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Desert Bighorn Council

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1996-1997

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DEDICATION

In fond memory of our friend, Sally Monson, and in gratitude for her service to the Ewes and her support of the Desert Bighorn Council, we dedicate the 1996 Transactions. She attended her first Council meeting in 1961 in Hermosillo, Mexico, with her husband Gale. Sally passed away December 11, 1995.

Desert Bighorn Council
1996 Transactions

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KEYNOTE ADDRESS
40th ANNUAL MEETING

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In the early 1950s, there were only a few biologists working on desert bighorn, largely in isolation from each other. As each of us pioneered techniques for gathering, interpreting, and correlating data and for implementing management practices, it became increasingly valuable to compare notes and exchange views with each other. These sporadic contacts were formalized in 1956 with the formation of the Desert Bighorn Council, which met the need for communicating with peers and from which numerous interagency cooperative efforts sprang to the benefit of both biologists and bighorns.

The ***Transactions*** of annual meetings became important contributions to the literature, facilitating review of data from many sources. The ultimate literature contribution was creation of ***The Desert Bighorn*** book, which brought together in one document all of the knowledge existing at that time (1981).

My life has been enriched by having made a critical decision in 1948 to do an MA thesis on Sierra Nevada bighorn instead of raccoons on the campus of the University of California, Berkeley. My advisor, Dr. A. Starker Leopold, convinced me that bighorn had sex appeal and, since the Sierra Nevada group had not been studied, a contribution to the literature could be made. What neither of us anticipated was the array of pathways to fascinating new opportunities that would appear as the years went on.

First was an invitation to coauthor a Sierra Club book, A ***Climber's Guide to the High Sierra,*** drawing on the records I had transcribed from registers on the summits of the many peaks I had climbed.

A few years after going to work with the California Department of Fish and Game, I returned to the Owens Valley on the east side of the Sierra Nevada to do a 3-year deer herd study, which involved the Sierra Nevada bighorn as competitors. Proximity to the desert led to a close association with Dick Weaver on numerous desert bighorn studies and surveys and later co-authorship of ***The Desert Bighorn*** book. During this period, I accompanied Dr. Hal Buechner on a Baja California bighorn field trip and became enamored with this magnificent peninsula, which opened many pathways later on.

More immediately, identification as a mountain big game researcher led to an assignment by the Food and Agriculture Organization of the United Nations to Iran involving urial sheep and ibex. This, in turn, led to helping found a conservation organization aimed at avoiding future debacles like the slaughter of wildlife following the Iranian revolution.

Our new group was approached by officials from Baja California Sur to assist with bighorn research and management and other natural resource projects, which expanded to Baja California Norte. Promotion of Baja bighorn projects with the Commission of the Californias led to a chairmanship of a Natural Resource Committee.

Baja experience and contacts led to managing a large travel club specializing in that area--Vagabundos del Mar. This led to freelance writing for magazines and newspapers, my current career, which led to my wife Gloria and I writing a popular book, ***The Complete Guide to Baja Camping.***

Writing and continuing involvement with bighorn and other natural issues in Mexico is opening new pathways for the future--all beginning with that decision 50 years ago to study bighorn instead of raccoons. I sincerely hope that each of you finds such pathways to new, exciting endeavors as your lives move forward.

Thank you.

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BEHAVIORAL RESPONSES OF MULE DEER AND MOUNTAIN SHEEP TO SIMULATED AIRCRAFT NOISE

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Abstract: We evaluated the effects of simulated, low-altitude jet aircraft noise on the behavior of captive desert mule deer (Odocoileus *hemionus crooki*) (N=6) and mountain sheep (Ovis canadensis mexicana) (N=5). We measured behaviors related to the number of simulated overflights/day (range=1-7) and noise levels (range=92-112 decibels [dB]). Animal behaviors were variable, but were consistently influenced less with increasing overflights, suggesting that the animals habituated to simulated sound pressure levels of low-altitude aircraft.

Key Words: aircraft noise, behavior, desert mule deer, mountain sheep, simulated noise.

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INTRODUCTION

The United States Air Force trains pilots to use terrain to avoid detection. To maintain proficiency, this training must be frequent (Holland 1991). Low altitude military training flights (<419 m above ground) are regulated by the Federal Aviation Administration and the Department of Defense. The establishment of training routes requires special air space designation 'and compliance with the National Environmental Policy Act. Most air space designations were made in the 1950s and 1960s (Holland 1991). Since then, public lands beneath military air space have often been set aside as national parks, wildlife refuges, or wilderness areas to be preserved for public use and enjoyment.

Recently, wildlife managers expressed concern about the influence of aircraft noise on ungulate populations (Asherin and Gladwin 1988). Espmark et al. (1974) reported that domestic animals responded more to low-altitude aircraft noise than to sonic booms. Caribou (*Rangifer tarandus*) exhibited strong panic responses to fixed-wing aircraft flying at <152 m, but responded less strongly to helicopters (Calef et al. 1976). Mountain sheep in Arizona's Grand Canyon, foraged less efficiently when helicopters were overhead (Stockwell et al. 1991). In California, mountain sheep moved 2 to 5 times farther the day following a helicopter survey than on the previous day and modified home range dimensions following helicopter surveys (Bleich et al. 1990). Desert mule deer in southcentral Arizona changed habitats in response to low-altitude (<100 m) aircraft, but did not change habitats when aircraft flew at altitudes >100 m (Krausman et al. 1986).

Domestic animals and wildlife initially respond to aircraft noise with a startled reaction. Jumping, galloping, bellowing, and haphazard movement were responses of large farm animals observed by Cottereau (1978). Harrington and Veitch (1991) reported that low jet overpasses caused a rather brief startle response in caribou on alpine tundra. Behavioral responses to noise have caused secondary injuries in domestic animals (Cottereau 1978) and may cause stampedes in wild animals that could result in drowning and trampling (Sinclair 1979) or other forms of mortality (Harrington and Veitch 1991).

The degree of reaction by an animal is influenced by sound intensity, duration (Ames and Arehart 1972, Borg 1981), and direction (Tyler 1991). Studies with laboratory rodents (Borg 1979), domestic sheep (Ames and Arehart 1972), and elk (*Cervus elaphus)* (Espmark and Langvatn 1985) have shown that animals can become habituated to noise, but habituation to intermittent sounds is gradual and limited in extent (Ames and Arehart 1972, Ewbank 1977, Espmark and Langvatn 1985).

The effects of auditory stimuli from jet aircraft are a potential threat to wildlife, and the response of animals to aircraft noise has become a consideration in the design of air space. Our objective is to describe the behavioral responses of desert mule deer and mountain sheep when exposed to the simulated noise of low-flying military jets.

S. K. Albert and J. Weisenberger helped maintain the captive animals. R. C. Kull, T. D. Bunch, and V. Geist reviewed earlier drafts of the manuscript. S. Klein typed the document. The project was funded by the United States Air Force and administered by the United States Fish and Wildlife Service and the School of Renewable Natural Resources, The University of Arizona, Tucson.

STUDY AREA

We conducted the study at the University of Arizona Agricultural Research Center in Tucson, Arizona Animals were enclosed in four contiguous outdoor pens (6.1 x ≥ 13.1 m) (only 2 conspecifics/pen) with ≥ 2.4-m-high fences during experiments as described by Weisenberger et al. (1996). We fed the animals alfalfa hay, mixed grain, supplemental salt, and water ad libitum.

The animals were visible from a 2.4 x 6 m observation center located 10 m from the pens. We placed reflective film on all windows of the observation center to allow free movement by observers without distracting the animals. The speaker used to simulate aircraft overflight noise was secured at a 41.5 degree angle directed toward the pens from the top of a 6-m-high scaffold, 1 m from the pens (Weisenberger et al. 1996).

METHODS

We used 5 captive-born bighorn (3M, 2F) and 6 captive-born desert mule deer (6 M). The sheep and deer were 1 to 3 and 2 to 6 years old, respectively. Use and care of captive animals followed guidelines established by the American Society of Mammalogists (1987) and the Institutional Animal Care and Use Committee (Univ. Arizona, Protocol no. 89-01-50).

The experimental design and data collection were similar to those of Weisenberger et al. (1996). During daylight hours, we simulated low-altitude aircraft noise (i.e., overflight) using a digital sound system installed in the observation trailer (Chavez et. al. 1989). We defined an overflight as each time a signal was played simulating noise generated from a low-altitude aircraft.

The sound system produced levels of simulated overflight noise from B1-B and F-4D aircraft described by Weisenberger et al. (1996). We determined the sound pressure level received by each area of the pen during the loudest overflight. Sound decreased with distance from the speaker. Animals were acclimated to the experimental pens for ≥4 weeks before overflights.

The experiment was conducted in three, 28-day seasons during summer (12 May-9 Aug 1990), late summer (13 Aug-12 Oct 1990), and spring (4 Feb-5 Apr 1991). Two deer were replaced in the study after late summer because of requirements for other studies. We exposed animals to one overflight daily (min. exposure) for days 1-7 and 22-28, and seven overflights daily (max. exposure) for days 8-21. We randomly selected type of simulated overflight (to test the type of disturbance on ungulates), time of day, and individual animals observed during simulation. We ensured there was 21 hour interval between each overflight when there were seven overflights daily so we could record behavioral data before and after each overflight.

We recorded data for 30 days preceding and 7-30 days (≤2 hours/day) succeeding each 28-day overflight period. Behavioral data (e.g., walking, standing, running, foraging, bedding) were collected during the pre- and post-overflight periods using scan sampling (Altmann 1974).

Behavioral responses of animals to simulation events were categorized as by Hicks and Elder (1979). When overt behavior did not indicate reaction to the stimulus, we entered a recording of "no response." "Alerted response" was recorded when animals looked toward or directed their ears toward the speaker, but did not otherwise alter activities.

We compared observations from baseline (prior to all simulated overflights) and treatment periods (after all simulated overflights) by season to determine if there were chronic behavioral changes in response to simulated overflights. We compared the observations in each behavior class between baseline and treatment periods, and among animals and seasons, with Chi-squared analysis.

We calculated the length of time spent in each activity during treatment periods from continuous focal animal sampling (Altman 1974). We conducted Chi-squared analysis on the time spent in each behavior class during treatments, and conducted repeated measures analysis of variance (ANOVA) to determine the relationship between low-level aircraft noise and behavior of ungulates by examining the amount of time animals were active across seasons.

RESULTS

Variation among individuals in the amounts of time spent in activities and the mean duration of activities among treatments was significant ($\underline{P} < 0.05$). We detected no consistent trend in time spent walking, standing, running, foraging, or bedding across seasons.

We measured duration of behaviors during treatments to see if rate of change between behaviors increased, even if total time in each behavior did not. There was significant ($\underline{P} < 0.05$) variation among individuals confounding effects in all seasons. However, some behavior was significantly ($\underline{P} < 0.05$) different between seasons: mountain sheep foraged more in spring than late summer; deer walked more in spring than summer, and bedded more in summer and late summer than spring (Table 1).

There were 112 simulated overflights/season but ≤34 responses by either species during any season (Weisenberger et al. 1996, Table 5). Alerted response times for mountain sheep decreased over the seasons with no consistent trend in number of alerted responses (Weisenberger et al. 1996, Table 5). The number of mule deer alerted responses decreased from summer to late summer, but response times were similar among seasons.

DISCUSSION

The decrease in response times for mountain sheep (Weisenberger et al. 1996) suggests they habituated to the aircraft noise, although Bleich et al. (1994) reported no habituation of mountain sheep to disturbances associated with helicopter surveys. Mule deer also appear to have habituated to the simulated noise (Weisenberger et al. 1996). However, because the two deer added to the study after late summer were not exposed to previous simulation, their increased reactions may have influenced the behavior of animals that had become habituated.

Mean ambient temperatures during summer, (32°C), late summer (29°C), and spring (18°C) may have contributed to behavior patterns. Overall, the animals engaged less in active behaviors during late summer than in other seasons. Although mean temperature was lower in late summer than in summer, the range of temperatures was greater and hotter temperatures were reached, possibly causing an extension of inactivity periods.

Animals can habituate to some human-related disturbances (Dorrance et al. 1975, MacArthur et al. 1979, Espmark and Langvatn 1985, Yarmoloy et al. 1988; but see Bleich et al. 1994). On the other hand, they strive to live in predictable, secure environments at the lowest maintenance costs (Geist et al. 1985). Elk (Czech 1988), mountain sheep (Geist et al. 1985), mule deer (Krausman et al. 1986), caribou (Harrington and Veitch 1991), and whitetail deer (Odocoileus *virginianus*) (Dorrance et al. 1975) have all been shown to respond more severely (per disturbance event) to unpredictable human disturbance than to regular human disturbance.

Because of the variation in behavior among individuals observed, it would be exceedingly difficult to ascertain the differential impact of specific original versus general maintenance behavior interruption, or to determine the level at which a disturbance could limit a population. Exposure to prolonged, frequent, and unpredictable human disturbance may severely affect behavior, with implications on the physiology of individuals and potentially the dynamics of populations (Geist 1971, Bleich et al. 1994). Our study shows that aircraft noise fits within the general set of disturbances that animals can habituate to at moderate levels, (i.e., ≤7 overflights/day). A set of such disturbances may comprise a "cumulative limiting factor." Therefore, managers and policy-makers involved in the use and designation of air space should strive to minimize the severity, frequency, and unpredictability of low-altitude aerial disturbance over areas used by wildlife.

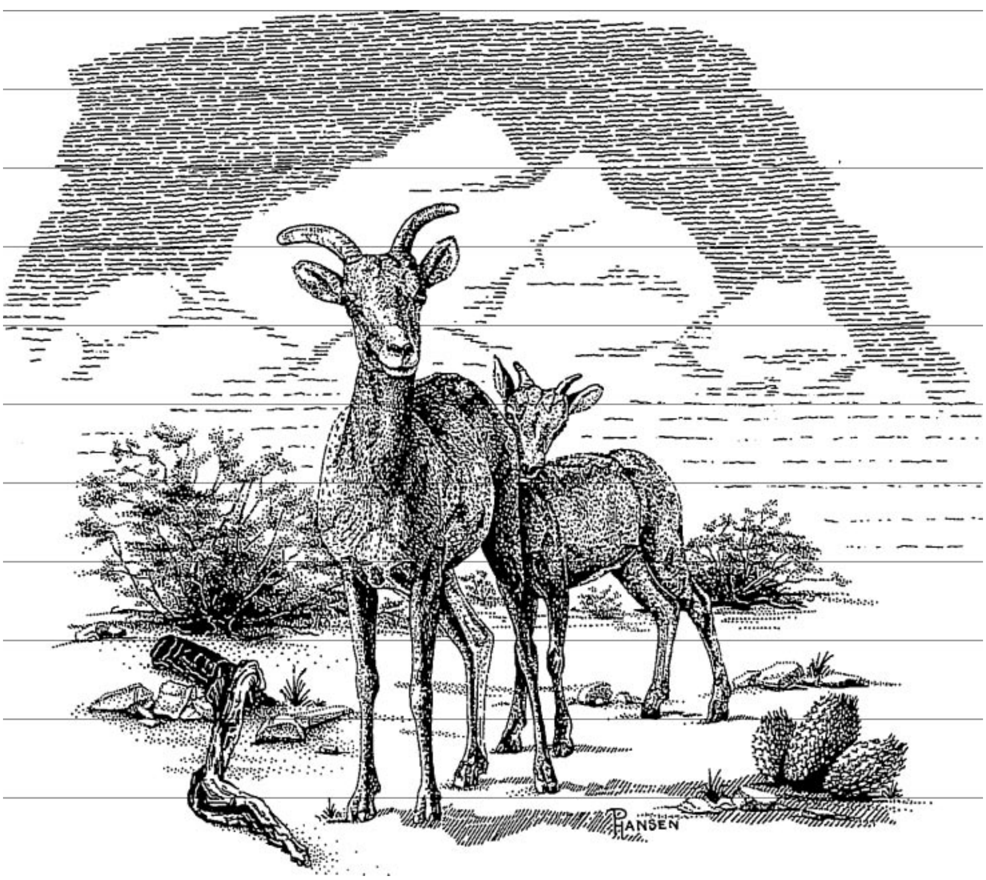

Table 1. *Mean duration (sec) of behaviors recorded for mountain sheep and desert mule deer during overflight treatment periods at the University of Arizona, Tucson, 1990-91.*

Behavior class	Mountain Sheep (N = 4) X̄	SE	N	Mule deer (N = 4) X̄	SE	N
Summer[a]						
Walk	32.22	2.44	337	26.64A[b]	3.15	157
Bed	999.97	198.95	87	1,761.51B	373.51	49
Stand	102.05	30.45	360	91.56	7.31	199
Run	11.35	1.42	63	21.71	4.04	14
Forage	130.98	17.01	50	132.05	14.54	55
Active[c]	58.82	15.48	710	49.03	4.26	315
Inactive[d]	999.97	198.95	87	1,761.51[c]	373.51	49
Late summer[a]						
Walk	30.89	4.63	283	22.94	4.27	89
Bed	731.01	69.40	68	1,183.78D	69.55	78
Stand	62.29	5.76	306	125.81	16.46	110
Run	11.79	2.08	14			
Forage	80.62E	10.40	68	208.97	36.44	33
Active	42.03	3.92	535	54.13	8.21	166
Inactive	731.01	69.40	68	1,183.78F	69.55	78
Spring[a]						
Walk	33.69	7.46	106	48.40A	8.15	131
Bed	729.7	82.73	46	905.59BD	117.38	29
Stand	107.7	11.54	148	135.42	13.03	148
Run	42.65	34.87	17	2.00		1
Forage	236.05E	45.06	22	202.98	30.06	45
Active	60.06	6.53	249	73.41	7.31	235
Inactive	729.70	82.73	46	905.59CF	117.38	29

[a]Summer = 12 May-9 Aug 1990, Late summer = 13 Aug-12 Oct 1990, Spring = 4 Feb-5 Apr 1991.
[b]Values in columns with the same uppercase letters differ significantly (P 0.05) (ANOVA).
[c]Active = walking, standing, running, forage, defecating, urinating, play, dominance display, and reproductive activity.
[d]Inactive = bedded, ruminating, panting, altering bedding positions.

