Size				
Status	<25	25-50	51-100	101-200	>200
Native	0	1	0	0	0
Supplement	0	0	2	0	0
Reintroduced	1	1	0	0	0
Captive	0	0	1	0	0

throughout the state. The San Andres is the only herd in the state exposed to scabies. One impediment to effective management has been the lack of information on mite genetics; specifically, we do not know if psoroptic mites on deer could be the source of the infection. Therefore, NMGF will fund a study to determine the host specificity of psoroptic mites found on deer and bighorn through a comparison of their DNA sequences. Future management actions are pending the results of this study.

HABITAT IMPROVEMENTS

The BLM installed a water catchment unit on Pratt Peak in the Peloncillo Mountains at a cost of $5,000. Maintenance of existing water units cost $4,000.

HARVEST

Desert bighorn are not currently hunted (Fisher 1993), although desert bighorn research, management, and restoration has benefitted from funds raised by the auction of 1 Rocky Mountain bighorn (*O.* c. canadensis) permit at the FNAWS convention. The auction has raised $214,200 between 1990-1993, and the 1993 auction permit sold for $55,000.

LITERATURE CITED

Clark, R.K. and D.A. Jessup. 1992. The health of mountain sheep in the San Andres Mountains, New Mexico. Desert Bighorn Council Transactions 36:30-35.

Dunn, W.C. 1991. Evaluation of desert bighorn sheep habitat in New Mexico. New Mexico Department of Game and Fish Final Report Federal Aid in Wildlife Restoration Project W127R-7 Job 4. Santa Fe, NM. 52pp.

Fisher, A.S. 1993. Status of bighorn sheep in New Mexico, 1992. Desert Bighorn Council Transactions 37:56-58.

MacCarter, J.S. 1993. New Mexico wildlife viewing guide. Falcon Press Publishing Company, Helena, Montana. 96pp.

Sandoval, A.V. 1980. Management of a psoroptic scabies epizootic in bighorn sheep (*Ovis canadensis mexicana*) in New Mexico. Desert Bighorn Council Transactions 24:21-28.

STATUS OF BIGHORN SHEEP IN TEXAS, 1993

GARY CALKINS, Texas Parks and Wildlife Department, P.O. Box 1292, Van Horn, TX 79855

Desert Bighorn Council Transactions 38:35-36.

POPULATIONS

The Trans-Pecos region of Texas currently supports 6 populations of free-ranging desert bighorn sheep in the Sierra Diablo, Baylor, Beach, Van Horn, Sierra Vieja, and Elephant Mountains. Intensive helicopter surveys were completed in these, plus the Quitman and Malone Mountains, in late September and early October, 1993. Helicopter survey time spent during 1993 totalled 71 hours. The surveys were conducted using 2 observers in a Jet Ranger helicopter. Mountain ranges were flown at 60 m contours from peak to base at 56 to 64 km per hour ground speed. Population estimates were then calculated using estimated observation success based upon the front seat observer's knowledge of the given mountain range. Updated population estimates for each range were determined following this survey (Table 1). The total estimated population for the State is 310 animals.

The Malone and Quitman ranges were flown for 3.5 hours to verify the presence of sheep after the confirmed sightings in January 1993. No sheep were observed, and it was determined that there are no sheep currently present in these ranges. It is assumed that sheep observed earlier in the year left the mountain ranges. Six yearling rams were released into the Sierra Diablo herd from the Sierra Diablo brood pen facility in May, 1993. An additional 15 six-month old rams and 3 adult rams were released into this range in November, 1993.

Ten ewes, eight lambs, and two yearling rams were released from an enclosure in the Beach Mountains to range free in June, 1993. These animals were placed in the enclosure from the Sierra Diablo facility in November, 1992.

There are currently 2 captive herds located in Texas. The primary herd is located in the Sierra Diablo brood pen facility. As of April 1, 1994, the facility contained 35 breeding ewes, 6 yearling ewes, 17 rams, and 13 lambs born prior to April 1, 1994. During 1993, 24 lambs were born with 23 surviving through weaning age. The second captive herd is located in a pasture on the Chilicote Ranch in the Sierra Vieja. There are currently 12 ewes and 11 rams in this enclosure with no lambs born as of April 1, 1994.

RESEARCH

Texas A&M University Kingsville, and Texas Parks and Wildlife Department (TPWD) have initiated a cooperative research project to evaluate forage availability and food habits of sheep in the Sierra Diablo, Beach, and Baylor Mountains. This 3 year project began in January 1994, and will be conducted by 2 graduate students from the university. Development of a feed supplement for captive sheep is nearing completion. Testing indicates the developed feed should be suitable for maintenance and reproductive success of captive herds within the Sierra Diablo facility. This feed is based on a creep feed formula and all-grain feeds used in the domestic sheep industry. Testing of captive sheep to determine genetic heritage and inbreeding coefficient in the Sierra Diablo brood facility is also proposed. Blood has been drawn and stored in a DNA buffer solution awaiting funding for lab testing. Maintenance of a sera library on captive animals has also been initiated.