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DESERT BIGHORN SHEEP RECOVERY PROJECT IN BAJA CALIFORNIA SUR, MEXICO

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Abstract: Carmen Island lies east of Loreto, Baja California Sur Mexico, and is privately owned by Salinas Del Pacifico Company. The island was operated as a salt mine until the early 1980s, but under new ownership, these operations have ceased and wildlife conservation programs have been established for the island. In October 1995, a proposal was made to the Mexican State and Federal Governments for the capture, introduction, and management of desert bighorn (Ovis canadensis weemsi) on Carmen Island, with the ultimate goal of improving the status of weemsi bighorn on the Baja California Sur mainland. The objectives of this project call for the research and conservation of *O.* c. weemsi, and include provisions for the future relocation of bighorn back to historical bighorn range on the mainland. In December 1995, 15 bighorn were captured from the El Mechudo area north of La Paz for translocation to Carmen Island. Bighorn on Carmen Island are monitored daily via radiotelemetry, and a patrol system has been established for protection from poaching. Research projects on the island include an analysis of bighorn demographics, habitat use, diet, and reproductive success, as well as inventories of bird and plant species.

Key Words: Baja California Sur, captive breeding, Isla del Carmen, Ovis canadensis weemsi, recovery program, reintroductions, translocation

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INTRODUCTION

Desert bighorn sheep (Ovis *canadensis*) originally occurred in the mountainous areas of northern Mexico in the states of Baja California, Baja California Sur, Sonora, Chihuahua, and Coahuila (Leopold 1977); however, presently they occur only in Sonora, Baja California, and Baja California Sur. Several factors are thought to be responsible for reducing the distribution of bighorn in Mexico. Among these are illegal hunting and habitat destruction due to human intrusions such as recreational use, mining, and road construction (Buechner 1960, Cassio 1975, Araujo 1976, Valverde 1976, DeForge et al. 1993). The introduction of livestock (mainly domestic goats and cattle) has also contributed to the decline of bighorn sheep by reducing the amount of habitat available and increasing the incidence of infectious disease and parasites (Araujo 1976, DeForge et al. 1989, DeForge et al. 1993).

Desert bighorn sheep (*O.* c. weemsi) in Baja California Sur occur principally in three areas: Las Virgenes (near Santa Rosalia), La Giganta (near Loreto), and El Mechudo (southern Baja Sur). We estimate that desert bighorn sheep in Baja California Sur occupy only about 40 percent of their historical range. Given the lack of published information on weemsi ecology and distribution, their declining status, and their ecological, aesthetic, and financial importance in Baja California Sur, a program for their recovery to a viable population is needed. The urgency of the situation and the difficulty in quickly remedying conditions for wild bighorn populations in Baja Sur make captive breeding a logical component of the recovery program. The advantages of captive propagation include: moderation of environmental variance; protection from poaching; management of genetic diversity; research opportunities; and expansion of animal numbers, ultimately to provide stock to augment wild populations. Releasing captive-born animals into the wild to support weak populations (restocking) or to repatriate historical habitat is an increasingly common practice for the recovery of small wildlife populations (Kleiman 1989, Snyder et al. 1996).

In 1995, Carmen Island, located in the Sea of Cortez, was designated as a preserve for the establishment of a managed, breeding herd of desert bighorn sheep. The island is an ideal area for introducing this species because the topography and vegetation are similar to habitat of *O.* c. weemsi on the mainland. In addition, Carmen Island has the following advantages: (1) an absence of large mammals, predators, and domestic or feral animals, which eliminates problems of spatial and forage competition and disease transmission; (2) very limited and controlled human activity; (3) an isolated location so that in the event of an ecological catastrophe Carmen Island can serve as a reservoir for the species, thereby preserving the species' genetic integrity. Besides providing stock for augmenting mainland bighorn populations, the Carmen Island bighorn project provides the opportunity to gather baseline data on weemsi bighorn and initiate long-term research. Here we provide an overview of the Carmen Island bighorn project, its objectives, progress, and future plans. Please refer to DeForge et al. (1996) for details regarding our population modeling, helicopter survey/search results, capture methods, and disease and nutrition testing of captured bighorn.

We appreciate the thoughtful conservation ethic of the Sada Family, who made this project possible. We also thank the Governor of Baja California Sur, the Mexican Wildlife Officials, and the local communities of Baja Sur for their cooperative efforts in the Carmen Island project.

STUDY AREA

Carmen Island is located 350 km north of La Paz, Baja California Sur, between 25 49'05" and 26 03'49" north latitude and 112 14'32" and 112 04'42" west longitude, approximately *6* krn east of Loreto. It encompasses a total surface area of 151 km^2 about 27 km long and 9 km wide, of which 80 percent consists of a mountain chain of volcanic origin (Gastil et al. 1983). The highest peak reaches 478 m. **A** large salt deposit in the northeast part of the island was mined by Salinas del Pacifico, S. **A.** until the early 1980s.

The island contains several large, year-round tinajas and three manmade wells. Vegetation is classified as Xerophilous Chaparral (Rzedowski 1981), dominated by grasses (Boutelova sp.), burrobush (Ambrosia), cholla (Opuntia cholla), cardon (Pachicereuspringlei), palo verde (Cercidium sp.) and mesquite (Prosopis *glandulosa*). Distribution of the plant *Ferocactus* diguetii is limited to the Gulf Islands, and one variety, *carmenensis* is thought to be endemic to Carmen Island (Case and Cody 1983). The vegetation on Carmen Island closely resembles the vegetation found in weemsi habitat on the Baja California Sur mainland, which Cowan (1940) described as subtropical.

Carmen Island lacks large mammal species and only four terrestrial mammals inhabit the island: the black-tailed jack rabbit (*Lepus californicus*), spiny pocket mouse (Perognathus spinatus), rata nupalera (Peromyscus eva), and desert woodrat (Neotoma lepida). Bird species include osprey (Pandion *haliaetus*), red-tailed hawks (Buteo jamaicensis), turkey vultures (*Cathartes* aura), great homed owls (Bubo virginianus), frigatebirds (*fregata magnificens*), and blue-footed boobies (*Sula nebouxii*). Sixteen species of reptiles (10 lizards and 6 snakes species) have been recorded on the island, including an endemic snake Leptotyphlopus *humilis* lindsayi (Case and Cody 1983).

CARMEN ISLAND BIGHORN PROJECT OBJECTIVES

The general objective of the Carmen Island bighorn project is to improve the status and management of *O.* c. weemsi populations in Baja

California Sur by providing the following three elements: (1) a genetic and demographic reservoir that can be used to reinforce wild populations by augmenting remnant populations or reestablishing populations that have gone extinct; (2) opportunities for research on capture animals that can provide information and technologies beneficial to wild populations, in addition to creating an impetus for research on wild populations; and (3) living ambassadors that can assist in educating the public and generating funds for conservation (Foose et al. 1995). Other spec c objectives are to: (1) maintain the integrity of the Carmen Island ecosystem by monitoring a number of plant and animal species; (2) elaborate a management master plan for the *weemsi* that includes population monitoring, captive breeding methodology, reintroductions, hunting, and community education; (3) improve habitat conditions by eliminating feral and domestic animals near or within bighorn habitat; and (4) create an interest in the conservation and rational use of bighorn in the community of Loreto and throughout Baja Sur.

SUMMARY OF ACCOMPLISHMENTS

In October 1995, we presented a detailed conservation program to the Federal and State governments, as well as to Mexican ecological organizations, for *O. c. weemsi*. The program involves transplanting bighorn from the mainland to Carmen Island and augmenting mainland populations with excess stock from Carmen Island. The program received total approval.

To evaluate the feasibility and logistics of transplanting a viable bighorn population to Carmen Island, we assessed habitat quality and modeled a bighorn population on the island using a computer simulation model. DeForge et al. (1996) provide results from using the software program VORTEX 7.0 (Lacy et al. 1995) to project the population's growth rate, probability of extinction, mean size, and genetic variation over the next 25 years, after accounting for demographic, environmental, and genetic stochasticity. We also conducted a helicopter survey/search for desert bighorn sheep populations in Sierra La Giganta near Loreto and in El Mechudo to determine where to remove bighorn from the mainland population. Only a small number of bighorn were observed near Loreto, but a dense population was located in El Mechudo (DeForge et al. 1996). Consequently, the Federal government authorized the capture of 15 bighom in the Sierra El Mechudo.

On December 5-8 of the same year, with the assistance of personnel from New Mexico State University and the Bighorn Institute of California, 15 bighorn were captured using a net-gun fired from a Hughes 500D helicopter. The captured animals were measured, biologically sampled, and fitted with radio collars and ear tags. After transport to an airport, the animals were moved by a Cessna 206 to Carmen Island and released.

Biologists and veterinarians are working full-time monitoring the wild sheep population, as well as the island ecosystem. The sheep are free-ranging on the island with no supplemental food or water, but habitat conditions are continually observed so that supplemental feed and water can be provided and additional native plants added if necessary. Data is being collected for bighom demographic, reproductive success, habitat use, and nutrition studies. The Carmen Island project offers a unique opportunity to measure survival and population growth rates in an ideal environment with no predation. To ensure that the ecological integrity of the entire island ecosystem is preserved and to prevent illegal hunting, personnel patrol the perimeter of the island daily. Bird and plant inventories are being conducted in cooperation with New Mexico State University. Fences are being constructed to protect rare and endemic plants on the island and to allow us to evaluate the impact that bighom have on the native vegetation. In an effort to include the local people in this conservation plan and to compensate them for the removal of bighorn sheep from the Baja Sur mainland, the Sada Family provided funding for water pumps, electric solar systems, and a classroom. Support from the local community is considered vital to the success of this project and to the recovery of *weemsi* bighorn.

FUTURE PLANS

To maintain genetic diversity within the Carmen Island bighorn population and to mimic natural gene flow, we will transplant three rams from the mainland to Carmen Island every 5 years. Beginning in the fourth year of the project, we expect to release a minimum of 5 males and 5 females back to the mainland every other year. We project having a population of 120-150 wild sheep on the island within 20 years (DeForge et al. 1996). Our plan to reintroduce bighorn to the mainland will more than compensate for the sheep initially removed from Sierra El Mechudo. Adaptive management must be exercised (Stanley Price 1991), but excess stock from the Carmen Island population will be used to augment small existing populations or to repatriate historical habitat on the mainland.

Several measures should be taken in preparation for returning bighorn sheep to the mainland. A helicopter survey of the entire *weemsi* range is needed to gain a cursory understanding of *weemsi* distribution and abundance so that we can optimize our restocking efforts. Once a population is identified for augmentation with sheep from Carmen Island, the local people will be consulted and their consent and support obtained prior to a final decision on the release site. Next, all domestic and feral livestock should be eliminated from bighorn habitat in the release area. All released bighorn will be disease-tested to ensure their health status and radio-collared to allow postrelease monitoring.

We are hopeful that the Carmen Island bighorn project will provide motivation to the government and people of Baja Sur to actively conserve bighorn sheep. As Valverde (1976) stated, unless we find ways to effectively protect bighorn sheep from man's illegal hunting and destruction of habitat, bighorn sheep will slowly disappear. For this reason, we will continue our public education efforts and community relations development. Our objective to conduct long-term research on *weemsi* bighorn and to improve the overall status of the population also provides the important opportunity to increase peninsular populations to huntable levels. The Carmen Island bighorn project is a key element of the recovery program to improve the overall status and management of *weemsi* bighorn, and our effort to preserve the diverse flora and fauna of Carmen Island.

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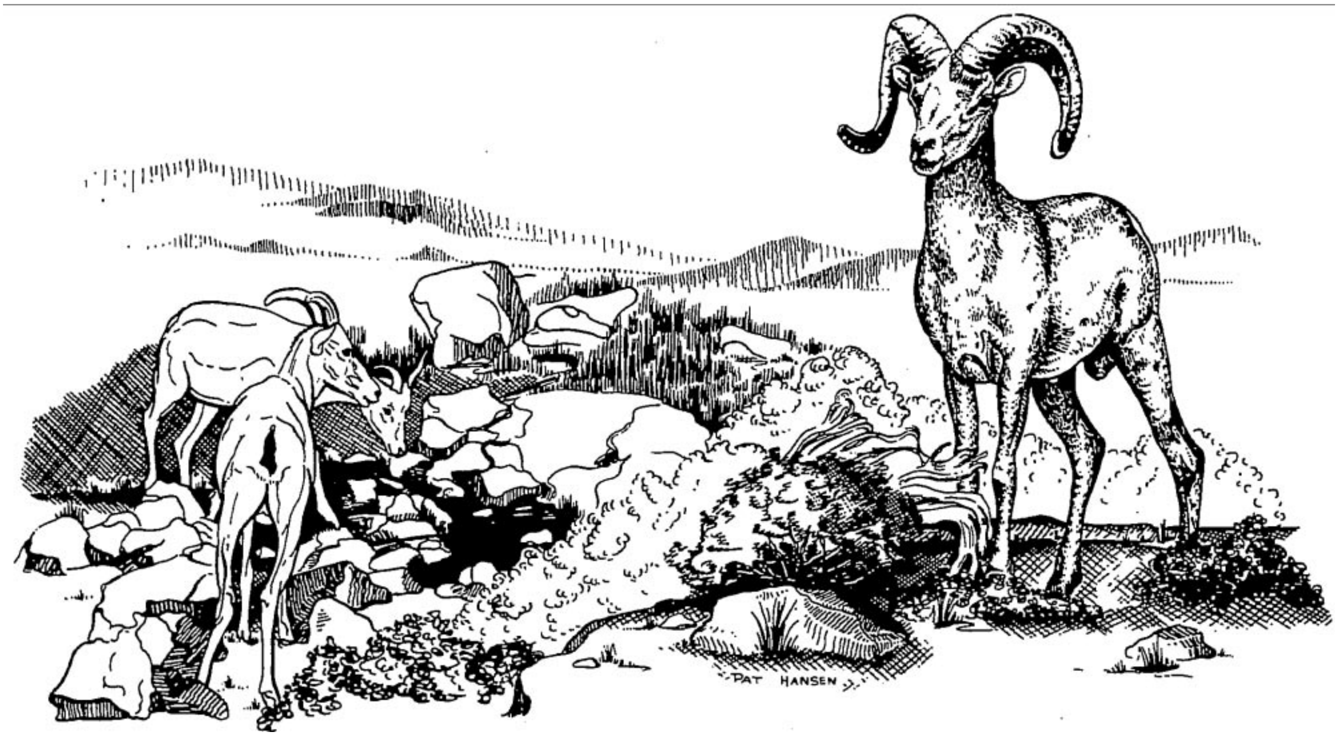

EFFECT OF SCALE ON DEFINING TOPOGRAPHICALLY SUITABLE DESERT BIGHORN SHEEP HABITAT.

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Abstract: Geographic Information Systems (GIS), satellite imagery, and other remote sensing tools have greatly aided research efforts in many areas of wildlife science, but not without both identified and hidden dangers. This study was specifically designed to show how composition or juxtaposition of a crucial habitat variable, Land Surface Ruggedness, is dependent upon the resolution of elevation data being used in the habitat evaluation.

Key Words: scale, GIS, satellite imagery, remote sensing, Land Surface Ruggedness Index (LSRI), habitat evaluation

Desert Bighorn Council Transactions 40:13-18

INTRODUCTION

Geographic Information Systems (GIS), satellite imagery, and other remote sensing tools have greatly aided research efforts in many areas of wildlife science, but not without both identified and hidden dangers. GIS programs are useful in identifying and viewing spatial patterns of critical resources, animal home ranges, and various habitat parameters. But caution must be used when employing GIS technology to examine data at multiple resolutions because researchers have known for several decades that the concepts of scale and pattern are inexorably linked (Hutchinson 1953). Wiens (1992) noted that researchers have realized many patterns seen in ecological studies are dependent upon the scale at which they are viewed. Levin (1992) stated that no environmental predictions can be made, or ecological parameters evaluated, without first referencing the scale relevant to the organism or process under investigation. Because of knowledge of these scalar issues, many researchers are very cautious in matching the scale of their measurements to the question under investigation. For example, a researcher studying an animal with a home range of a few square meters will not measure vegetation via square hectare quadrats. Unfortunately, researchers often do not consider how the resolution of their underlying data (e.g., elevation data) can potentially alter their findings. The purpose of this study is to highlight the effects of scale on habitat evaluation. Specifically, this study is designed to show how composition or juxtaposition of a crucial habitat variable, Land Surface Ruggedness, is dependent upon the resolution of elevation data being used in the habitat evaluation.

STUDY AREA

The study area for this investigation is the Eldorado Mountains, located in Clark County, in southern Nevada. The range stretches approximately 60 km from north to south, and encompasses approximately 930 km^2. Elevations range from 197 m to 973 m (Ebert and Douglas 1993).

METHODS

To illustrate this specific scalar danger, we used a modified version of the Land Surface Ruggedness Index (LSRI) that Ebert and Douglas (1993) adapted from Beasom et. al. (1983). The basic tenet behind LSRI is that the total length of topographic contour lines traversing an area is a function of the "ruggedness" of that area. Beasom et. al. (1983) measured Land Surface Ruggedness by overlaying a regularly spaced grid over the area under investigation and counting the number of intersections between contour lines and the grid. The number of intersections reflects the ruggedness of the area, with a higher number of intersections equating to a "rougher" landscape. Although this method is replicable and straightforward, it does not transfer easily into GIS applications. Thus, Ebert and Douglas (1993) adapted Beasom et. al's. (1983) technique for use in a GIS program by developing a Land Surface Ruggedness Index generated by gridding an elevation map into 100 m x 100 m squares and measuring the slope from each cell to each of its surrounding eight cells. It was found that both total slope (the summation of all slope values within the 300 m x 300 m window) and average slope (the average of all slope values within the 300 m x 300 m window) gave equally good approximations of total contour line length. However, because total slope gave a larger range of values to subdivide into categories, total slope was chosen over average slope to serve as the LSRI value. Because this current study is designed to compare two different resolutions of elevation data, and because the number of cells in a 300 m radius circle differs between resolutions, we had to choose average slope instead of the total slope as used by Ebert and Douglas (1993) to maintain an equitable comparison. Based on the data in Ebert and Douglas (1993), this alteration is not a significant departure from the original method utilizing total slope.

Two resolutions of elevation data, 30 m data and 3-arc-second data, were obtained from United States Geological Service (USGS) digital files and downloaded into Geographic Resources Analysis Support System (GRASS) GIS. Cell size of 30 m data is 30 m X 30 m, and cell size of 3-arc-second data, in this region of the country, is approximately 90 m X 70 m. To calculate an LSRI for the **30** m data, we first generated a slope map from the elevation data using percent slope as the output. Slope values were then averaged within an 11 X 11 cell window (330 m X 330 m) centered over each cell (Figure la). To calculate an LSIU for the 3-arc-second data, the elevation data were first re-sampled using ARC/INFO to produce a regular 100 m X 100 m grid. Percent slope values were then calculated within GRASS and averaged within a 3 X 3 cell window (300 m X 300 m) centered over each cell (Figure lb). The cell windows cannot be the exact same size for both resolutions because the necessity of a center cell dictates an odd number of rows and columns. Thus cell window size for 30 m data can be 270 m x 270 m, or 330 m by 330 m, but not 300 m x 300 m. We decided it was appropriate to use the 330 m x 330 m window because it is slightly larger than the 300 m x 300 m window in 3-arc-second data.