Geographic Information System evaluations of the Sierra Diablo for sheep management is currently being completed by the TPWD. This mapping will be used to evaluate landowner cooperatives for hunting as well as management objectives within the mountain range. Upon completion, the criteria developed will be used for future mapping of other mountain ranges for release evaluations and management decisions.

HABITAT IMPROVEMENTS

During March 1994, the TPWD and the Texas Bighorn Society (TBS) cooperated in the construction of 2 guzzlers north of the Victorio Canyon area on the Sierra Diablo Wildlife Management Area. One of these guzzlers was auctioned off for a primary sponsorship at the 1993 TBS Banquet. Remaining construction costs were carried by the TBS.

HARVEST

Two private landowner permits were issued for 1993 in the Sierra Diablo. Two rams were harvest-

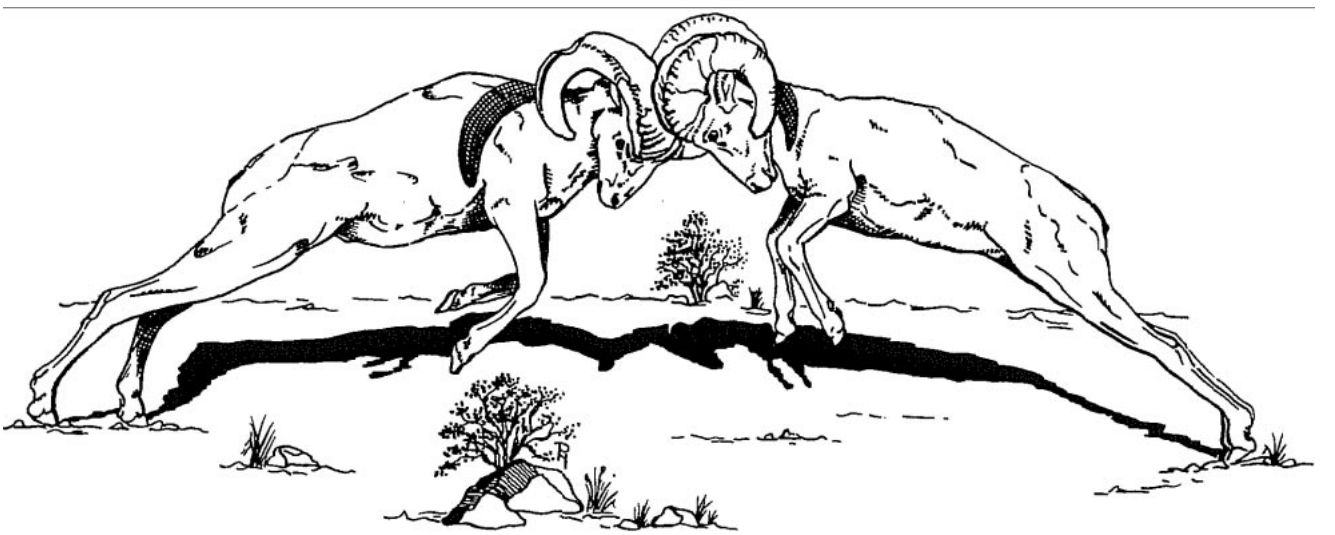
ed during late October and early November on 1 day and 3 day hunts. The Boone and Crockett "green" score of the first ram, 9.5 years old, was $157^{7/8}$. The second ram was 11.5 years old and received an official Boone and Crockett score of $168^{4/8}$. A governor's permit for the Sierra Diablo was auctioned off at the 1994 Foundation for North American Wild Sheep convention for $70,000.

PROBLEMS/OPPORTUNITIES

The Apache Mountains in Culberson County were evaluated during 1993 for potential release of desert sheep. The mountain range was found to be inadequate for release due to lack of escape terrain, sufficient available water, and the presence of exotic ungulates. Evaluations are underway for the Eagle Mountains in Hudspeth County and the Chinati Mountains in Presidio County. These evaluations will be completed by mid-1994.

Table 1. 1993 Helicopter Survey Results.

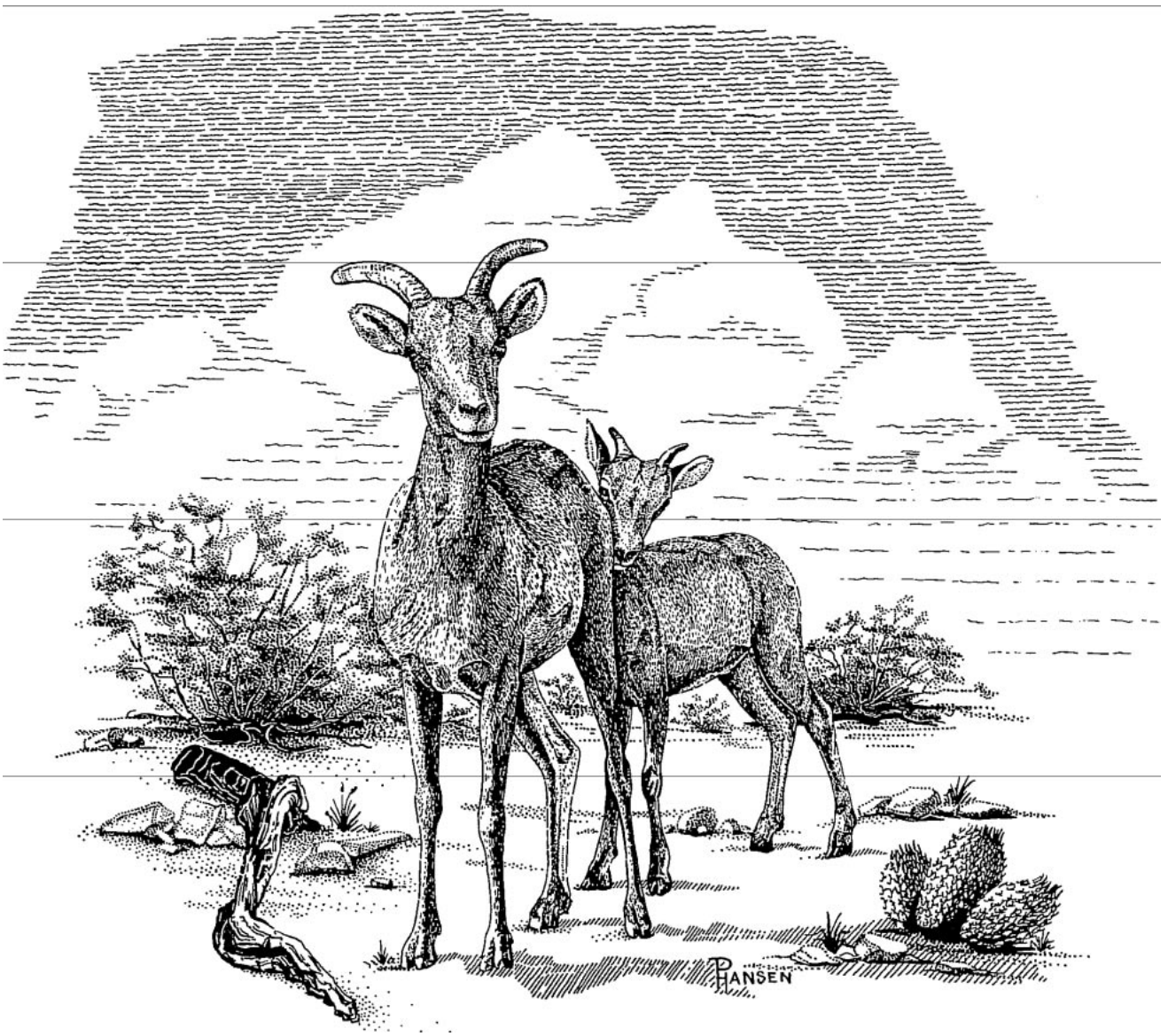
Mountain Range	Sheep Observed	Ram:Ewe:Lamb:Yearling	Estimated Population	Increase/Decrease
Sierra Diablo	58	100:100:8:24	145	Decrease
Beach	58	58:100:58:25	61	Increase
Baylor	6	100:100:50:50	12	Decrease
Van Horn	11	40:100:80:0	26	Unchanged
Sierra Vieja	4	50:100:50:0	10	Unchanged
Elephant	53	70:100:22:4	56	Increase
Total			310	



OBITUARY

Marvin Wood
1909-1994

Marvin Wood was born in Arkansas, and immigrated to California during the dust bowl era, becoming a successful farmer. He is survived by his wife, Pauline, two sons, and numerous grandchildren and great grandchildren. Aside from his family, bighorn sheep were the most important thing in his life. He joined the Society for the Conservation of Bighorn Sheep more than forty years ago, and was an energetic and active member. Attending his first meeting of the Desert Bighorn Council at Redlands, California, in 1965, Marv soon became a regular attendee. He used any information he gained at meetings to influence bighorn management practices as best he could. Marv did not seek recognition for his efforts on behalf of wild sheep, preferring to work through others and support sheep organizations. He was a life member of three wild sheep conservation organizations besides the Desert Bighorn Council. Marv gave money, time and sweat to bighorn programs and projects, regularly volunteering for capture efforts and construction of water catchments. For almost twenty years, Marv voluntarily maintained all of the natural and artificial water sources in the Old Woman Mountains, San Bernardino County, California. Additionally, he would recruit help and make water hole counts for the California Department of Fish and Game. One of many water catchments Marv helped to install in the Mojave desert is now dedicated to him. This selfless man will be much missed by the Desert Bighorn Council, but it is the desert bighorn who have truly lost a generous friend. Richard *Weaver, Cortez, CO*


P HANSEN

PROGRAM 38th ANNUAL MEETING
DESERT BIGHORN COUNCIL
MOAB, UTAH, APRIL 6-8, 1994

WEDNESDAY, APRIL 6, 1994

8:00 CONVENE
8:15 WELCOME AND INTRODUCTION
Jim Guymon, Utah Division of Wildlife Resources
8:25 KEYNOTE ADDRESS
David Almand, Chief, Division of Wildlife and Fisheries, Bureau of Land Management, Washington, D.C.
8:45 20TH ANNIVERSARY, A TRIBUTE TO DR. CHARLES HANSEN AND A HISTORY OF THE HANSEN-WELLES MEMORIAL FUND
Dick Weaver