Location data from 39 radio-collared bighorn sheep (22 females and 17 males) were supplied by Ebert and Douglas (1993). Each animal was relocated approximately once a week over a 2-year period, yielding a total of 2909 sheep locations. Sheep locations were then associated with their corresponding LSRI value in each data set. **A** paired t-test (Zar 1984) was conducted to determine if the mean LSRI value of sheep locations was different between the two resolutions.

RESULTS

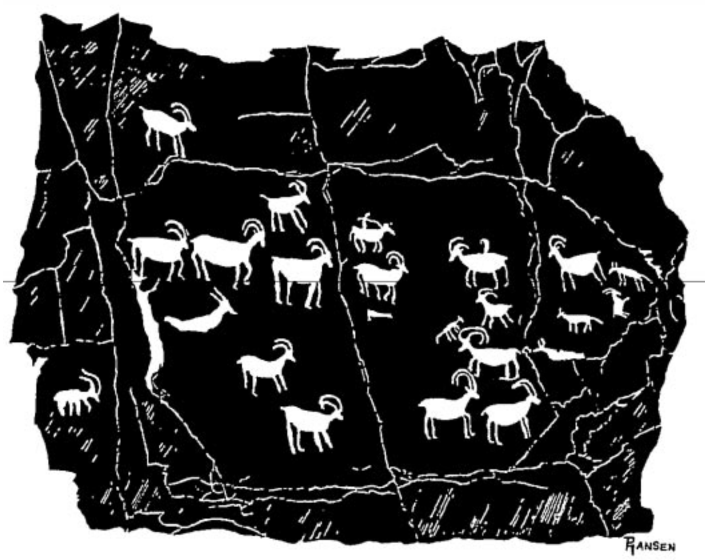
The distribution of sheep locations relative to LSRI values changed from one data resolution to the other. Thirty meter data (Figure 2) show a fairly normal distribution of LSIU usage. Three-arc-second data (Figure 3) shows a distribution heavily skewed towards the left and lower LSRI values.

At the 95 percent significance level, the mean LSRI values of each data set are not equivalent (Table 1). The mean LSRI value of the 30 m data set is 36.56, while the mean LSRI value of the 3-arc-second data set is 20.43 (Table 1). The t value of 76.35 is much larger than the two-tailed critical t value of 1.96, indicating that the two means are statistically different (Table 1).

DISCUSSION

LSRI values of sheep habitat change dramatically depending upon which elevation data are used. The reason for the disparity is the relative smoothness of the underlying data. Elevation values in 3-arc-second data tend to be smoother than elevation values in 30 m data. In 3-arc-second data, an area of approximately 6300 m^2 (90 m x 70 m) is only assigned a single elevation value. Therefore, any elevational variation due to peaks and valleys within that 6300 m^2 tends to be masked. Using 30 m data, that same area is represented by approximately seven elevation values (30 m x 30 m cells). Although elevation data are still being averaged within each of the seven 900 m^2 cells, the six additional elevation values within each 6300 m^2 area helps to unmask elevational variation due to peaks and valleys. This difference in relative smoothness can have severe consequences for data evaluation. At 30 m resolution, 80 percent of the sheep locations were represented by average slope values (LSRI) of 0-49 percent. At 3-arc-second resolution, these locations were represented by average slope values (LSRI) of only 0-29 percent.

The take-home message from this investigation is to be extremely mindful of underlying data sets. We are not trying to argue for use of one resolution over another, mainly because there is no absolute 'best" resolution, and because often data for an area under investigation may only be available at a limited number of resolutions. The "best" resolution is the one that best fits the question under investigation. The point we are trying to make is that a researcher must be aware that patterns discovered at one resolution are not automatically present at other resolutions. It is dangerous to assume that because one habitat parameter appears to be the most important variable in habitat delineation at one resolution, that same habitat parameter will continue to be the most important at some other resolution. As you move up and down in the resolution at which you view a landscape, the proportions and relative importance of components making up that landscape may change and rearrange. It is the researcher's responsibility to ensure that when comparing data from different spatial or temporal scales, the resolutions are carefully noted and that a valid comparison is being made.



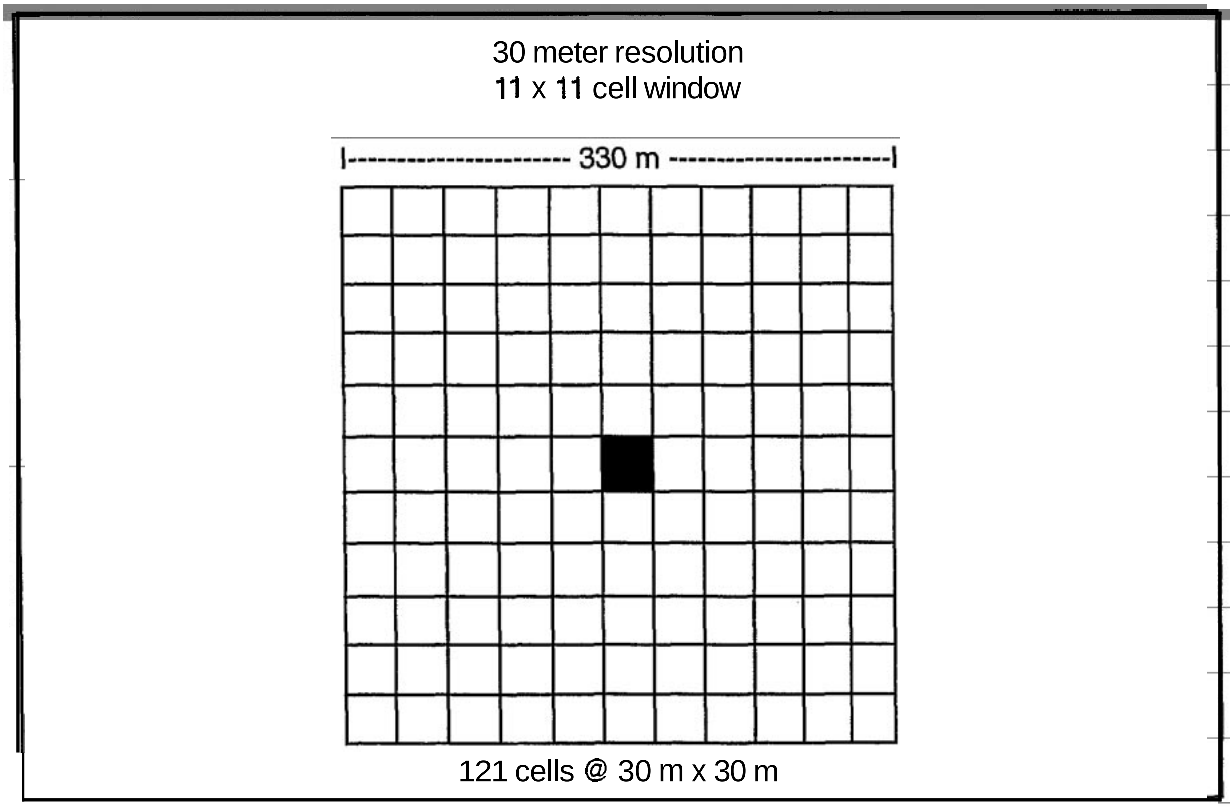


Figure 1a.

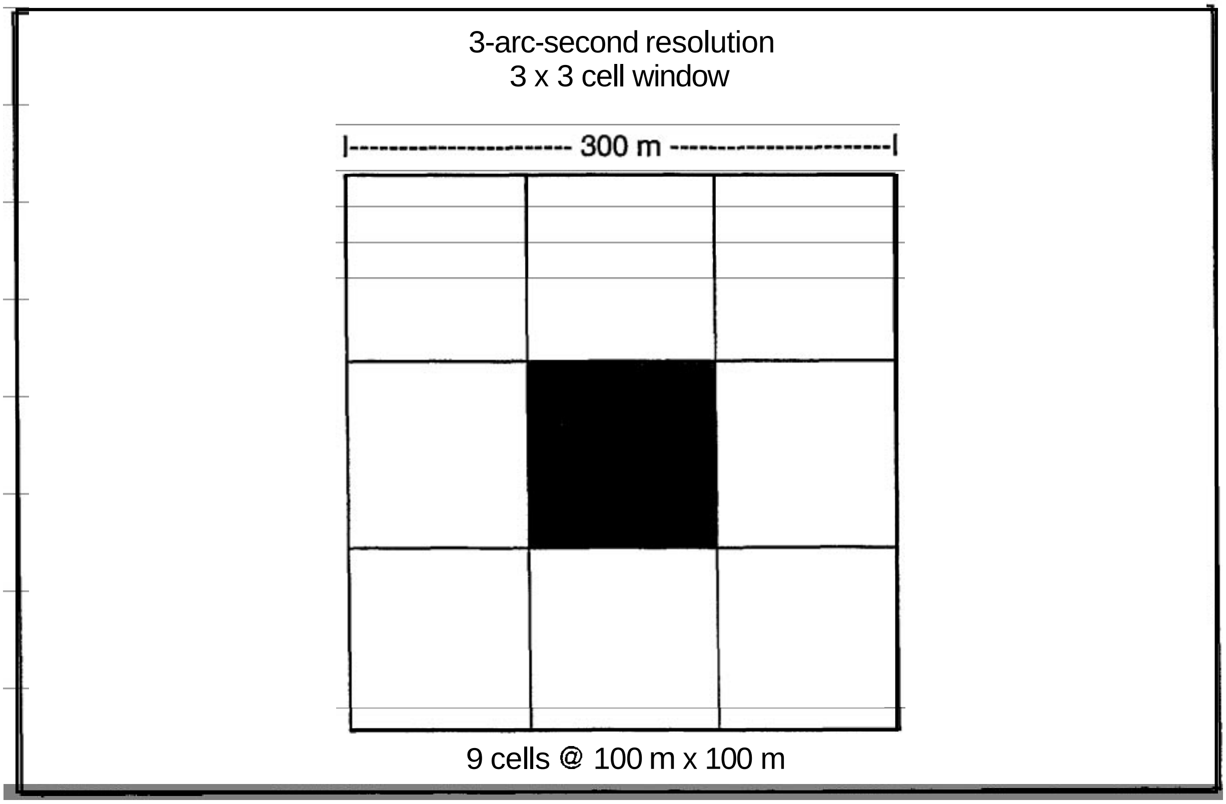


Figure 1b.

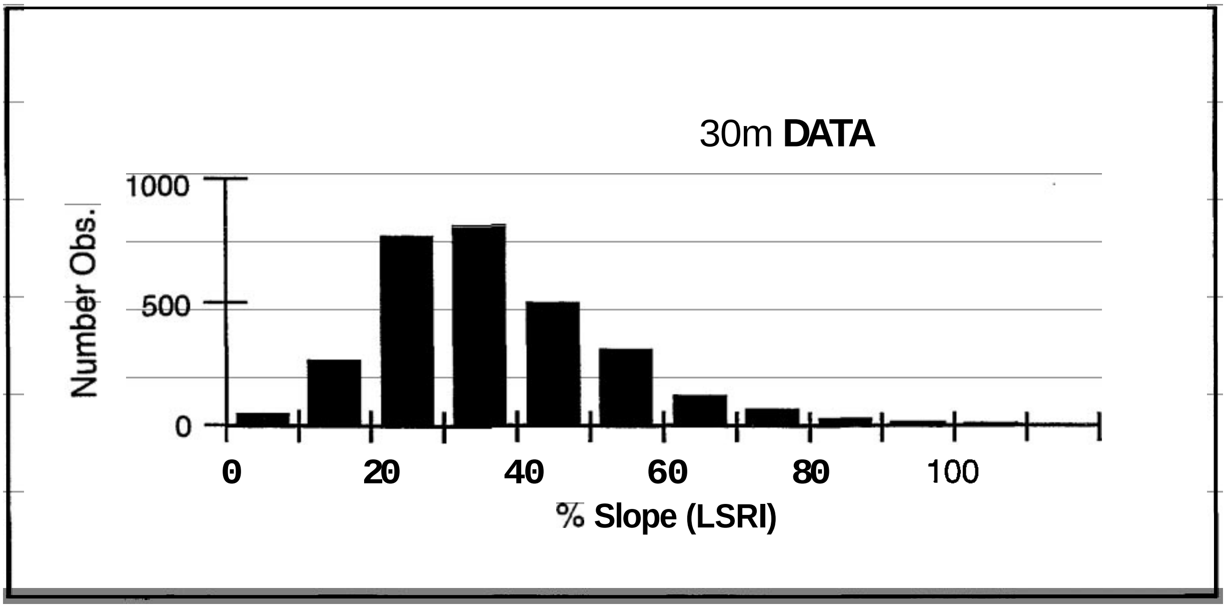


Figure 2. *Histogram showing distribution of sheep locations relative to slope (LSRI) values for 30 m resolution elevation data.*

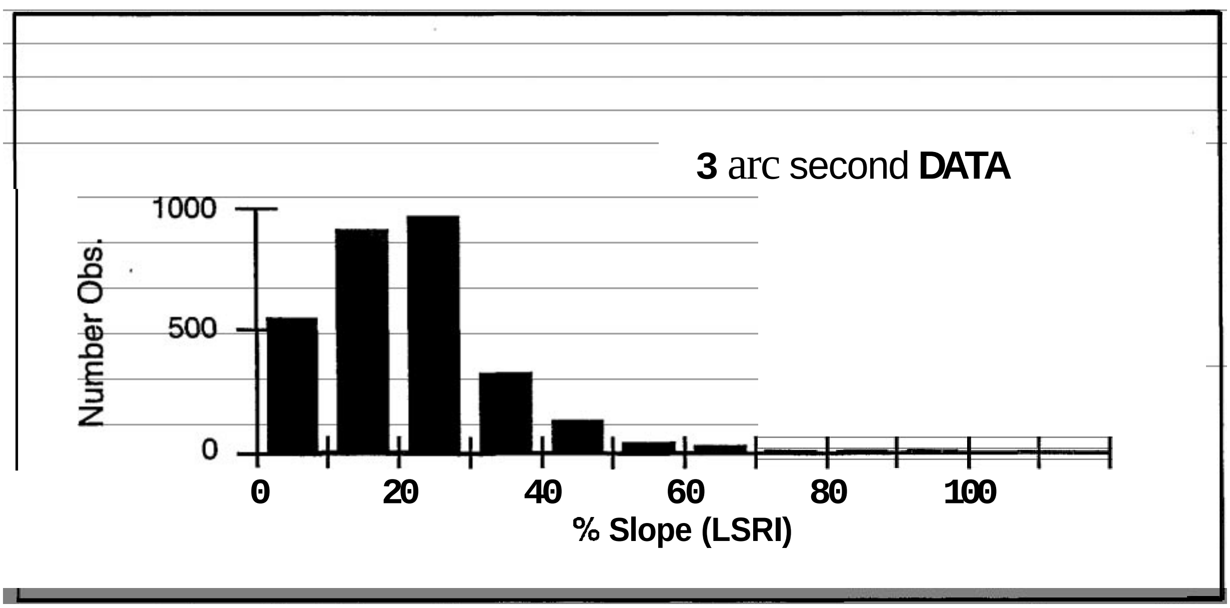


Figure 3. *Histogram showing distribution of sheep locations relative to slope (LSRI) values for 3-arc-second resolution elevation data.*

Table 1. *Results of a paired t-test comparing slope (LSRI) values of sheep locations at 30 m and 3-arc-second resolution elevation data.*

t-Test: Paired Two-Sample for Means	30 meter	3 arc second
Mean	36.56	20.43
Variance	244.50	132.25
Observations	2909	2909
Pearson Correlation	.6866	
Pooled Variance	123.47	
Hypothesized Mean Difference	0	
df	2908	
t	76.35	
t Critical one-tail	1.6454	
t Critical two-tail	1.9608	

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ERROR ASSOCIATED WITH LORAN-C: EFFECTS OF AIRCRAFT ALTITUDE AND GEOGRAPHIC LOCATION

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Abstract: We examined effects of altitude of a fixed-wing aircraft and geographic location on the accuracy of LORAN-C at a series of reference points (n=8) within a 420 km^2 area of the eastern Mojave Desert of California. No relationship between error (distance between the "actual" location of the reference point and its estimated location using LORAN-C) and aircraft altitude above the point was detected (P=0.910). Additionally, no significant difference was detected between the mean error when flying at high (>500 m) or low (≤500 m) altitudes; however, precision was greater at low altitudes, suggesting parallax was a potential source of error. The effect of individual geographic locations on mean error was highly significant when aircraft altitude was used as the concomitant variable (P<0.001), suggesting that landscape features associated with the reference points were potential sources of error. Researchers using LORAN-C should be aware of the variability in accuracy of this technology, even within small study areas.

Key Words: accuracy, aerial telemetry, biotelemetry, California, LORAN-C, survey, telemetry, ungulate

Desert Bighorn Council Transactions 40:19-21

INTRODUCTION

The use of aerial observations and aerial telemetry has become common among biologists (Caughley et al. 1976, White and Garrott 1990). Since the advent of complex navigational systems such as LORAN-C and Geographic Positioning Systems (GPS), investigators have become increasingly reliant on these technologies for estimating the location of telemetry transmitters, wildlife observations, or landscape features that may not appear on topographic maps.

Jaeger et al. (1993) cautioned about effects of geographic location on the accuracy of LORAN-C among study areas, but such differences within study areas have not been reported. Moreover, the effect of elevation on the accuracy of locations estimated with LORAN-C has been investigated only from the standpoint of the elevation of the location in question, without respect to aircraft altitude (i.e., the altitude of the aircraft above the "target") (Leptich et al. 1994). Our objectives were to: 1) examine the relationship between LORAN-C error (distance from the target's true location and its estimated location using LORAN-C) and aircraft altitude; and 2) examine effects of unique geographic locations on the accuracy of LORAN-C within a small study area. We hypothesized that: 1) there would be a positive relationship between error and aircraft altitude; and 2) within our study area, there would be no effect of geographic location on our ability to accurately determine the locations of predetermined points (i.e., mean error would not differ among those points).

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STUDY AREA

We conducted this research in the Mojave Desert, about. 30 km southeast of Baker, San Bernardino County, California. The study area (420 km^2) is topographically diverse and has been the site of considerable mining activity, suggesting the potential for extensive mineral deposits. A major power transmission corridor bisects the study area from east to west.