STATUS REPORTS: Chair - Rick *Brigham*, Bureau of Land Management, Carson City, NV

9:30 ARIZONA
Ray Lee, Arizona Game and Fish Department
9:50 CALIFORNIA
Steve Torres, California Department of Fish and Game
10:10 COLORADO
Van Graham, Colorado Division of Wildlife
10:30 NEVADA
Pat Cummings, Nevada Department of Wildlife
10:50 NEW MEXICO
Amy Fisher, New Mexico Department of Game and Fish
11:10 TEXAS
Gary *Calkins,* Texas Parks and Wildlife Department
11:30 UTAH
Norman McKee, Utah Division of Wildlife Resources
11:50 BIGHORN INSTITUTE
Jim DeForge, Bighorn Institute
12:00 MEXICO
Jim DeForge, Bighorn Institute

PANEL DISCUSSION: Panel Moderator - Mike Miller, Colorado Division of Wildlife, Fort Collins, CO

1:00 LIVESTOCK/BIGHORN SHEEP DISEASE TRANSMISSION
Walter Boyce, University of California, Davis;
Mane Bulgin, University of Idaho, Caldwell;
Bill Foreyt, Washington State University;
David Hunter, Idaho Department of Fish and Game;
Terry Spraker, Colorado State University;
Al Ward, University of Idaho, Caldwell

TECHNICAL REPORTS: Parasites and Disease: Chair - *Guy* Wallace, Utah Division of Wildlife Resources, Monticello, UT

3:30 ENZYME-IMMUNOASSAY OF SOLUBILIZED FECAL SAMPLES TO MONITOR PREGNANCY IN FREE-RANGING BIGHORN SHEEP
Dori Borgesson, Walter M. Boyce and *Bill L. Lasley*, University of California, Davis, CA; *James* R. *DeForge*, Bighorn Institute, Palm Desert, CA

3:50 PHYLOGENY, HOST SPECIFICITY AND THE EVOLUTION OF VIRULENCE IN PSOROPTIC MANGE MITES (*Psoroptes* spp.): HOW DNA SEQUENCING CAN SOLVE AN OLD PROBLEM
Rob R. Ramey II, Cornell University, Ithaca, NY; *Walter* M. *Boyce*, University of California, Davis, CA; *Brian Farrell*, University of Colorado, Boulder, CO

4:10 THE ROLE OF RESPIRATORY SYNCYTIAL VIRUS IN PNEUMONIA OF FREE-RANGING MOUNTAIN BIGHORN SHEEP IN COLORADO
Teny R. Spraker and *J.C. Collins*, Colorado State University, Fort Collins, CO; *W. Adrian, G.G. Schounveld*, and *M. Miller*, Colorado Division of Wildlife, Fort Collins, CO

4:30 PROBLEMS WITH "MULTIPLE LAND USE" DEALING WITH BIGHORN SHEEP AND DOMESTIC LIVESTOCK
Terry R. *Spraker*, Colorado State University, Fort Collins, CO; *W. Adrian*, Colorado Division of Wildlife, Fort Collins, CO

THURSDAY, APRIL 7, 1994

TECHNICAL REPORTS: Population Biology and Genetics: Chair - *Linda Seibert*, Bureau of Land Management, Moab, UT

8:00 AN ANALYSIS OF ELEVEN YEARS OF HELICOPTER SURVEYS OF PENINSULAR BIGHORN SHEEP IN THE SANTA ROSA MOUNTAINS, CALIFORNIA
James R. *DeForge*, *Elaine M. Barrett*, and *Stacy D. Ostermann*, Bighorn Institute, Palm Desert, CA; *Steven G. Torres*, California Department of Fish and Game, Sacramento, CA

8:20 RANGE EXPANSION AND POPULATION DYNAMICS OF REINTRODUCED DESERT BIGHORN, ZION NATIONAL PARK, UTAH
Henry E. McCutchen, National Biological Survey, Flagstaff, AZ; *Jim Guymon*, Utah Division of Wildlife Resources, Cedar City, Utah; *Stephen King*, National Biological Survey, Flagstaff, AZ

8:40 ANALYSES OF HELICOPTER SURVEY DATA WITH INDEPENDENT EMPIRICAL POPULATION ESTIMATES
John D. *Wehausen*, University of California, White Mountain Research Station, Bishop, CA; *Vernon C. Bleich*, California Department of Fish and Game, Bishop, CA

9:00 A REANALYSIS OF COWAN'S (1940) ORIGINAL MORPHOLOGICAL DATA DOES NOT SUPPORT MANY OF HIS ORIGINAL CONCLUSIONS
Rob R. Ramey II, Cornell University, Ithaca, NY

9:20 PHYLOGENY AND EVOLUTION OF NORTH AMERICAN MOUNTAIN SHEEP INFERRED FROM THE ANALYSIS OF RESTRICTION SITE VARIATION IN MITOCHONDRIAL DNA
Rob R. Ramey II, Cornell University, Ithaca, NY

TECHNICAL REPORTS: Habitat Use, Behavior, Predation and Management: Chair - Jim *Karpowitz*, Utah Division of Wildlife Resources, Price, UT

10:00 STATUS OF MAJOR ECOTYPES OF BIGHORN SHEEP IN THE UNITED STATES
James A Bailey, New Mexico Department of Game and Fish, Santa Fe, NM

10:20 BIGHORN WATER DEVELOPMENT
Leon Lesicka, Brawley, CA

10:40 TIMING, SUCCESS AND CLIMATIC RELATION OF LAMBING IN DESERT BIGHORN SHEEP AT RED ROCK, NEW MEXICO
Kristina A. Ernest and ***Daniel D. Beck,*** Red Rock, NM; ***Amy S. Fisher,*** New Mexico Department of Game and Fish, Santa Fe, NM

11:00 REASSESSING FIFTY YEARS OF BIGHORN WATER DEVELOPMENTS IN SOUTHWESTERN ARIZONA
Bill Broyles, Tucson, AZ

11:20 HUNTER HARVEST OF MOUNTAIN SHEEP IN CALIFORNIA **(1987-1993):** AN ANALYSIS OF POPULATION PARAMETERS, HUNTER HARVEST AND EFFORT
Steven G. Torres, California Department of Fish and Game, Sacramento, CA; ***Vernon C. Bleich,*** California Department of Fish and Game, Bishop, CA; ***John D. Wehausen,*** University of California, White Mountain Research Station, Bishop, CA

11:40 SURVIVORSHIP AND MOVEMENT OF DESERT BIGHORN SHEEP RELEASED FROM AN ENCLOSURE ON THE EAST PAHRANAGAT MOUNTAINS IN NEVADA
Bruce L. ***Zeller***, Desert National Wildlife Range, Las Vegas, NV

12:00 THE NEW ENDANGERED SPECIES ACT IN RELATION TO ***Ovis canadensis*** REVISITED
Donald J. Annentrout, Bureau of Land Management, Riverside, CA

12:20 MOUNTAIN SHEEP ECOSYSTEM MANAGEMENT ON PUBLIC LANDS - A PRELIMINARY SURVEY
Donald J. Armentrout, Bureau of Land Management, Riverside, CA

PANEL DISCUSSION: Panel Moderator - ***Walter Boyce***, University of California, Davis, CA

1:00 PROBLEMS AND CONCERNS ASSOCIATED WITH BIGHORN TRANSLOCATIONS
Jim Bailey, New Mexico Department of Game and Fish;
Tom Bunch, Utah State University, Logan;
Amy Fisher, New Mexico Department of Game and Fish;
Rob Ramey, Cornell University;
Francis Singer, National Biological Survey, Fort Collins;
John Wehausen, University of California, Bishop;
Al Ward, University of Idaho, Caldwell

3:30 BUSINESS MEETING
5:00 ADJOURN
7:00 BANQUET - hosted by the Utah Chapter of the Foundation for North American Wild Sheep

FRIDAY, APRIL 8, 1994

8:30 Field trip to Potash/Canyonlands Bighorn Sheep habitat
3:00 ADJOURN

DESERT BIGHORN COUNCIL MEMBERSHIP LIST - 1994

Clair Aldous
126c McComb Road
Sequim, WA 98382

Nancy Andrews
Dept Nat Resource Sciences
212 Woodward Hall
Univ Rhode Island
Kingston RI 02881

Henry Apfel
PO Box 326
Pine AZ 85544

Donald Armentrout
5225 Canyon Crest Dr
#71-343
Riverside CA 92507

John Augsburger
RR 2 Box 2073
Paul ID 83347-9605

John Axtell
1332 Kim St
Minden NV 89423-9069

Jim Bailey
2101 Sandstone
Ft Collins CO 80524

Elaine Barrett
51000 Hwy 74
Palm Desert CA 92260

Jim Barrett
PO Box 134
Payson AZ 85547

Daniel Beck
405 South Pine St
Ellensburg WA 98926

Steve Berendzen
PO Box 756
Las Cruces NM 88004

James A Blaisdell
5425 Indian Beach Ln
Friday Harbor Way 98250

Vern Bleich
CA Dept of Fish and Game
Bishop CA 93514

Dori Borgesson
1441 Drake Dr #4
Davis CA 95616

Walter Boyce
2712 Eel Place
Davis CA 95616

Ray Boyd
608 Brown Ave
Ft Collins CO 80525

William R Brigham
PO Box 71478
Reno NV 89570-1478

Mark Brown
PO Box 2977
Yuma AZ 85366

Bill Broyles
5501 N Maria
Tucson AZ 85704

Marie S Bulgin
1020 E Homedale Rd
Caldwell ID 83605

Bill Burger
PO Box 8542
Mesa AZ 85214-8542

Thomas D Bunch
Advs Dept
Utah State University
Logan UT 84322-4815

Gary Calkins
PO Box 1292
Van Horn TX 79855

Marguerite Carpenter
6260 N Palm #117
Fresno CA 93704

Bill Clark
Dept of Fish and Game
1701 Nimbus # D
Rancho Cordova CA 95070

Debi Clark
28972 Spadra St
Barstow CA 92311

Tom Clark
28972 Spadra St
Barstow CA 92311

Tim Coonan
Channel Island National Park
1901 Spinnaker Dr
Ventura CA 93001

Leonard Cooper
Box 678
Roosevelt AZ 85545

Paul Creeden
268 N Cedar Ct
Fruita CO 81521

Joe Cresto
BLM
474 Nichols Ln
Moab UT 84532

Mary Jo Croonquist
Arizona Game and Fish Dept
5325 N Stockton Hill Rd
Kingman AZ 86401