METHODS

We selected eight readily identifiable targets (road intersections or mountain peaks) to serve as reference points in evaluating our ability to accurately estimate their locations using LORAN-C. We used 7.5 minute USGS topographic maps and a digitizing tablet to determine the geographic coordinates of each of the targets. These coordinates, and those obtained using LORAN-C, were referenced to the 1983 North American Datum. We used the program CALHOME (Kie et al. 1996) to convert all geographic coordinates to Universal Transverse Mercator Grid coordinates prior to data analysis.

The pilot approached each target at various altitudes (range=136 to 1,111 m above ground level [agl]) and from randomly selected directions. When the pilot determined the aircraft was directly over the target, the latitude and longitude of the aircraft were calculated to the nearest 0.10 minute using LORAN-C instrumentation aboard the aircraft (Jaeger et al. 1993); these geographic coordinates were then used as location estimates (hereafter referred to as trials) for the selected target. Trials were conducted concurrently with telemetry flights during November 1990 through February 1991 until the location of each of the eight targets had been estimated 14 times. For each trial, we calculated LORAN-C error as the hypotenuse of a right triangle, its legs being the absolute difference between the estimated and the actual northing and easting at each target. Because most aerial observations are made from altitudes <500 m agl (Caughley et al. 1976, Hoskinson 1976, Leptich et al. 1994), we restricted 75 percent of our sampling effort to that range.

We eliminated four trials with extreme outlying values (likely the results of transcription errors) from the data set prior to data analysis, yielding a total of 108 trials. We pooled trials across locations and used simple linear regression to examine the relationship between error and aircraft altitude. Additionally, we used one-way analysis of variance (ANOVA) to compare effects of high (>500 m) and low ($\leq$500 m) altitude trials on mean error, and analysis of covariance (ANCOVA) to control for the effect of aircraft altitude when examining the influence of geographic location on mean error.

RESULTS

We detected no relationship between error and aircraft altitude ($P=0.910$). Location estimates determined from low (=341 m, $SD=160$ m, $n=81$) and high altitudes (=302 m, $SD=135$ m, $n=27$) did not differ (ANOVA, $F=1.309$, df=1,106, $P=0.255$); mean location error for all trials was 331 m ($SD=154$ m). However, precision was greater for low ($SE=17.7$ m) than for high ($SE=25.9$ m) altitude trials. The effect of the unique location of each target on mean error was significant when aircraft altitude was included as a covariate (ANCOVA, $F=6.204$, df=7,99, $P<0.001$).

DISCUSSION

We rejected our hypotheses that 1) there would be a positive relationship between error and aircraft altitude, and 2) within our study area, there would be no effect of geographic location on mean error. Because accuracy of estimated locations may be affected by perturbations to the

LORAN-C signals as they pass over the earth (Leptich et al. 1994), the lack of a relationship between LORAN-C error and altitude could potentially be attributed to unique characteristics associated with the specific targets, including powerlines, terrain features, and mineral deposits (IIMorrow, inc. 1989). Eeptich et al. (1994) suggested that such factors explained much of the bias they detected at specific locations in northern Idaho. Alternatively, the pilot's inability to determine precisely when he was over the target (i.e., parallax), or the rate at which the aircraft's location was updated by the instrumentation, may explain the absence of a relationship between LORAN-C error and aircraft altitude. Our observation of increased precision of location estimates at altitudes ≤500 m is consistent with the notion that parallax is problematic when observations from aircraft are used to determine locations of features on the ground.

In the eastern Mojave Desert, Jaeger et al. (1993) reported significant differences in the accuracy and precision of location estimates using different LORAN-C receivers in a single study area and between different study areas when using one receiver. These authors suggested that the general geographic location of each study area and biases associated with the individual receivers were both potential sources of error. Indeed, accuracy of LORAN-C is affected by the geometric configuration of the transmitting stations relative to the location of the receiver (Leptich et al. 1994), and the accuracy of LORAN-C would be expected to vary among widely separated study areas.

We concur with Jaeger et al. (1993) that researchers using LORAN-C must consider the resolution required for their analyses, and that a correction factor (Patric et al. 1988) should be determined for each study area in which this technology is employed. We extend the caution of Jaeger et al. (1993), and suggest that investigators explore the need for site-specific correction factors within even small study areas where heterogeneous terrain features, or unevenly distributed mineral deposits, or electromagnetic radiation could affect the accuracy of locations determined with LORAN-C. If, however, a substantial amount of the error we detected was related to parallax, then we predict results similar to ours will be obtained when GPS technology is employed. Investigators using a GPS receiver to determine the locations of unmapped features should be mindful of this possibility.

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COMMENTS AND STATUS REPORTS

STATUS OF BIGHORN SHEEP IN ARIZONA - 1995

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Desert Bighorn Council Transactions 40:23-26

POPULATIONS

Estimates of Arizona's desert bighorn sheep (*Ovis canadensis mexicana* and *O. c. nelsoni*) indicate a stable population of approximately 6500 animals. The 1995 helicopter surveys produced 2212 classifications in 204.0 flight hours (10.8 sheep/hour). Survey results yield ratios of 51 rams:100 ewes:24 lambs:9 yearlings (Figure 1).

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 28 animals from Colorado in January. The 25.7 hours of helicopter surveys resulted in the classification of 345 animals (13.4 sheep/hour). Survey results yield ratios of 40 rams:100 ewes: 48 lambs:14 yearlings.

RESEARCH

The Arizona Game and Fish Department (AGFD) is currently involved in several sheep research and management projects. These include evaluation of survey methodology and observation rates; movement and mortality studies with Rocky Mountain sheep; and the evaluation of desert bighorn sheep in Sonora, Mexico. This latter project is supported by an $80,000 grant from the National Fish and Wildlife Fund. These funds were a portion of a restitution payment for a poaching incident occurring in Mexico.

HABITAT IMPROVEMENTS

The AGFD, primarily in cooperation with the Bureau of Land Management, the Arizona Desert Bighorn Sheep Society (ADBSS), and more recently with Desert Wildlife Unlimited, develops up to 10 bighorn sheep waters annually. These water projects 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.

TRANSPLANTS

Since 1981, a mean of 76.3 sheep has been transplanted annually. In 1995, a record 160 bighorn sheep were successfully captured and transplanted to seven release sites. These transplants included the conclusion of a desert bighorn for Rocky Mountain bighorn trade with Colorado and the release of 21 desert bighorn sheep into southern Utah.

To date, the AGFD has transplanted 1279 bighorn sheep, with 93 going to Colorado, 46 to Utah, 36 to Texas, 11 to New Mexico, and 9 to various zoos and universities (Figure 2). Arizona is presently hunting transplanted bighorn sheep populations in 15 units, with 31 permits being offered in these areas.

This year, the AGFD hired two Wildlife Specialists to evaluate bighorn sheep habitat in Arizona for potential bighorn sheep release sites. Using a modified Cunningham/Hansen habitat suitability model, all potential reintroduction sites will be scored with the higher scoring areas being prioritized for future transplants.

HARVEST

Bighorn sheep permits remain the most sought after hunting permits in Arizona There was a record 6256 applicants (4632 resident and 1624 nonresident) for the 111 regular season permits (Figure 3). This represents more than 56 hunters applying for each permit, with individual unit odds varying from as low as 13:1 to 356:1, depending on the unit's accessibility and harvest history.

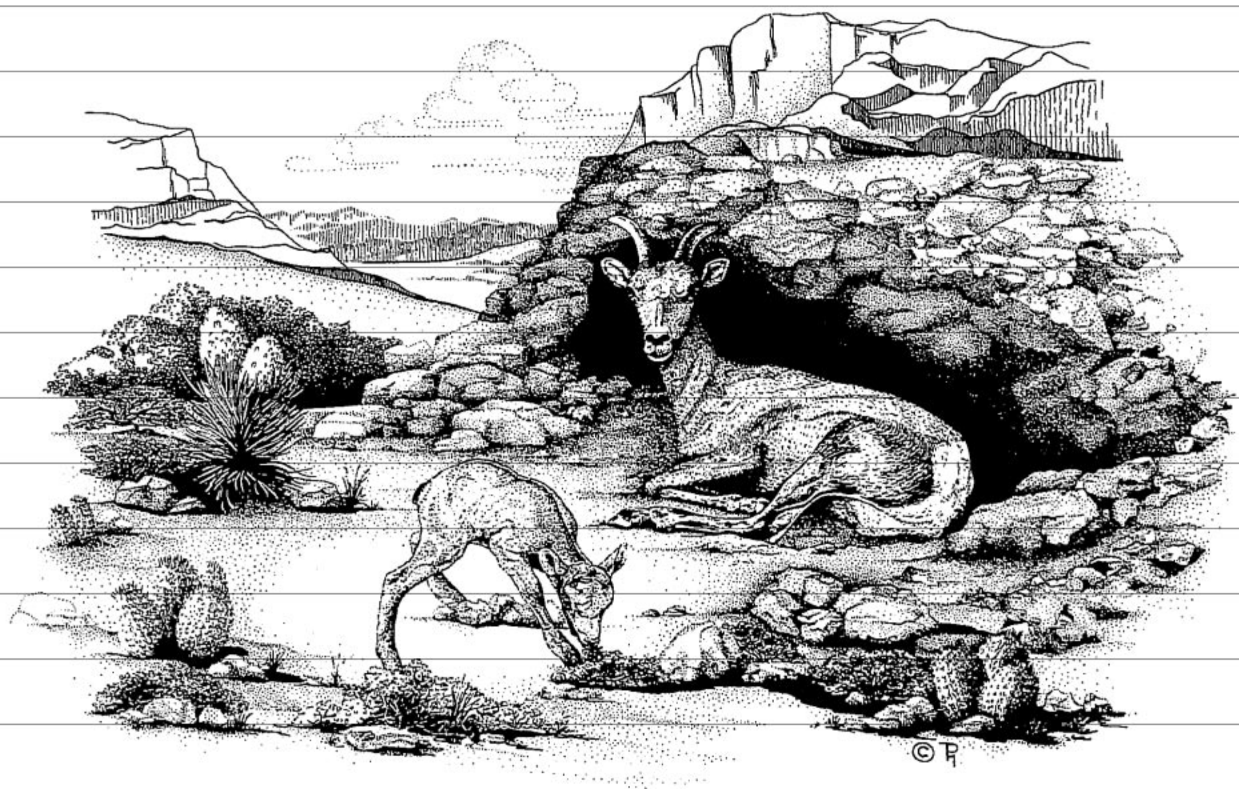
During the 1995 hunting season, a record 114 hunters participated (one additional permit was issued due to a drawing irregularity), harvesting a record 109 rams, for a 96 percent success rate (Figure 4). The average age of the harvest was 7.0 years. The 1995 season produced 38 animals (35 percent of the harvest) qualifying for the Arizona Trophy Book (minimum score of 162 Boone and Crockett points). Of these rams, 15 (14 percent) scored >170 points, with 2 scoring above 180 points. During the last 5 years, these trophy harvest percentages have averaged 38 percent and 19 percent, respectively.

As a result of this year's surveys, permits for the 1996 season will be decreased from last year's record 111 permits to 106. Two additional permits will again be issued to raise funds for bighorn sheep management programs. Game Management Unit 10 will be opened for bighorn sheep hunting this year to take advantage of expanding sheep populations.

The bighorn sheep season length was changed last year on the floor of the Hunt Set Commission Meeting. Nearly all seasons were increased from 17 to 31 days. The AGFD was also directed at that time to evaluate the rule for hunter check-in prior to the season with the intention of eliminating this requirement.

For the past 11 years, the AGFD and the ADBSS have entered into an agreement whereby the ADBSS auctions one 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, $1,888,860 has been raised from the 22 permits ($1,028,000 from the auction tags and $860,860 from the raffle tags).

In 1996, the auction permit was sold for $285,000. This makes a total of $1,064,000 from the last four bighorn sheep auction tags offered in Arizona. The success of Arizona's bighorn sheep management program is dependent upon the funds derived from these permits.



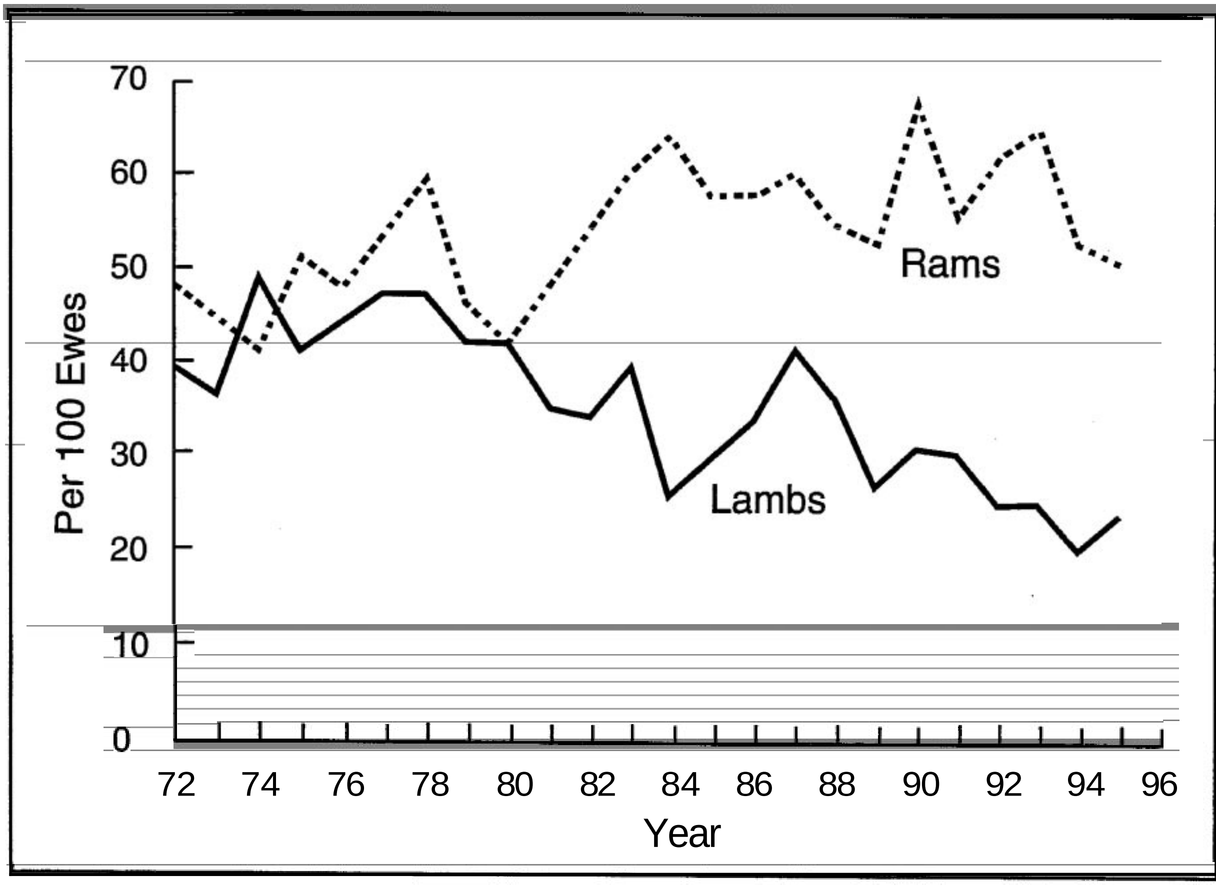


Figure 1. Desert bighorn sheep survey data.

Years	Number Released	
	DESERT	ROCKY MTN
1956 - 1960	23 (15)*	0
1961 - 1965	0	0
1966 - 1970	3	0
1971 - 1975	10	0
1976 - 1980	77 (34)*	20
1981 - 1985	384 (54)*	0
1986 - 1990	368 (21)*	0
1991 - 1995	346 (84)*	48
TOTALS	1211 (208)*	68

* Parenthesis ( ) indicate total number released out of state.

Figure 2. Bighorn sheep transplant history.

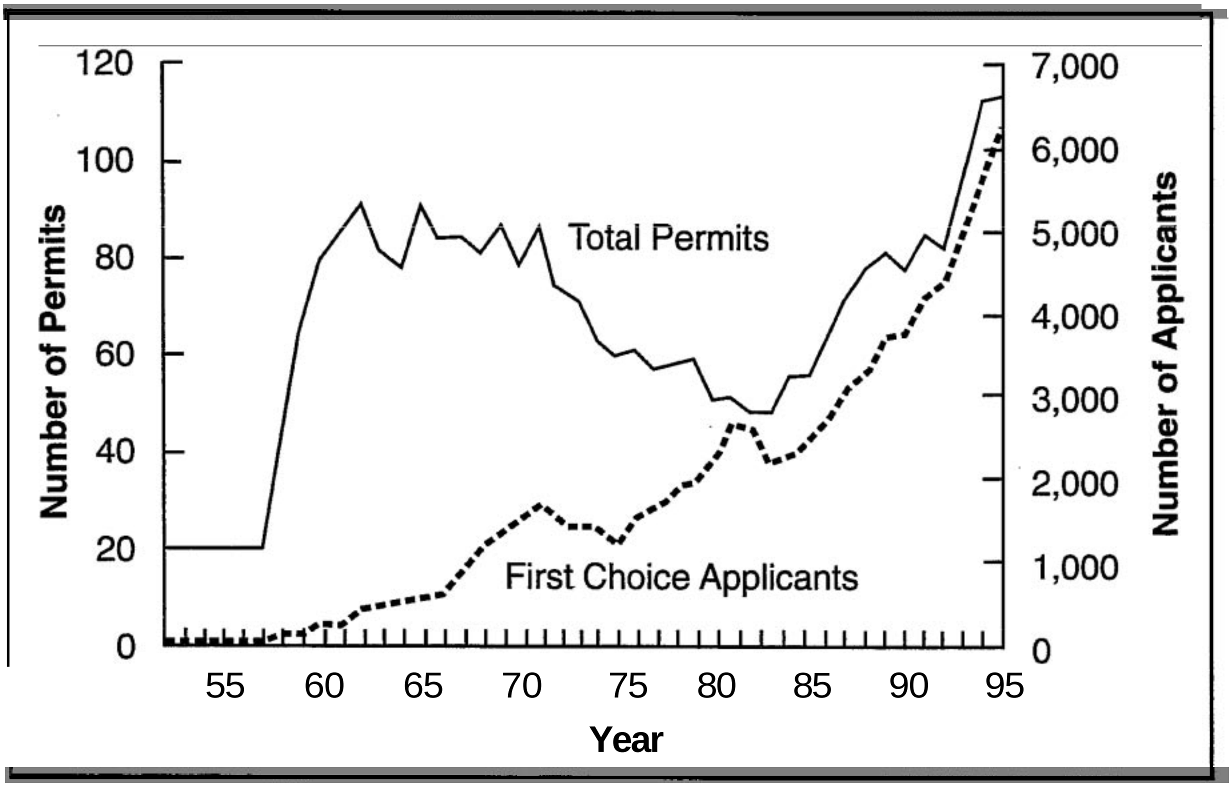


Figure 3. *Permit and application data.*

Year	# Rams	% Success	162+	170+	180+	190+
1986	56	88	29	7	1	
1987	68	96	34	9	2	
1988	75	97	30	9	4	1
1989	74	91	25	10	0	
1990	68	88	28	11	3	
1991	78	93	37	19	2	
1992	74	89	21	10	3	
1993	92	93	37	17	7	1
1994	101	92	41	23	3	
1995	109	96	45	15	2	
10 Year Totals	**795**	**92**	**327**	**130**	27	**2**

Figure 4. *Harvest history.*

STATUS OF BIGHORN SHEEP IN CALIFORNIA - 1995

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Desert Bighorn Council Transactions 40:27-34

POPULATIONS

Statewide

Ten metapopulations of bighorn sheep have been defined within California (Table 1). These include three subspecies by Cowan's (1940) taxonomy. California bighorn (*Ovis canadensis californiana*) are restricted to the Sierra Nevada; Peninsular bighorn (*O.* c. cremnobates) occur in the western Sonoran Desert of Riverside, Imperial, and San Diego counties; and Nelson bighorn (*O.* c. *nelsoni*) occur in the eastern Sonoran Desert, the Mojave Desert, the Transverse ranges, and the Great Basin Desert of Mono and Inyo counties. California and Peninsular bighorn are listed by the state as threatened, and all populations of Nelson bighorn are fully protected by state law.