Paul Crosbie
Dept Vet Path Micro & Immuno
Univ of California, Davis
Davis CA 95616

Patrick J. Cummings
4747 W Vegas Dr
Las Vegas NV 89108

Stan Cunningham
Arizona Game and Fish Dept
2221 W Greenway Rd
Phoenix AZ 85023

G E David
3560 Frances Ave
Los Angeles CA 90066-2703

Gary Davis
PO Box 1074
Springerville AZ 85938

James R Deforge
PO Box 262
Palm Desert CA 92261

Desert National Wildlife Range
1500 N Decatur
Las Vegas NV 89108

Jim Devos Jr
Arizona Game and Fish Dept
2221 W Greenway Rd
Phoenix AZ 85023

Darren Divine
5010 Indian River Dr # 370
Las Vegas NV 89103

Charles Douglas
1444 Rawhide Rd
Boulder City NV 89005

Bill Dunn
NM Dept of Game & Fish
Villagra Bldg
PO Box 25112
Santa Fe NM 87504

Don Ebert
1974 Fort Laramie Ln
Las Vegas NV 89123

Janet Edmonds
73-143 Sequva Ct
Palm Desert CA 92260

Thomas Egan
150 Coolwater Ln
Barstow CA 92311

Lee Elliot
Dept Vet Path Micro & Immuno
Univ of California, Davis
Davis CA 95616

Holly Ernest
Dept Vet Path Micro & Immuno
Univ of California, Davis
Davis CA 95616