Ramey (1993) and Wehausen and Ramey (1993) have demonstrated the lack of taxonomic validity of the Peninsular subspecies; therefore, we consider the Nelson subspecies a polytypic taxon that combines the Nelson and Peninsular subspecies, as recommended by Wehausen and Ramey (1993). However, state-listed threatened status remains for the Peninsular metapopulation of bighorn sheep. This metapopulation also remains Federally proposed as endangered by the U.S. Fish and Wildlife Service (USFWS). Separate subspecies classification should remain for California bighorn; however, Ramey and Wehausen (1996) reported that California bighorn in the Sierra Nevada are morphometrically distinct from those in Washington, British Columbia, and the adjacent Great Basin, and suggest that a separate subspecies designation may be appropriate.

The California Department of Fish and Game (CDFG) supports the concept of regional management for the long-term viability of bighorn sheep metapopulations (Bleich et al. 1990, Torres et al. 1994, Bleich *et* al. 1996). The status of these metapopulations was first compiled in 1994 (Torres et *al.* 1994). Current data indicate that several populations have declined (Tables 2 and 3). In California, the estimate is that there are about 3600 bighorn sheep distributed across 61 mountain ranges (Table 1) compared with the 1994 estimate of about 4600. This 21.7 percent decrease can be attributed to a combination of some previous overestimates and some declining populations. Bighorn sheep population declines have been most dramatic in the Sierra Nevada and San Gabriel Mountains, and parts of the Mojave Desert (Table 2). Our updated inventory of populations by size categories shows fewer large populations (Table 3). The number of bighorn sheep remaining in the Sierra Nevada are very low (Table 4). Natural population recolonization events have recently been documented in the South Bristol Mountains south of 1-40 in San Bernardino County and the Deep Springs Range of Inyo County.

Sierra Nevada

Two native populations and three reintroduced populations of bighorn exist in the Sierra Nevada Mountains: Lee Vining Canyon, Mono County (reintroduced); Wheeler Ridge, Inyo

County (reintroduced); Mount Baxter, Inyo County (native); Mount Williamson, Inyo County (native); and Mount Langley, Inyo County '(reintroduced). In February 1995, two ewes were captured, sampled, and released with radio collars in Lee Vining Canyon. In June 1995, a cooperative and very successful ground census of this population by experienced biologists and volunteers documented that the population had declined by more than 50 percent to 39 sheep, following the particularly snowy previous winter. It remains a priority to capture and install additional radio collars to enhance future monitoring efforts.

Population survey efforts indicate that winter range use did not increase from 1991 through 1995 for the Mt. Baxter herd. Therefore, winter population assessments continue to be of limited use. Indices derived from summer surveys of this population continue to document a declining trend that has resulted from winter range abandonment that is possibly a behavioral reaction to high mountain lion predation. Summer surveys in 1995 by the Sierra Nevada Bighorn Sheep Foundation estimated the remaining ewe population at only 15 to 20 individuals, and it is likely that the total population is well under 50 individuals. In addition to ground surveys, there are plans to monitor this population by time-lapse video cameras placed at narrow high passes used regularly by these sheep.

Surveys of the Wheeler Ridge population in 1995 indicated that it had declined to fewer than 20 sheep during the heavy winter of 1995. Twelve sheep were found dead in a single snow avalanche. Summer surveys in 1996 indicated that the Mount Williamson population is on the verge of extinction, with possibly only one single sheep remaining. The Mt. Langley population was documented to persist, but appears also to have declined and may number below 30. In total, fewer than 150 sheep remain in the Sierra Nevada. A new conservation strategy for Sierra Nevada bighorn sheep is being developed by the Sierra Nevada Bighorn Sheep Interagency Advisory Group. The continued monitoring of all bighorn sheep populations in the Sierra Nevada remains a high priority. Recent population decline warrants a change in state-listing status from threatened to endangered.

Peninsular Metapopulation

In 1995, preliminary analysis of data estimated the Peninsular population at approximately 350 adult bighorn sheep distributed in eight or nine distinct populations (Boyce 1995). During 1992 through 1995, bighorn sheep in the Peninsular Ranges did not experience poor lamb production or survivorship. However, this research has indicated that adult bighorn sheep survivorship is relatively low and that >65 percent of all mortalities were caused by mountain lions. Population monitoring will continue through 1996 and a final assessment of population status and management recommendations will be prepared.

Old Dad Mountain (Source Stock Population)

On August 25, 1995, during a routine telemetry flight, CDFG unit biologist Andy Pauli noted that two bighorn sheep radio collars were on mortality mode. On a subsequent ground check (August 29, 1995), he discovered 14 dead bighorn sheep at the Main Peak guzzler. After further investigation, at least 45 bighorn sheep were believed to have been involved in the die-off. The total includes 19 lambs, 16 ewes, and 10 rams. Field investigation revealed that sheep jumped onto the guzzler tank top from a nearby ledge. Subsequently, the 17 to 20 inch lid was opened, thereby making water available to sheep. As the water level receded, 13 lambs fell into the tank and drowned. Laboratory diagnostics indicated botulism (*Clostridium botulinum*, type C) resulted from the decaying lamb carcasses, and subsequently poisoned sheep drinking from the tank. It was estimated that 20 to 35 percent of the population was lost to this die-off. This population has been one of the most productive in the state and has provided 222 bighorn sheep for reintroduction projects from 1983 through 1992. Recovery is anticipated if suitable environmental conditions follow.

Dr. Pam Swift (CDFG) prepared a detailed report of this die-off that includes field examination and laboratory tests. It can be obtained from Dr. Swift at Wildlife

Investigations Laboratory, 1701 Nimbus Road, Suite D, Rancho Cordova, CA 95670.

San Gabriel Mountains

The San Gabriel Mountains previously supported one of the largest desert bighorn sheep populations in the southwestern United States, and has been surveyed by CDFG in cooperation with the Forest Service and the Society for the Conservation of Bighorn Sheep (SCBS) since 1976. From 1979 to 1985, 400 to 500 bighorn sheep were routinely counted from the helicopter and this population was estimated at >600 animals. Although a population decline had been predicted as part of a population cycle (Holl and Bleich 1983), rapid decline since 1990 is of concern. Recent helicopter counts have recorded only 62 (1995) and 67 (1996) individuals, and the current population is estimated at 101 to 150 animals. There are very few bighorn sheep remaining in the Cucamonga Wilderness and Lytle Creek areas. Our current hypothesis is that the lack of wildfire over the last 20 years has resulted in habitat succession that altered the abundance of suitable sheep habitat and enhanced the vulnerability of sheep to mountain lion predation. The CDFG is conducting an analysis of changes in winter range and any associated changes in the distribution of bighorn sheep. Other factors such as disease, human activity, and drought are also being evaluated for any potential relationship with this population decline.

RESEARCH

The CDFG continues to cooperate with several universities and agencies in support of bighorn sheep research and management in California. CDFG conducted several bighorn sheep captures and survey efforts in 1994 and 1995. In total, 119 bighorn sheep were captured, sampled, radio-collared, and released (50 in 1994, 69 in 1995) for intensive population monitoring projects. These efforts occurred as part of ongoing research on bighorn populations in Lee Vining Canyon (Mono County); Avawatz, Old Dad/Kelso Peak, Mesquite, and Clark Mountains (San Bernardino County); Panamint Mountains (Inyo County); and Eagle, Orocopia, San Jacinto, and San Bemardino Mountains (Riverside County). Additionally, population surveys and monitoring continue for all bighorn sheep populations in the Sierra Nevada and Peninsular Ranges. Long-term population monitoring efforts continued in Avawatz, Bristol, Bullion, Clark/Kingston, Granite, Marble, Old Dad/Kelso Peak, and Old Woman Mountains (San Bernardino County); Eagle, Orocopia, and San Bernardino Mountains (Riverside County); San Gabriel Mountains (Los Angeles County); and East Chocolate Mountains (Imperial County).

Ways to improve ground and aerial survey methods to incorporate prior year data (time series approach) to estimate population parameters continue to be investigated.

HABITAT IMPROVEMENTS

The CDFG, in cooperation with volunteers from Desert Wildlife Unlimited and the SCBS, constructed one artificial catchment to benefit bighorn sheep in the East Chocolate Mountains of Imperial County. In addition, 143 maintenance inspections were made on bighorn sheep guzzlers and springs. Members of the Volunteer Desert Water and Wildlife Survey of the SCBS contributed 4844 hours of labor and 109,500 vehicle miles to the CDFG while accomplishing these tasks. The CDFG Region 5 habitat development crew additionally contributed 3500 hours and 25,000 vehicle miles toward bighorn sheep projects. All development and maintenance work occurred cooperatively with the Bureau of Land Management (BLM) or National Park Service (NPS).

HARVEST

Since bighorn sheep hunting was authorized by the California Legislature in 1987, nine hunting seasons have been held (Table 5). To date, a total of 83 adult rams in four hunt zones (Marble, Kelso Peak/Old Dad, Clark/Kingston, and East Chocolate Mountains) have been harvested for an overall success rate of 88 percent. Animals taken during annual hunts have ranged from 4 to 213 years of age, and 18

(22 percent) have qualified for the Boone and Crockett records book based on their "green" scores.

For the seventh consecutive year, 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 this document, CDFG proposes to open two new areas to hunting (Zones 5 and 6) in Riverside County (Figure 1), and to issue a total of 14 tags for the 1996197 hunting season as follows: one at the Marble Mountains (Zone 1), three at the Old Dad/Kelso Mountains (Zone 2), two at the Clark/Kingston Mountain Ranges (Zone 3), three in the East Chocolate Mountains (Zone 4), two in the Orocopia Mountains (Zone 5), one in the San Gorgonio Wilderness (Zone 6), one fund-raising tag that is valid in any hunt zone (open zone), and one fund-raising tag that is valid in either the Marble or Orocopia Mountains.

State law limits the number of tags issued to 515 percent of the mature rams (22 years old) estimated in each hunt zone during annual CDFG surveys. For hunting purposes, legal rams are those possessing ≥ curl. The open-zone, fund-raising tag sold for $102,000 at the February 1996 convention of the Foundation for North American Wild Sheep (FNAWS), and the Marble/Orocopia fund-raising tag sold for $92,500 at the March 1996 banquet of the Orange County Chapter of Safari Club International. All of the funds generated from this hunting program are dedicated to bighorn sheep research and management projects. This program has generated $1,169,877 to date.

PROBLEMS/OPPORTUNITIES

In 1994, the California Desert Protection Act (S. 21) designated many Federal lands in the California Desert as wilderness, established Death Valley and Joshua Tree National Parks, and created the Mojave National Preserve. The implementation of this legislation continues to be unclear with regard to provisions for access, maintenance and implementation of habitat improvement projects, and the continuance of CDFG's reintroduction program, as these policies tend to vary regionally and between agencies (e.g., NPS, BLM). The CDFG continues to participate in interagency planning efforts to ensure that access for conservation and restoration activities are maintained as stipulated in the California Desert Protection Act.

The CDFG Bighorn Sheep Management Program is currently developing bighorn sheep metapopulation plans that will inventory and evaluate the population status of all bighorn sheep populations/subpopulations within the state. This planning effort will identify and prioritize management activities to ensure the long-term viability of this species. Protection of important habitats and intermountain movement corridors, identification of future reintroduction sites, and the maintenance, improvement, and development of guzzlers will be addressed. Given the tragedy of the bighorn die-off at Old Dad Mountain, maintenance and improvement of guzzlers are particularly important. This planning will occur in cooperation with the BLM, the California Division of Parks and Recreation, the Department of Defense, and the NPS.

The USFWS has remained undecided in 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, 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.

This status report is a contribution from the CDFG Bighorn Sheep Management Program.

Table 1. Bighorn sheep population estimates by metapopulation in 1995 (1993 estimates).

Metapopulation	Low	Median	High	Median (1993)
Peninsular Ranges	303	402	500	426
San Gabriel	101	126	150	500
Western Transverse Range	1	13	24	13
Sonoran	328	414	500	514
South Mojave	640	954	1268	1006
Central Mojave	303	439	574	514
North Central Mojave	178	264	350	340
North Mojave	586	854	1122	967
Southern Sierra Nevada	76	125	174	277
Central Sierra Nevada	25	38	50	76
Total	2541	3629	4712	4633

Table 2. Reclassification of populations of bighorn sheep in California between 1993 and 1995.

METAPOPULATION	POPULATION	POPULATION STATUS	POPULATION SIZE CLASS 1993	POPULATION SIZE CLASS 1995
Peninsular Ranges	Pinto/Inkopah (S. of I-8)	E	<25	0
	Jacumba/Inkopah	N	25-50	51-100
	N. Anza Borrego	N	151-200	101-150
San Gabriel	San Gabriel	N	>300 (400-600)	101-150
W. Transverse Range	San Rafael	R	25-50	<25
Sonoran	Chocolate (Gunnery)	N	151-200	101-150
	Chocolate (Colorado R.)	N	151-200	101-150
South Mojave	Marble	N	101-150	51-100
	S. Bristol	C	0	<25
Central Mojave	Old Dad/Kelso/Marl	N	201-300	101-150
	Granite	N	<25	25-50
	Castle/Hart/Piute	N	<25	25-50
North Central Mojave	Clark	N	101-150	51-100
	Kingston/Mesquite	N	101-150	51-100
	Avawatz	A	25-50	51-100
North Mojave	S. Panamint	N	101-150	51-100
	Deep Springs	C	0	<25
	N. White	N	201-300	151-200
Southern Sierra Nevada	Mt. Langley	R	51-100	25-50
	Mt. Williamson	N	25-50	<25
	Mt. Baxter	N	101-150	25-50
Central Sierra Nevada	Lee Vining/Bloody Cyn.	R	51-100	25-50

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

Table 3. Bighorn sheep population size class profile and summary by metapopulation (1995).

Metapopulation	0	<25	25-50	51-100	101-150	151-200	201-300	>300
Peninsular Ranges	4	0	2	1	2	0	0	0
San Gabriel	0	0	0	0	1	0	0	0
Western Transverse Range	1	1	0	0	0	0	0	0
Sonoran	2	0	1	0	3	0	0	0
South Mojave	7	7	3	5	3	0	0	0
Central Mojave	0	1	6	1	1	0	0	0
North Central Mojave	1	0	1	3	0	0	0	0
North Mojave	3	3	3	7	0	1	0	0
Very Southern Sierra	2	0	0	0	0	0	0	0
Southern Sierra Nevada	6	1	3	0	0	0	0	0
Central Sierra Nevada	3	0	1	0	0	0	0	0
Northeastern California	7	0	0	0	0	0	0	0
Total	36	13	20	17	10	10	0	0
Total (1993)	34	14	16	14	10	3	2	1

Table 4. Bighorn sheep population estimates by subspecies (1995).