Kristina A Ernest
405 South Pine St
Ellensburg WA 98926

Sheri Fedorchak
PO Box 63
Springdale UT 84767

Amy Fisher
NM Dept of Game & Fish
PO Box 25112
Santa Fe NM 87504

Fraternity of Desert Bighorn
PO Box 27494
Las Vegas NV 89126-1494

Art Fuller
5325 N Stockton Hill Rd
Kingman AZ 86401

Nita M Fuller
PO Box 1306
Albuquerque NM 87103

Eric Gardner
Arizona Game and Fish Dept
5025 N Stockton Hill
Kingman AZ 86401

James Kirk Gardner
2370 S 2300 W
Salt Lake City UT 84119

Bruce Garlinger
10375 Los Pinos St
Onyx CA 93255

Jeff Gould
Arizona Game and Fish Dept
7200 E University
Mesa AZ 85207-6502

Van K Graham
CO Division of Wildlife
711 Independent Ave
Grand Junction CO 81505

Anita Green
2706 W Ashlan #204
Fresno CA 93705

Gerald A Gronert
UC Davis
Dept of Anesthesia TB 170
Davis CA 95616

Jim Guymon
Utah Wildlife Resources
PO Box 606
622 N Main
Cedar City UT 84720

Milton Haderlie
PO Box 6290
Yuma AZ 85366

Ross Haley
1201 Avenue K
Boulder City NV 89005

Craig Hanke
401 Loveridge Dr
Moab UT 84532

Michael C Hansen
33911 Mt Tom Dr
Harrisburg OR 97446

Patricia Hansen
PO Box 596
Kenwood CA 95452

Dave Harper
PO Box 596
Dove Creek CO 81324

Christine Hass
Dept of Biology
Box 8238 University Station
Grand Forks ND 58202

Chuck Hayes
PO Box 1274
Julian CA 92036

Mike Hawkes
PO Box 6290
Yuma AZ 85366

Jim Heffelfinger
555 N Greasewood
Tucson AZ 85745

Robert J Henke
SAIC
14062 Denver W Pkwy # 200
Golden CO 80401

Bob Henry
9140 E County 10 1/2 St
Yuma AZ 85365

John Hervert
4119 14th St
Yuma AZ 85364

Mike Hobson
1600 W Hwy 90
Alpine TX 79830

Kenneth Holmes
1714 Royal Dr
Las Cmces NM 88001

Bryon Holt
School of Agribusiness
ASU
Tempe AZ 85287

Doug Humphreys
PO Box 954
Alpine TX 79831

Jef Jaeger
Dept of Bio Sciences
UNLV
Las Vegas NV 89154

Charles Jenner
11381 Loch Lomond Rd
Los Alamitos CA 90720

F Clair Jensen
1037 S Cedar Knolls
Cedar City UT 84720

David A Jett
390 E 2nd North
Mountain Home ID 83647

Dennis R Jones
455 W Railroad Ave
Price UT 84501

Mark C Jorgensen
Anza-Borrego
Desert State Park
Borrego Springs CA 92004

Robert W Jurgens
61111 Chuckanut Dr
Bend OR 97702

Jim Karpowitz
455 W Railroad Ave
Price UT 84501

Ronald L Kearns
PO Box 6290
Yuma AZ 85366-6290

Warren Kelly
85408 Glenada
Florence OR 97439

Steven D Kovach
PO Box 670996
Chugiar AK 99567

Paul Krausman
325 Bio Sciences East
Univ of Arizona
Tucson AZ 85721

Ray Lee
Arizona Game and Fish Dept
2221 W Greenway Rd
Phoenix AZ 85023

Leon M Lesicka
411 W "D" St
Brawley CA 92227

Kathy Longshore
Dept of Biological Sciences
UNLV
Las Vegas NV 89154

Wayne Ludington
1311 Haycock Ln
Helper UT 84526

Thomas A Lytle Sr
6895 Zenobia CR #3
Westminster CO 80030

Richard Martucci
UC Davis
Dept of Anesthesia TB 170
Davis CA 95616

Craig McCarty
PO Box 38
Hygeine CO 80533

Kathleen McCoy
PO Box 277
Window Rock AZ 86515

Henry McCutchen
3138 N Connor St
Flagstaff AZ 86004

Bill McIntyre
45431 N Elm
Lancaster CA 93534-1825

Norman McKee
PO Box 142
Panguitch UT 84759

Karen McKinlay-Jones
Arches National Park
PO Box 907
Moab UT 84532

Henry J Messing
17435 N 7th St # 2138
Phoenix AZ 85022

Bill Miller
School of Agribusiness
ASU
Tempe AZ 85287

Gale Monson
8831 N Riviera Dr
Tucson AZ 85737

Don Moore
2004 Hwy 6 & 50
Fruita CO 81521

Ralph Moore
Zion National Park
Springdale UT 84767

Miles Morett
455 W Railroad Ave
Price UT 84501

Gerald P Mulcahy CDFG
PO Box B-D
Blythe CA 92226

Brad Mullens
Dept of Entomology
University of California
Riverside CA 92521

Ron Olding
555 N Greasewood
Tucson AZ 85745

Leonard Ordway
Arizona Game and Fish Dept
7200 E University
Mesa AZ 85207-6502

Stacey Ostermann
51000 Highway 74
Palm Desert CA 92260

Andy Pauli
21091 Sioux Rd
Apple Valley CA 92308

Rebecca Peck
3125 Ross Ave
Kingman AZ 86401

Allan Pfister
BLM
E 101 Spikes Rd
Needles CA 92363

Fred E Phillips
1101 Allstow Way
Williams AZ 86046

Bob Price
Arizona Game and Fish Dept
5025 N Stockton Hill
Kingman AZ 86401-5499

Denyse Racine
5079 Westridge Rd
Bishop CA 93514

Jim Ramakka
BLM
1535 Hot Springs Rd # 300
Carson City NV 89706

Rob Roy Ramey
N112 Ramaley
Campus Box 334
Boulder CO 80309-0334

John W Ray
Box 67
Grand Canyon AZ 86023

Elena Robish
PO Box 357
Death Valley CA 92328

Esther Rubin
Dept Vet Path Micro & Immuno
Univ of California, Davis
Davis CA 96616

Pete Sanchez
PO Box
Glenwood NM 88039

Andrew Sandoval
NM Dept of Game & Fish
Villagra Bldg
PO Box 25112
Santa Fe NM 87504

Linda Seibert
PO Box 8 Moab UT 84532

Duane L Shroufe
Arizona Game and Fish Dept
12221 W Greenway Rd
Phoenix AZ 85023

Frances J Singer
Nat Resources Ecology Lab
CSU
Ft Collins CO 80523

Jerry Sintz
9209 Shad Ln
Sandy UT 84093

Bruce Sitko
Arizona Game and Fish Dept
1160 Suffock Ave
Kingman AZ 86401

William Sloan
Canyonlands National Park
Moab UT 84532

Mike Small
BLM AZ Strip
225 N Bluff
St George UT 84770

David Smith
PO Box 99
Pine AZ 85366

Terry R Spraker
2905 Stanford Rd
Fort Collins CO 80525

Craig Stevenson
Nevada Division of Wildlife
4747 W Vegas Drive
Las Vegas NV 89108

Marietta Sumner
PO Box 278
Glenwood NM 88039

Tice Supplee
Arizona Game and Fish Dept
2221 W Greenway Rd
Phoenix AZ 85023

Commanding General, US Army
White Sands Missile Range
STEWS-DES-E
Attn: Daisan Taylor
WSMR NM 88002-5048