Subspecies	Low	Median	High	Median (1993)
California	101	163	224	353
Nelson	2440	3465	4488	4280
Total	2541	3628	4712	4633

Table 5. ***Summary*** *of Nelson bighorn sheep tag allocations, harvest, applications, and revenue* ***from*** *1987-1996 in California.*

Year	Allocated	Harvested	Applicants	Auction Revenue	License & Tag Fees	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	10	4,692	$162,000.00	$ 28,422.00	$190,422.00
1995	16	14	4,217	$187,000.00	$ 26,312.00	$213,312.00
1996	14		4,493	$193,500.00	$ 28,591.75	$222,091.75
Totals	108	83	37,579	$951,500.00	$218,377.25	**$1,169,877.25**

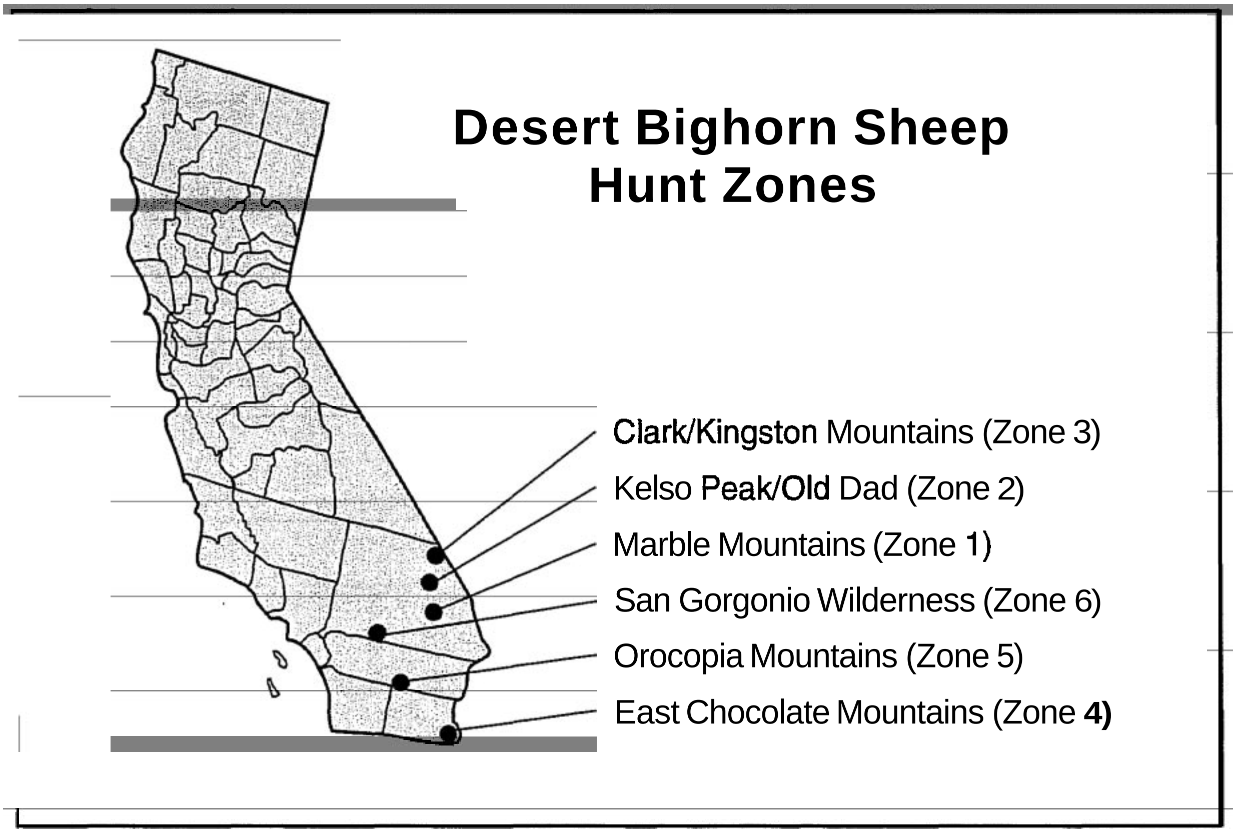

Figure 1. *Location of 1996 Nelson bighorn sheep hunt zones.*

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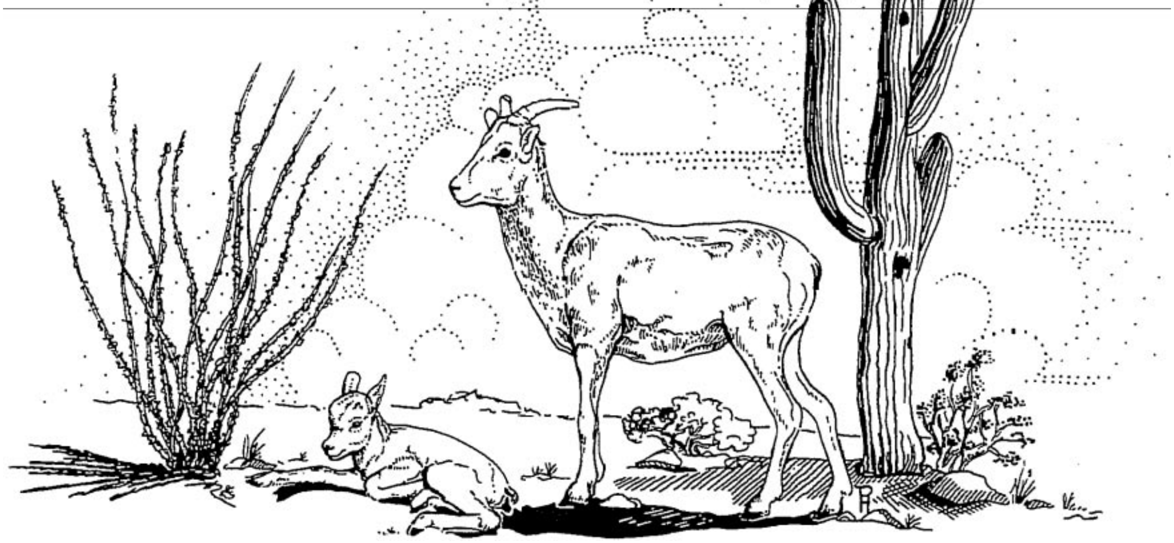

STATUS OF BIGHORN SHEEP IN MEXICO - 1995

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Desert Bighorn Council Transactions 40:35-39

SONORA

Prior to recent survey efforts, it was felt that the bighorn sheep population in Sonora probably did not exceed 1000 animals, but it was also not known whether the population was considerably below this number. Surveys were designed to evaluate the present distribution of bighorn sheep and to provide population estimates for Sonora.

In 1992, using 20.7 hours of helicopter time, 25 mountain ranges were surveyed for desert bighorn sheep. A total of 155 groups were seen, resulting in 528 individual classifications. In 1993, using 16.3 hours of helicopter time, 17 mountain ranges were surveyed for desert bighorn sheep. A total of 132 groups were seen in 11 of the areas flown, resulting in 442 individual classifications. 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 resulted in a 2-year total of 893 individual sheep observed, with desert bighorn sheep seen in 32 of the 39 ranges surveyed.

Surveys that depend upon direct observations tend to underestimate the total number of animals in an area. Survey studies indicate that only 30 to 60 percent of the population is seen during a helicopter bighorn sheep survey. Using these observation rates results in a population estimate of between 1488 and 2977 animals for that portion of Sonora that was surveyed. It should be noted that not all of the area of each mountain range and not all of the sheep habitat was flown.

Due to differences in terrain, it is difficult to determine the number of animals per area. Therefore, animals per unit effort represents a more comparable method of evaluating sheep densities. Observation rates varied considerably between the northern and southern mountain ranges. In the mountains north of Caborca, the mean observation rate was 11.3 animals per hour. In the mountains south of Caborca, the mean observation rate was 39.9 animals per hour. By comparison, in Arizona in 1993 and 1994, average observation rates were 8.6 and 9.4 sheep per hour, respectively. This indicates the similarity between sheep population densities in Arizona and northern Sonora and shows the divergence that occurs in those ranges south of Caborca.

In 1995, 30 bighorn sheep were radio collared in three areas in Sonora These animals are being monitored to determine mortality rates, movement patterns, and habitat selection. Blood samples were also taken to determine previous exposures to common domestic livestock diseases. Results of this work will be reported at future Desert Bighorn Council Meetings.

In 1996, using 10.6 hours of helicopter time, 11 mountain ranges were surveyed for desert bighorn sheep. A total of 523 sheep were classified. Observation rates in both Sierra Viejo and Sierra Kun-Kaak exceeded 90 bighorn sheep per hour. While these 11 ranges had been flown in the past, observation rates were higher in the majority of ranges flown in 1996, indicating that the bighorn population in Sonora is at least stable if not increasing. The 37:100 lamb:ewe ratio and the 20:100 yearling:ewe ratio indicates a very productive population.

Using the information provided in these surveys, private landowners persuaded the Mexican Government to issue bighorn sheep hunting permits in Sonora. Seven permits were issued. These permits brought bids of $45,000. Six sheep were harvested. One scored in the low 180s, with four scoring below 160. At this time, there is no conservation program for the management of bighorn sheep in Sonora. Permits offered for the 1996197 season will have a minimum bid of $70,000.

BAJA CALIFORNIA

In December 1990, the President of Mexico issued a decree halting the hunting of bighorn sheep in the state of Baja California. Prior to the closure of bighorn sheep hunting, the state of Baja California provided considerable bighorn sheep hunting opportunities. During the 10 hunting seasons between 1980-81 and 1989-90, 625 permits were issued (with approximately 60 percent of the permits going to Mexican nationals and 40 percent going to nonresidents). Nonresidents paid $12,000 for a permit. During this period, hunter success was approximately 75 percent. The mean score for rams harvested was 166 points.

During the 1989-90 season, four zones were open to hunting in the state. These zones were divided into six areas during the first hunt period and five areas during the second hunt period with a total of 33 permits. Hunters had 10 days to hunt within the period fi-om January 4 through March 12. Hunters harvested 24 animals that ranged from 129 2/8 to 175 3/8 points, with an average score of 161 7/8 points. Seven of the sheep scored above 170 points.

Historically, Baja California has provided some exceptional trophy animals. The fifth edition of the Safari Club International trophy book lists 17 entries between 180 and 189 points, and three others between 190 and 195 points.

In 1993, the Mexican Foundation for the Conservation of Bighorn Sheep was founded. This organization has worked to establish a conservation program for bighorn sheep throughout the range of the species in Baja California. In their efforts, they enlisted the aid of the Foundation for North American Wild Sheep (FNAWS). Through funding from FNAWS, a helicopter survey of bighorn sheep ranges in Baja California was conducted during September 1995.

Previous Survey Efforts

A helicopter survey of Baja California was conducted in April 1992 by biologists from the Bighorn Research Institute. During this survey, 116 groups of bighorn sheep were seen in 68 hours of helicopter survey time resulting in an observation rate of 8.9 sheep per hour. During this survey, 97 rams, 303 ewes, 135 lambs, and 68 yearlings were observed for a total of 603 observations. This resulted in ratios of 32 rams:100 ewes:45 lambs:22 yearlings. Average group size was 5.2 animals per group, with a range from 1 to 26 animals.

A population of 780 to 1170 adult bighorn sheep was estimated for the areas surveyed. Conclusions of this survey were that:

- It was possible that previous population estimates for Baja California were too high, and/or that the survey underestimated the current population.
- The major differences between spring and fall surveys were that 45 percent fewer lambs were seen during fall surveys.
- It was necessary for a stable population to be shown to cause the withdrawal of the proposal to list the Peninsula.Range populations as endangered.
- Observation rates of 40 to 60 percent were appropriate for this survey.
- There was considerable competition and potential for disease exposure from cattle, goats, and burros, all of which were observed in bighorn sheep habitat during the survey.

Methods

From September 19-26, 1995, surveys were conducted in the mountainous areas of Baja California. A Hughes 500D helicopter equipped with a Global Positioning System and with the doors removed to increase visibility was used for the survey. The helicopter was flown with three observers and the pilot. The surveys were flown at 60 mph contouring the area to be surveyed. When animals were seen, the helicopter would be maneuvered close to the group to facilitate classifications. Most ranges were flown concentrating on the more rugged areas.

Results

Nearly all mountainous areas in Baja California were sampled to some degree; obviously with the number of hours expended some areas were merely cursorily flown, more for presence of sheep rather than enumeration and classification (Table 1). The main areas flown included San Pedro Martir, Sierra Santa Isabel, Sierra San Felipe, Sierra Juarez, and Sierra Las Tinajas. There is an estimated 10,875 km^2 of potential bighorn sheep habitat in Baja California. This survey covered approximately 3,000 km^2.

During 32.1 hours of survey effort, 97 groups of sheep were seen. Survey totals were 76 rams, 134 ewes, 57 lambs, and 12 yearlings for a total of 279 individual sheep (Table 1). This represents an observation rate of 8.7 sheep seen per hour of survey time. The average group size was 2.9 animals per group, with a range of from one to eight animals.

Discussion

Of particular importance is the comparison between the 1992 and the 1995 surveys. Overall, there were no statistical differences between animals seen per flight hour on a mountain range by mountain range basis (Table 2). Therefore, there is nothing to indicate that the bighorn sheep population in Baja California has decreased since the 1992 survey.

The 1992 survey was carried out in April, while the 1995 survey was done in September. The majority of lamb mortality occurs during the summer months. Despite this, the lamb:ewe ratio during 1992 differs only marginally from the 1995 lamb:ewe ratio (45 lambs:43 ewes), indicating that the actual reproductive rate of the population was considerably higher in 1995.

Moreover, during the spring, as evidenced by the larger average group size (5.2 in 1992 versus 3.0 in 1995), the sheep occur in larger groups, making them more visible. At the same time, the spring observations would include a large number of lambs later to be lost due to different causes (predation, diseases, etc.). The slightly higher average number of sheep/hour in 1995 than in 1992 (10.7 vs. 8.9, respectively) might indeed represent actual increases in population size and reproductive rate.

The 1995 survey exhibits a much larger percentage of rams in the population, a fact that might indicate a lower illegal harvest than generally thought (Table 3). Indeed, Class III and IV rams increased from 61 percent of all rams in 1992 to 79 percent in 1995.

Significant differences between the 1992 and the 1995 surveys were seen in the ram:ewe ratio and in the lamb:ewe ratio. In the 1992 survey, the ram:ewe ratio was 32:100, while in 1995 it was 57:100. The latter value is more typical of a desert bighorn sheep population. Arizona, for example, has a ratio of 58 rams:100 ewes as the average for the last 3 years.

The difference in the season of the surveys may have produced the difference in these ram ratios; however, it is also very marked in the lamb ratios. During the 1992 survey, which occurred in April, the lamb:ewe ratio was 45:100. During the 1995 survey, which occurred in September when much of the lamb mortality should have already occurred, the ratio was 43:100. The lambing success, therefore, is higher in 1995 and reflects a productive population.

Conclusions/Recommendations

Like many wildlife management agencies, the Arizona Game and Fish Department uses a simple worksheet to assist in making permit recommendations for the bighorn sheep hunting season. This bighorn sheep hunting program has been in effect for more than 40 years and there are now more bighorn sheep in Arizona than there were prior to the legalization of hunting.

Using the field data, worksheets for various scenarios were prepared. Using the information from both the 1992 and the 1995 surveys combined with no extrapolation into unsurveyed areas would result in a recommendation for up to 12 permits. Using only the information from the

1995 survey with no extrapolation into unsurveyed areas would result in a recommendation for up to 11 permits. Using only the information from the 1995 survey with no extrapolation of any kind, and using only the animals actually classified during this survey, would result in a recommendation for up to 9 permits.

These permit recommendations are much more conservative than the past permit levels in Baja California, which averaged 62.5 permits/year over the last 10 years of hunting, and even less than the 33 permits that were offered during the last year a hunting season was authorized.

Table 1. Bighorn sheep classified during the September 1995 survey in the state of Baja California.

Range	Area	Time	Rams	Ewes	Lambs	Year	Total	Groups
Juárez	602	2.8	0	1	1	0	2	1
San Pedro Martir	630	5.1	4	6	4	0	14	8
Las Pintas	206	2.0	10	16	1	0	27	9
Las Tinajas	252	2.1	6	10	5	2	23	8
San Felipe	740	5.2	12	19	8	1	40	15
Santa Rosa	78	1.5	8	23	12	2	45	18
Santa Isabel	495	5.3	28	53	23	7	111	31
Cucapi	92	.5	0	0	0	0	0	0
SUBTOTAL		24.5	68	128	54	12	262	90
Other[1]		7.6	7	6	3	1	17	7
TOTAL		32.1	76	134	57	12	279	97

[1] Observations in areas surveyed in 1995, but not in 1992.

Table 2. Comparison of numbers of **bighorn** sheep seen per hour **of flight** in the several mountain ranges, which were flown both in 1992 and 1995 in the state of Baja California.

SIERRA	1992	1995
Juárez 0.2	0.7	
San Pedro Mártir	6.1	2.7
Las Pintas	5.6	13.5
Las Tinajas	12.2	11.0
San Felipe	9.6	7.7
Santa Rosa	86.0	74.7
Santa Isabel	13.1	21.1
Cucapá	1.0	0.0
AVERAGE	8.9	10.7

Table 3. Percentage of the different **sex/age** groups in the 1992 and 1995 bighorn sheep surveys from the state of Baja California.

	1992	1995
Rams	16.1	27.2
Ewes	50.2	48.0
Lambs	22.4	20.4
Yearlings	11.3	4.3

STATUS OF DESERT BIGHORN SHEEP IN NEVADA - 1995

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Desert Bighorn Council Transactions 40:40-42

POPULATIONS

Three subspecies of bighorn sheep (*Ovis* canadensis) inhabit Nevada. California bighorn (*O.* c. califomiana) have been released at 18 sites in northcentral and northwestern Nevada. In the northeast portion of the state, Rocky Mountain bighorn (*O.* c. canadensis) occupy five mountain ranges. Desert bighorn (*O.* c. nelsoni) have the broadest distribution and occupy most of Nevada's central and southern mountain ranges. Inclusive of each subspecies, there are approximately 6500 bighorn sheep in Nevada.

During fall 1995, aerial surveys conducted on 33 mountain ranges enabled observations of 2605 desert bighorn sheep. Upon classification, the statewide bighorn sample was comprised of 1285 ewes, 749 rams, and 571 lambs (58 rams:100 ewes:44 lambs). Based primarily on data collected during aerial surveys, there are an estimated 5500 desert bighorn sheep in Nevada. The 1995 population estimate reflected a 7 percent increase relative to the 10-year statewide average, and represents a 12 percent increase above the 5-year statewide average.

Due to Nevada's varied temporal and spatial distribution of precipitation, some bighorn populations experienced recent successive years of drought, while others experienced more favorable moisture conditions. Regionally, measurable precipitation was below average from March 1995 through March 1996. Overall, water developments have served to lessen the severity of reduced water availability endured by some populations of bighorn during drought years. Water catchment construction remains an integral program element in efforts to reestablish mountain sheep in historic ranges.

In the summer of 1995, a limited desert bighorn capture operation was conducted in the River Mountains, Clark County. The objectives were to refamiliarize personnel with trapping equipment and to increase the number of marked individuals in the population. Prior to trapping and while personnel were absent, one yearling ram died after becoming entangled in the drop net. Subsequently, five animals were captured, marked, and released.

In October 1995, Nevada Division of Wildlife (NDOW) personnel conducted a capture operation in the Newberry Mountains following an apparent population decline. Of five desert bighorns that were marked and released, four were fitted with telemetry collars (Telonics Inc., Mesa, Arizona) to facilitate monitoring efforts and increase understanding of current sheep distribution and recruitment. Analyses of serum samples collected from three ewes demonstrated that each were pregnant and bacteriology results revealed isolates of *Pasteurella* haemolytica biotypes T and **A.**

Later in the month, 90 desert bighorn sheep were captured by private contractor in the Muddy Mountains, Clark County, and the River Mountains, Clark County. All bighorn captures were accomplished using an aerial net-gun technique. The ensuing translocation phase involved five augmentations in Nevada. The trapping operations were initiated in the south River Mountains with the capture and removal of 31 desert sheep. Included therein were rams that frequented Hemenway Valley Park, of which five were released in the Bare Mountains, Nye County, and five were released in the Specter Range, Nye County. The remaining 21 animals were captured from the northern portion of the range and released in Pine Grove Hills, Lyon County.

The capture operation in the River Mountains was temporarily halted following a complaint to the governor's office by a golf course and community developer. The protest centered upon the removal of sheep that were routinely observed on the periphery of the developing Lake Las Vegas Community and the loss of an extraordinary and unprecedented marketing advantage. Apart from capture. efforts, a ram reported as frequenting and later dying in the Lake Las Vegas development was determined to be 18 years old; as evidenced by his ear tag, the oldest known bighorn in Nevada was captured in 1983 as a 6 year old.

In the Muddy Mountains, 59 desert bighorn were captured of which a complement was given to the state of Colorado (*n*=22). One ewe adult died from injuries sustained during capture and the remaining 36 sheep were released in the Hot Creek Range, Nye County (*n*=21), and the East Range, Pershing County (*n*=15).

Since 1968, 1090 desert bighorn sheep have been transplanted to 28 mountain ranges in Nevada. In addition, 232 desert bighorns have been furnished to Colorado (*n*=115), Texas (*n*=87), and Utah (*n*=30) to assist efforts to reestablish populations in other states. Future plans have been approved to translocate desert bighorn sheep into additional mountain ranges within Nevada. Bighorn capture and transplant operations are scheduled to occur during summer and fall 1996.

HABITAT IMPROVEMENTS

In 1995, one water catchment was constructed in each of the following mountain ranges: Desert Range, Clark and Lincoln Counties; Pahranagat Range, Lincoln County; Fairview Peak, Churchill County; and Slate Mountain, Churchill County. Water storage capacity was added to four existing projects: two in the Specter Range; one in the Last Chance Range, Nye County; and one in the Monte Cristo Range, Esmeralda County. The storage capacity upgrades to each of the first three projects entailed additions of a third 2300-gallon tank. In the Monte Cristo Range, the existing water development was fitted with two new storage tanks and a dam. Collectively, water project construction and unit upgrades equated to 31,700 gallons of additional water storage capacity.

There are now 110 water developments in Nevada for desert bighorn sheep with a combined storage capacity of 520,400 gallons. 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), the Foundation for North American Wild Sheep, and Safari Club International (Desert Chapter). Catchment construction and maintenance is accomplished largely by volunteers from these organizations. Projects were constructed by the U.S. Fish and Wildlife Service, the Nevada Division of Wildlife, and by, or in cooperation with, the Bureau of Land Management.

HARVEST

The desire to hunt desert bighorn rams in Nevada remains great. There were 3062 applicants for 111 resident tags (28:1 odds) and 1423 applicants for 13 nonresidents tags (109:1 odds). Two special auction tags were also allotted. In 1995, 91 rams were harvested, which equated to a hunter success rate of 74 percent (3 tag holders did not hunt). Hunter success approximated the 5-year average and was similar to the success encountered last season. The average age of rams harvested was 6.4 years, slightly above the average age encountered last year. Five rams exceeded the Boone and Crockett minimum score of 168 points. A ram harvested in the Black Mountains attained the highest Boone and Crockett score, 171 4/8.

Thirty-eight (31 percent) tags of the available 124 resident and nonresident tags corresponded to hunt units with bighorn populations established through translocations. Twenty-nine units were hunted in 1995, including the Egan Range (Unit 221), a newly authorized bighorn hunt unit with a resident herd established through releases of 19 bighorn in 1986 and 20 in 1993. The estimated population in this range is 62. The Newberry Mountains

(Unit 264) were not authorized in the 1995 hunt season. Aerial survey data indicate the Newberry Mountains population has declined and monitoring data suggest bighorn sheep distribution narrowed from essentially the entire mountain complex to an area bounded roughly by White Rock Wash, Lake Mohave, S.R. 163, and Christmas Tree Pass Road.

In Nevada, harvest permits for desert bighorn sheep have been issued to sportsmen since the early 1950s. For most of the hunt areas since then, the permits have included a regulation that specified trophy ram. Over the years, a trophy or legal ram had several arbitrary definitions that stipulated minimum age and score. Upon a mandatory check-out procedure, rams that failed to meet the criteria were confiscated indefinitely by the state. The current trophy requirement, which applied to 19 of the 29 hunt units in 1995, authorized tag holders to harvest rams that had attained either the age of 7 or 144 Boone and Crockett points (Nevada Score). Whether a trophy ram requirement has merit has been an issue since its inception. Within the last year, sentiments among sportsmen and county game board members have evidently swayed toward eliminating a legal ram requirement. Thus, it is likely there will be no trophy regulation in the 1996 desert bighorn season.

A Partnership in Wildlife (PIW) program has been developed as a means to increase revenues for game management and to enhance recreation opportunities for Nevada sportsmen. Under the PIW draw, one to three desert bighorn harvest permits will be allotted each year. Hunters unsuccessful in the primary draw may elect to enter the PIW draw by donating 50 percent of their tag refund to game management in Nevada. Funds generated through PIW will be placed in a Wildlife Heritage Trust Account. Dispensation of funds from this account for projects benefitting game species will involve only earned interest. NDOW anticipates the PIW program will be well received by Nevada sportsmen, and that the Wildlife Heritage Trust Account will become a reliable, long-term source of revenue for game management.

In May 1996, the Nevada State Board of Wildlife Commissioners will authorize desert bighorn harvest quotas, as well as PIW tags, and will decide whether to reinstate the trophy ram requirement in the 1996 season. Hunt areas and quotas are expected to remain largely unchanged relative to last year. In 1996, the first of two bid tags was auctioned at the Nevada Bighorns Unlimited (Reno Chapter) banquet and generated $55,000; the second harvest permit will be hosted by Wildlife Habitat Improvement of Nevada (Las Vegas) and will be auctioned June 1, 1996.

PROBLEMS/OPPORTUNITIES

On July 5, 1995, the Bureau of Land Management implemented a significant revision of the ***Interim Management Policy for Lands Under Wilderness Review (1987) (IMP).*** This document sets forth management policy for the 5,169,587 acres (8077 sq. mi.) under wilderness study area (WSA) status in Nevada. Earlier modifications of the original document were largely inconsequential with regard to wildlife management actions. However, the latest alterations of this guiding policy effectively disallow installation of water developments in WSAs. Additional implications relate to wildlife management activities that are within the purview of the state (e.g., aerial surveys and wildlife releases).

Most WSAs in Nevada consist of current and historic bighorn sheep habitat. The qualities of remoteness, rugged terrain, and limited access, which qualified those areas for wilderness consideration, constitute key habitat for bighorn sheep. However, bighorn use of that habitat has been greatly impacted due to human encroachment. Without the construction of wildlife water developments, the Division is unable to reestablish natural distributions of bighorn sheep and other species both within and adjacent to WSAs.

The new policy has yet to be contested. However, evaluation of the new policy by NDOW personnel has uncovered an apparent conflict of Federal laws that may invalidate the revised policy.

STATUS OF BIGHORN SHEEP IN TEXAS - 1995

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Desert Bighorn Council Transactions 40:43-44

POPULATIONS

The Trans-Pecos region of Texas contains seven free-ranging bighorn sheep populations. The populations occur in the Sierra Diablo/Baylor/Beach Mountains (metapopulation), Van Horn Mountains, Sierra Vieja Mountains, and the Texas Parks and Wildlife Department's Elephant Mountain and Black Gap Wildlife Management Areas (WMAs). Thirty-seven hours of helicopter flight time was used to conduct surveys during early September on all areas. A total of 231 bighorn sheep were observed during the surveys. The following summary is provided:

Area	Observed	Ratio per 100 Ewes (Rams/Lambs)	Trend
Metapopulation	160	83131	Stable
Sierra Diablo Mtn.	58	117135	
Baylor Mtn.	32	108158	
Beach Mtn.	70	55120	
Van Horn Mtn.	5	501100	Stable
Elephant Mtn. WMA	54	100125	Stable
Black Gap WMA (Radio-Collared Animals Monitored)	12	5010	Decreasing

The Black Gap WMA bighorn sheep population, consisting of 16 ewes and 4 rams, was transplanted from Nevada in October 1994. Four mortalities occurred from 1995 to 1996--a ram to unknown causes, and a ram and two ewes to a mountain lion. Twelve mountain lions have been removed since December 1994. Three rams from Elephant Mountain WMA were transplanted to augment the Black Gap WMA population to ensure breeding was accomplished. A surviving ram from the initial transplant moved into Mexico soon after release and returned to Black Gap WMA in late November 1995.

There are two captive bighorn populations in Texas. They are located on the Sierra Diablo WMA and Chilicote Ranch in the Sierra Vieja Mountains. The Sierra Diablo WMA facility contains 35 adult ewes, 9 yearling ewes, 9 lambs (1996), 2 adult rams, and 12 yearling rams. The population on the Chilicote Ranch contains 16 adult ewes, 9 adult rams, and no lambs reported for 1996. A mountain lion entered the pens at the Chilicote Ranch and killed all 1995 lambs and a yearling ram before it was removed.

RESEARCH

Texas A&M University-Kingsville and the Texas Parks and Wildlife Department have completed the second year of a 3-year project to determine food habits of free-ranging bighorn sheep in the Sierra Diablo/Baylor/Beach

Mountains. The information from this project will be included in a Geographic Information System (GIS) analysis.

HABITAT IMPROVEMENTS

The Texas Parks and Wildlife Department and the Texas Bighorn Society cooperated in the construction of two slickrock water catchments and construction of a cabin on the Black Gap WMA in March **1996.**

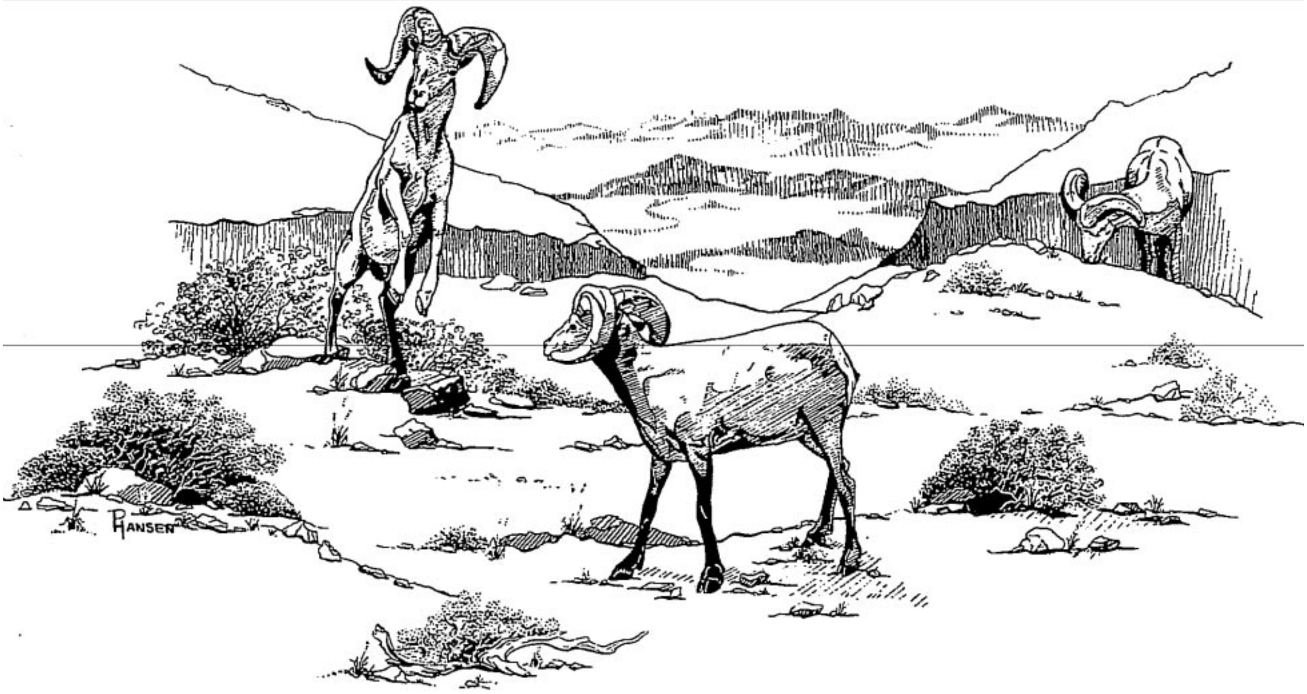
HARVEST

A permit was issued for hunting a desert bighorn in the Beach Mountains. One ram was harvested with a Boone and Crockett "green" score of **161** in the fall of **1995.** Two permits have been authorized for **1996;** one of the permits was auctioned at the **1996** Foundation for North American Wild Sheep (FNAWS) convention and the second will be sold in a lottery.

PROBLEMS/OPPORTUNITIES

Plans for augmenting the Black Gap WMA population with bighorns from Nevada and Elephant Mountain WMA have been initiated.

Efforts continue toward treating bighorn disease complexes within the Sierra Diablo WMA pens.



STATUS OF DESERT BIGHORN SHEEP IN UTAH - 1995

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Desert Bighorn Council Transactions 40:45-47

POPULATIONS

Desert bighorn sheep are native to the canyon country of southern and southeastern Utah. An aggressive transplant program over the past 20 years has restored desert bighorns to much of their native habitat in Utah. A helicopter survey in the fall of 1995 produced 978 observations of desert bighorns. The current estimated desert bighorn population in Utah is just over 2300 sheep and increasing. The fall helicopter survey and the estimated population by management unit is listed in Table 1.

Since 1973, a total of 471 desert sheep have been translocated into areas of historic habitat in Utah. In December 1995 and January 1996, 83 desert bighorns were released to begin new herds or to supplement small existing populations.

Twenty desert bighorns were captured on the Island-in-the-Sky District of Canyonlands National Park and relocated to Capitol Reef National Park. These bighorns were captured by Utah Division of Wildlife Resources personnel as part of a National Park Service cooperative bighorn initiative. This transplant was designed to help fill vacant habitat in the northern part of the park.

The Utah Division of Wildlife Resources also captured bighorns in two of the hunted herds and relocated them in three areas to supplement small populations. Twenty-one bighorns were captured on the San Rafael Reef and relocated to the North Wash area near the Little Rockies. Twenty sheep were captured in the Escalante unit. Eighteen of these sheep were relocated to the Bowns Canyon area near Lake Powell and two rams were released near the Paria Canyon sheep.

In a cooperative project with the Arizona Game and Fish Department, 22 desert bighorns were captured at Black Canyon in Arizona and released in the Coyote Canyon area east of Kanab, Utah. This project was funded by the Arizona Bighorn Society.

Most of the transplant projects in Utah have proven successful and have resulted in the establishment of new herds. The San Rafael and Escalante herds, which began from transplants in the mid-1970s and early 1980s, are now providing sources of transplant stock. It is anticipated that Utah's bighorn population will continue to expand and grow as a result of transplant efforts.

RESEARCH

Several research projects were continued or completed in 1995. Most of these projects were cooperative efforts with various management agencies.

A sightabiity model was further tested and refined in the Island-in-the-Sky and Potash herds and is now providing information on survey accuracy and population estimation. The development of this model has been a cooperative project with the National Park Service, the Bureau of Land Management (BLM), and the Utah Division of Wildlife Resources.

Disease and genetic work continued on sheep in Canyonlands and Arches National Parks with the capture and sampling of 30 bighorns in January. Blood and tissue samples were collected and are currently being analyzed. Scabies specimens were also collected from some animals and are involved in a DNA study by Dr. Rob Ramey.

Radiotelemetry studies are underway in several areas including Arches and Zion National Parks. Recently relocated bighorns are also being studied in several areas including Capitol Reef National Park, North Wash, Coyote Canyon, Roger's Canyon, the Dirty Devil, and Paria Canyon. These telemetry studies of relocated bighorns are focusing on habitat selection and the movements and survival of transplanted animals.

HABITAT IMPROVEMENTS

The Utah Chapter of the Foundation of North American Wild Sheep (FNAWS) and the Utah Division of Wildlife Resources were successful in resolving a domestic sheep problem In the South San Rafael unit in the past year. The foundation secured agreements from two permittees to convert from sheep to cattle on two key allotments in the unit. This area is now free of domestic sheep and the risk of disease transmission has been eliminated.

The Utah Chapter of FNAWS was also successful in obtaining funding from the Minnesota-Wisconsin chapter to purchase a domestic sheep grazing permit on the Little Rockies. The BLM agreed to reallocate these AUMs to wildlife. This purchase cleared the way for the release of bighorns in the nearby North Wash area in January 1996.

The BLM, with the assistance of volunteers, installed a new guzzler in the South San Juan Unit and improved an existing guzzler. New catchments are planned for Lockhart Basin and improvements are planned for the guzzlers on the Potash Unit.

HARVEST

Thirty-three hunters harvested a record **33** desert bighorns in 1995. The previous high harvest for any year was in 1994 when 18 rams were harvested. The increased number of permits and increased harvest is a reflection of the expanded bighorn population in Utah. Most of the rams taken were older age class rams which scored as high as 165 points. A record book ram has not been taken in Utah although several rams have been very close.

A total of 31 permits have been approved for 1996. A slight reduction was made in the North San Rafael permits because of the heavy harvest in 1995. Hunting opportunities are expected to increase in future years as the desert bighorn populations continue to improve. Hunter interest for bighorns remains high in Utah and is increasing.

PROBLEMS/OPPORTUNITIES

The growth of the bighorn population in Utah in recent years has allowed managers to become cautiously optimistic about the future. Transplant efforts have proven successful in several areas and habitat projects are improving conditions which will allow for future expansion of herds.

Disease issues continue to remain a major concern. The loss of the North San Juan/ Needles herd demonstrated how fast populations can be depleted. Domestic sheep continue to utilize areas in close proximity to several bighorn populations. The continued trailing of domestic sheep through the North San Rafael and the potential for reactivation of a domestic sheep permit near Lockhart Basin are specific concerns. The presence of scabies in several herds is also a concern, even though no large die-offs have been attributed to scabies in Utah in recent years.

The pending designation of 2 million acres of wilderness in Utah would protect habitats for bighorn sheep, but could create problems for bighorn sheep managers. Many of the areas proposed for wilderness designation are occupied by desert bighorns. It is important to the future of bighorn sheep that existing management programs such as helicopter capture projects and water development be allowed to continue.

Wild burros on the San Rafael units are increasing and are threatening desert bighorn habitat. In the South San Rafael unit, burros have increased and expanded use areas into bighorn habitats. Steps need to be taken to reduce and control burro populations.

Dramatically increased recreation use, particularly in the Moab area, may be impacting and stressing bighorn populations. Thousands of mountain bikers, off-road vehicle users, and tourists are flocking to the Moab area and recreating in bighorn areas. The cumulative impacts of increased recreation use are unknown but are cause for concern.

There remain vast areas of vacant desert bighorn habitat in Utah. Opportunities for restoration of bighorn populations exist in many areas. Limited sources of acceptable transplant stock is the main obstacle to continuing restoration efforts. The Utah Division of Wildlife Resources plans to continue to pursue transplant projects utilizing both in-state and out-of-state sources. The Division remains committed to restoring desert bighorn sheep to their native habitats in Utah.

Table 1. Helicopter surveys and population estimates of Utah desert bighorn sheep (1995).