Elroy Taylor
3948 Development Ave
Boise ID 83705

Larry Thomas
125 W 200 South
Moab UT 84532

Laura Thompson-Olais
1611 N 2nd Ave
Ajo AZ 85321

Steven Torres
CA Dept of Fish and Game
1416 9th St
Sacramento CA 95842

Dale Toweill
7253 Wapiti
Boise ID 83709

George Tsukarnoto
NV Dept of Wildlife
PO Box 10678
Reno NV 89520

Vic Vieira
Zion National Park
Springdale UT 84767

Guy Wallace
Po Box 1112
Monticello UT 84767

Mark Wallace
Dept Nat Resources Sciences
212 Woodward Hall
Univ Rhode Island
Kingston RI 02881

James H Watkins
BLM
1661 S 4th St
El Centro CA 92243-4561

Larry Watt
PO Box 5000
Central Point OR 97502

Richard A Weaver
PO Box 786
Cortez CO 81321

John Wehausen
1417 Bear Creek
Bishop CA 93514

Mara Weisenberger
210 Biosciences East
U of A
Tucson AZ 85721

George W Welsh
1954 Golden Gate Ave
Kingman AZ 86401

Robert L West
3407 S Chadbourne
San Angelo TX 76904

Steven Yamashita
711 Independent Ave
Grand Junction CO 81505

Rob Young
Arizona Game and Fish Dept
2221 W Greenway Rd
Phoenix AZ 85023

Bruce Zeller
Desert Nat Wildlife Range
1500 N Decatur Blvd
Las Vegas NV 89108

Mathew Zine
210 Biological Science
University of Arizona
Tucson AZ 85721

DESERT BIGHORN COUNCIL MEETINGS 1957-1994

Year	Location	Chair	Secretary-Treasurer	Transactions Editor
1957	Las Vegas, NV	M. Clair Aldous		
1958	Yuma, AZ	G. Monson & W. Kelly		
1959	Death Valley, CA	M. Clair Aldous	Fred Jones	
1960	Las Cruces, NM	Warren Kelly	Fred Jones	
1961	Hermosillo, Mexico	Jon V. D. Akker	Ralph Welles	
1962	Grand Canyon, AZ	James Blaisdell	Charles Hansen	C. Hansen & L. Fountein
1963	Las Vegas, NV	Al Ray Jonez	Charles Hansen	Jim Yoakum
1964	Mexicali, Mexico	Rudolfo H. Corzo	Charles Hansen	C. Hansen & D. Smith
1965	Redlands, CA	John Goodman	John Russo	Jim Yoakum
1966	Silver City, NM	Cecil Kennedy	John Russo	Jim Yoakum
1967	Kingman, AZ	Claud Lard	John Russo	Jim Yoakum
1968	Las Vegas, NV	Ray Brechbill	John Russo	Jim Yoakum
1969	Monticello, UT	R. & B. Welles	W. Glen Bradley	Jim Yoakum
1970	Bishop, CA	William Graf	W. Glen Bradley	Jim Yoakum
1971	Santa Fe, NM	Richard Weaver	Tillie Barling	Jim Yoakum
1972	Tucson, AZ	George Welsh	Doris Weaver	Charles Hansen
1973	Hawthorne, NV	Warren Kelly	Doris Weaver	Juan Spillet
1974	Moab, UT	Carl Mahon	Lanny Wilson	Juan Spillet
1975	Indio, CA	Bonnar Blong	Lanny Wilson	Juan Spillet
1976	Bahia Kino, Mexico	Mario Luis Cossio	Lanny Wilson	Charles Douglas
1977	Las Cruces, NM	Jerry Gates	Peter Sanchez	Charles Douglas
1978	Kingman, AZ	Kelly Neal	Peter Sanchez	Charles Douglas
1979	Boulder City, NV	Bob McQuivey	Peter Sanchez	Charles Douglas
1980	St. George, UT	Carl Mahon	Peter Sanchez	Charles Douglas
1981	Kerrville, TX	Jack Kilpatric	Peter Sanchez	Charles Douglas
1982	Borrego Spgs., CA	Mark Jorgensen	Rick Brigham	Charles Douglas
1983	Silver City, NM	Andrew Sandoval	Rick Brigham	Charles Douglas
1984	Bullhead City, AZ	Jim de Vos, Jr.	Rick Brigham	Charles Douglas
1985	Las Vegas, NV	David Pulliam, Jr.	Rick Brigham	Charles Douglas
1986	Page, AZ	Jim Guymon	Bill Dunn	Paul Krausman
1987	Van Horn, TX	Jack Kilpatric	Bill Dunn	Paul Krausman
1988	Needles, CA	Vernon Bleich	Donald Armentrout	Paul Krausman
1989	Grand Junction, CO	Jerry Wolfe	Donald Armentrout	Paul Krausman
1990	Hermosillo, Mexico	Raul Valdez	Donald Armentrout	Paul Krausman
1991	Las Cruces, NM	Bill Montoya	Donald Armentrout	Paul Krausman
1992	Bullhead City, AZ	Jim de Vos, Jr.	Stanley Cunningham	Paul Krausman
1993	Mesquite, NV	Kathy Longshore	Charles Douglas	Walter Boyce
1994	Moab, UT	Jim Guymon	Charles Douglas	Walter Boyce

TABLE OF CONTENTS

TECHNICAL REPORTS

COMMENTS AND STATUS REPORTS