Area	Rams	Ewes	Lambs	Total	Lambs: loo Ewes	Rams: 100 Ewes	Est. Pop.	Trend
North San Rafael	70	83	37	190	45	84	300	Stable
South San Rafael	81	100	50	*243	50	81	350	Up
Potash	41	47	26	114	55	87	200	Up
South San Juan				NoSurvey			150	Stable
North San Juan				No Survey			10	Down
Professor Valley				No Survey			30	Up
Lockhart				NoSurvey			30	Stable
Little Rockies/North Wash				No Survey			75	Up
Dirty Devil				No Survey			50	Up
Westwater				No Survey			25	Stable
Escalante	44	63	35	142	56	70	300	Up
Kaiparowits	15	19	6	40	32	79	150	Up
Rogers Canyon				No Survey			10	New
Paria				No Survey			10	New
Coyote Canyon				No Survey			22	New
Arches National Park				No Survey			125	Up
Canyonlands National Park	55	115	43	213	37	48	300	Stable
Capitol Reef National Park	3	8	1	12	13	38	50	Up
Zion National Park				No Survey			70	Stable
Navajo Tribe	5	14	6	25	43	36	70	Up
TOTAL	314	449	204	*979	45	70	2327	Up

*Includes 12 unclassified

1995 REPORT TO THE DESERT BIGHORN COUNCIL ON THE WILD BURRO MANAGEMENT PROGRAM

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Desert Bighorn Council Transactions 40:48-49

Efforts to control the growth of significant wild burro populations in four western states, where they may compete with populations of desert bighorn sheep, continue to fall short of stated management goals (Table 1).

As in the past, population estimates in all four states (Table 2) exceed published Appropriate Management Levels (AMLs) (Table 3). Program goals for the coming season, as well as funding levels, are inadequate to reverse this trend. The estimates show that growth has been somewhat controlled since 1992 with the population only growing by approximately 252 (3.25 percent) during that time period. However, as evident in Table 3, stopping or slowing population growth is not adequate to achieve management goals. The number of animals in excess of the AML has risen from 4149 in 1992 to 4414 in 1995 (6.4 percent) despite the fact that 5178 burros have been removed during that time period.

Although past capture efforts have failed to keep up with the annual recruitment, with an average of 1295 animals being captured in each of the past 4 years (Table 4), BLM capture goals for FY 96 amount to just 575 burros (AZ-375, CA-200, NV-0, UT-0), which is 720 short of the 4-year average. The National Park Service at Lake Mead National Recreation Area plans to fund captures of an additional 750 burros in Nevada and approximately 300 in Arizona. If both agencies meet their capture goals, the potential exists to remove 1625 burros this year. This is approximately 300 less than last year's effort, but is still more than 300 above the 4-year average. This will be accomplished in spite of the fact that BLM's Wild Horse and Burro Program budget was cut by over $2 million this year (FY 95=$16,920,000 vs. FY 96=$14,800,000), a reduction of approximately 12.5 percent.

On a more positive note, in 1995 this author predicted in a report to the Desert Bighorn Council that 1749 burros would need to be removed in order to keep the population from increasing. This prediction was based upon a 20 percent recruitment rate, which seems to be relatively conservative in the areas around Lakes Mead and Mojave. However, based on the population estimates from 1994, the number of animals removed, and the subsequent 1995 estimates, it appears that the four-state crude average recruitment rate was closer to 13.5 percent last year. Using this more conservative estimate, calculations show that population growth may be nu ed at this time by removing 1185 burros in the coming year.

The data further suggests that population growth rates in 1995 varied from a low of 6.8 percent in California to a high of 24.9 percent in Nevada. Arizona was intermediate with 11.8 percent. These numbers are crude estimates based on survey and census data gathered throughout a four-state area by a variety of methods, some more accurate than others. For example, in most of the area around Lake Mead National Recreation Area, the mark and recapture census data provides estimates with confidence limits from as low as 7 percent to as high as 30 percent in some lower density areas. Most areas in the four-state region covered by this report have less accurate data from which to derive their estimates.

The data presented in this paper suggests that to meet established management goals (i.e., published AMLs), the capture goal for 1996 should be approximately 5297 burros if one assumes a 20 percent rate of increase, and 5010 if one assumes a 13.5 percent increase, as was apparently observed in the four-state area last year. Either way, it is clear there is a long way to go before those goals can be achieved.

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Table 1. *Burro captures compared with appropriate management levels (1995).*

	Pop. Estimate	AML	Difference
Arizona	3555	1942	1613
California	2419	975	1444
Nevada	1894	597	1297
Utah	130	70	60
Totals	7998	3584	4414

Table 2. *Annual burro population estimates in four Western states.*

	1992	1993	1994	1995
Arizona	3536	3018	3482	3555
California	2084	1708	2761	2419
Nevada	2022	1784	2369	1894
utah	104	100	132	130
Totals	7746	6610	8744	7998

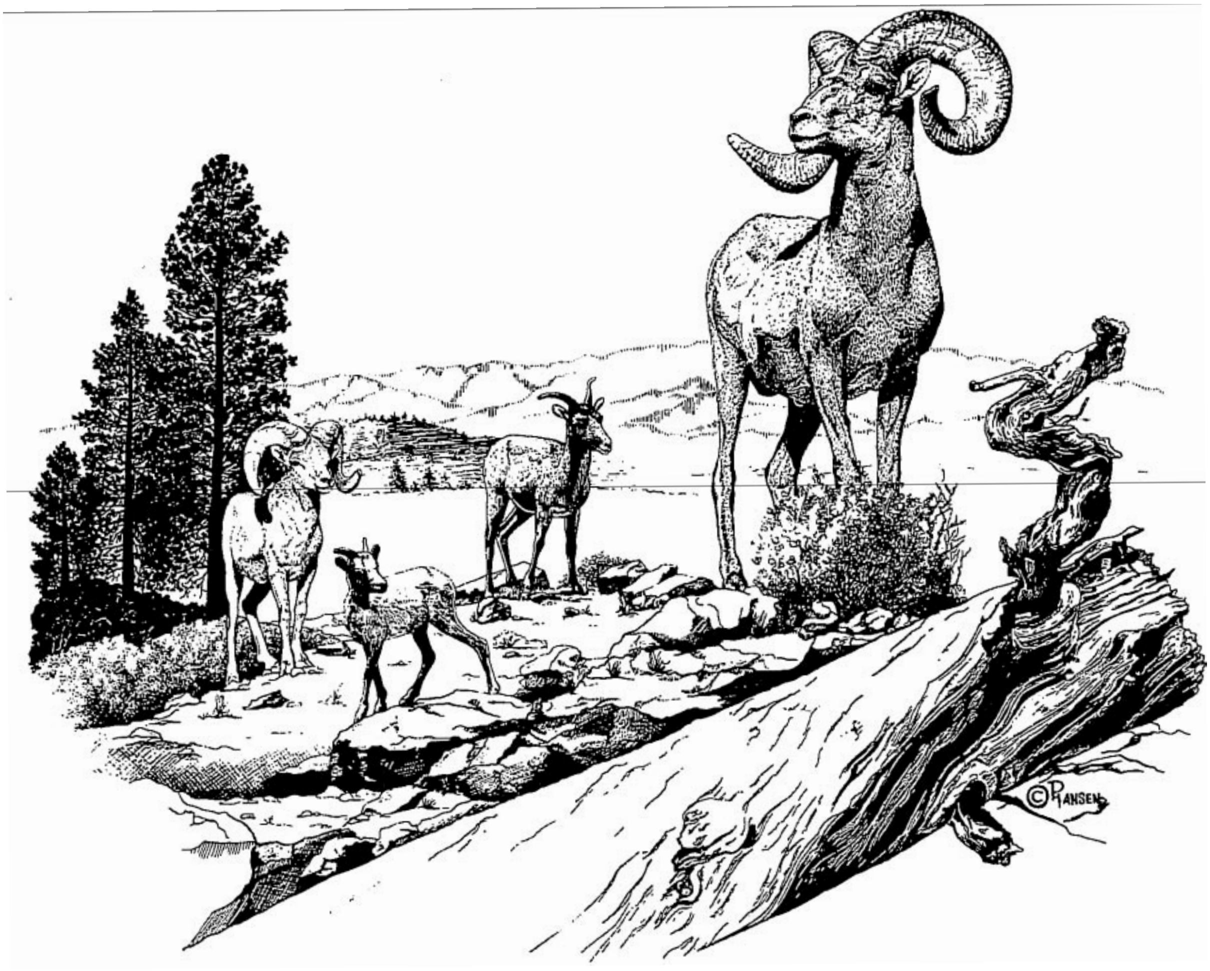
Table 3. *Annual estimates of the number* ***of*** *wild burros in excess of appropriate management levels in four Western states.*

	1992	1993	1994	1995
Arizona	1951	1623	1462	1613
California	1094	718	1786	1444
Nevada	1070	459	1592	1297
utah	34	30	62	60
Totals	4149	2830	4902	4414

Table 4. *Number of burros captured annually in four western states*

	1992	1993	1994	1995
Arizona	341	605	240	337
California	487	522	105	530
Nevada	29	471	447	1064
Utah	0	0	0	0
Totals	857	1598	792	1931

PANEL DISCUSSIONS



During the 1994 Desert Bighorn Council meeting, a panel discussion was conducted on problems and concerns associated with bighorn translocations. The discussion was recorded. Panel members had the opportunity to edit their comments that are presented in this volume.

PROBLEMS AND CONCERNS ASSOCIATED WITH BIGHORN TRANSLOCATIONS

Moderator: Walter Boyce, University of California, Davis, CA

Panel: Jim Bailey, New Mexico Department of Game and Fish, Santa Fe, NM
Tom Bunch, Utah State University, Logan, UT
Amy Fisher, New Mexico Department of Game and Fish, Santa Fe, NM
Rob Ramey, Cornell University, Ithaca, NY
Francis Singer, National Biological Service, Ft. Collins, CO
John Wehausen, White Mountain Research Station, Bishop, CA

Walter Boyce - What I'd like to do this afternoon is to set up a few ground rules. Hopefully, we'll have another microphone available in a short time so that those of you who have questions and comments out in the audience will be able to be heard. I'd like to ask each of you to identify yourself by name at the beginning of your comment or question. The reason is that this panel discussion is being taped and in order for us to identify various comments by their author, we need to have you say your name each time. That holds true for the panel members as well. It gets a little boring and tedious, but it certainly helps those people who are going to be transcribing the recording of this panel.

I wanted to start off by making a few general comments regarding translocations. Initially, let's cover some definitions. We talk about this frequently, but I just want to make sure that we're all on the same page.

What* is *a transplant or translocation? It's the intentional release of animals into the wild to either introduce or establish a new population, to reintroduce or reestablish a free-ranging population, or to restock or augment an existing population.

From 1973 to 1986, over 700 translocations were done per year. More than 93 species were involved in these translocations. More than 90 percent of these involved native game species, 7 percent involved threatened and endangered species, and close to 40 percent involved ungulates. The vast majority of translocations were done by a small number of agencies, and approximately 21 percent of all translocations were done by the same agencies. In other words, some of you were actually doing the vast majority of all relocations in North America The release size--the majority were those involving 75 or fewer animals--72 percent of all translocations were under 75, and of those, 46 percent were under 30.

What are some of the considerations in a translocation? Success is typically defined as the establishment of a self-sustaining population. This gets into the issue of what size is appropriate, when is a population large enough that we can say it is indeed self-sustaining, and over what period of time. Many times, that's not defined. We can talk about minimum viable population size and over what time period. Don Armentrout brought up, I believe, one hundred generations. We're certainly not going to be around for that length of time, so it's going to be pretty difficult for us to ever evaluate whether or not our management actions actually had the results we intended them to have. But there are some theoretical considerations that should promote both the successful establishment and persistence of transplanted populations. Increased numbers of founders should promote increased success. If you are transplanting a population that has a high intrinsic rate of increase, and if there's little variance from year to year in that high rate of increase, it doesn't necessarily describe bighorn sheep does it? The presence of refujia and reduced environmental variation, again, should promote an increased chance of success. Herbivores theoretically will fare much better as colonizers than carnivores in relocation. Also, if you can control limiting factors and if you have proper care and training of captive-reared animals. So that's on the theoretical end. Well, what did they find when they looked at the relocations over this 20-year period since the enactment of the Endangered Species Act? Wild-caught versus captive-reared animals fared better. There's about a 50 percent increase in the establishment of wild-caught versus captive-released animals. Native animals--native species--did better than threatened and endangered species. Species did better when you put them in a higher quality habitat. You could break that down further by saying that there was an increased chance of success when animals were translocated into core historic habitat instead of onto the periphery of historic habitat or outside of historic habitat. There was an increased chance of success if the source population density was high. They broke it into three categories: high, medium, and low. There were significant differences between the medium and high populations from the low density populations. Likewise, if the source population was increasing rather than stable or decreasing, the chance of animals taken out of that population to become successfully established in a new environment was increased. And finally, release size played a significant role. Now, again keeping in mind that this takes into account both birds and mammals, what they found was an asymptote that's reached much like what John Wehausen was discussing this morning in terms of surveys, where once you reach a certain critical number of individuals in a release, there's no benefit derived by going above that number. That number seems to be under 200 for almost all vertebrates that have been translocated in North America and typically its under 100. There's approximately a 60 percent probability of success at 100 individuals in a single release or several releases over a several year period.

Some of the things I'd like you to talk about this afternoon are: What are the goals of a translocation program? How much effort and thought is put into prerelease evaluations? Are habitat and prerelease examinations of the individual animals performed (let's say from a veterinarian-care point of view, what sort of diseases they might be harboring)? How intensive a postrelease effort is made in terms of monitoring? The review from the 73 to 86 translocations showed that approximately 25 percent of those releases were monitored postrelease. The rest were essentially put out and let go.

One of the ground rules for this is that we're going to work our way through the panel and then we'll have those who want to provide a presentation. Francis Singer will go first, but if you have questions at any point during this panel discussion, please bring them up.

Francis Singer - Why don't we start with the slides. I'm going to give you some information on a review of about 115 translocations of bighorn sheep in a six-state region. The six states are those states that constitute the Rocky Mountain Region of the National Park Service. We only included herds that had 10 or more years of data on them. The data includes a few desert bighorns, but most of the analysis deals with Rocky Mountain subspecies and a few transplants of a California subspecies in North Dakota. We excluded some herds: those that had been held in large enclosures, those with less than 10 years of data, and those whose status wasn't well determined. Our objective was to correlate the success or failure of these transplants with a variety of factors. Some of our hypotheses fit in well with the review that Walter gave us. Increasing founder size would be correlated with success if the source population was high density increasing and possibly if several source groups were used. Jim Bailey, in his review of Colorado bighorn sheep herds, called this the genetic diversity hypothesis. He noted that a relatively small number of transplants in Colorado (he didn't have enough to do any statistics) seemed to do exceptionally well where founder groups from different sources had been mixed.

Right away we had to separate these herds into categories. Using Berger's work, we tried to avoid the word successful, which has a lot of anthropomorphic connotations. We defined a persistent translocation (this would be short-term) as one numbering more than 100 animals for at least the most recent 4 years. I hate to use the word failure. A lot of these herds did fail, but we also included any that numbered less than 100 and there's been a lot of problems with setting an exact figure like this. In fact if we redo the analysis for 75 and 125, it won't change things very much. It's just that we don't happen to have very many herds in that 75-100-125 range. Many of them were either extirpated or of. quite small population numbers.

We ended up using a proportional hazards model because we felt it was most appropriate when only partial information is available. In other words, the ultimate fate of some of these populations isn't really known. We're still watching them. The dichotomous variable was persistence and failure, and it's a stepwise procedure. For those of you who are really interested in the statistics, we also used logistic regression and there was only about one variable that differed between the two tests.

What we found was that persistent translocations were negatively correlated with distance to domestic sheep. In fact, we then had to remove that variable in order to work on the other ones--it was such an overwhelming effect. Migratory tendencies, in other words, whether or not the herd moved off of their winter range, even if it was a short distance versus year-round on the same range was positively correlated to persistence. Hunting of the population--we can talk about that a little bit--it could be that the most successful populations are hunted. So obviously there could be a correlation there. Multiple source and founder groups were correlated; founder size was correlated to persistence. Higher ram ratios were correlated to persistence. Whether or not an indigenous source stock was used versus dilution, and by dilution we mean going to a population that had already been transplanted from someplace else influenced persistence. Indigenous source stocks appeared to be better. We found a negative correlation with the number of supplemental translocations. So it doesn't look like supplementally adding sheep does any good. It could be that the least successful herds tended to get supplements more. We didn't find any relationship to subspecies. Oddly enough, we found no relationship to nearest bighorns. Whether or not it was an isolated group versus a subpopulation that was part of a metapopulation where movement exchange was documented.

This slide shows the percentage of translocations persisting by state. I'm not sure this really means too much. North Dakota's done a lot of transplanting, but most of those are less than 10 years old so they really don't provide us with much data. This slide shows the distance to domestic sheep. Translocations were a lot more persistent if they were greater than 32 kilometers, or an intermediate distance if 16 to 32 kilometers, and of a poor success rate if less than 16 kilometers from domestic sheep.

We've already heard evidence from Jim Baily at this meeting that two or more sources in the founder group were correlated to persistence. Again, we had a negative correlation with number of supplemental translocations. Again, the herds that were not doing well were most likely to receive supplementals. Interestingly enough, we're not going to make too much of this in the manuscript, but herds did better if they didn't have domestic cattle on their range. It was statistically significant. The P value was significant. The problem is we only had seven of these herds that didn't have domestic cattle, so we're not really positive of the biological significance of that. As I mentioned before, hunted herds were more persistent translocation~. Obviously, there's a correlation there. The herds that were doing better were more likely to be hunted. There's also a possibility that hunted herds would get more management. As I mentioned, migratory tendencies seemed to be correlated to persistence.

Steve Torres -Why did you use the 10-year criteria?

Francis Singer - The reason was we wanted to make sure there was a long enough period of time where we could tell whether the herd was successful. Most of the herds had been out there more than 10 years. Some of these herds date back to the 1940s.

Steve Torres - But then your leading herds didn't persist for 10 years, correct?

Francis Singer - Well, any herd that was extirpated would have made it into the failure category.

Steve Torres - Two questions just for clarification. All the bar graphs, were those using variant comparisons or differences that came out of the multivariant model?

Francis Singer - All the bar graphs are actually numbers, so those were percent of the populations that made it into this persistence category, which was more than 100 animals at least for the last 4 years. So the bar graphs don't really have any statistics necessarily associated with them. However, I didn't show any bar graphs that didn't have any statistical significance. In other words, I could have shown you other bar graphs of nonsignificant variables, but I didn't. Those are just simply numbers, a percentage of 100 basically.

Steve Torres - Second question. If the state transplants 20 sheep for 3 consecutive years, is that a transplant or a transplant and two supplements?

Francis Singer - We call that a transplant. We describe that in the methods, if they're just 1 year apart. More than 1 year apart, that's how we defined supplementals.

Speaker Unidentified - What percentage of the transplants are categorized as failures?

Francis Singer - I think about two-thirds--one-half to two-thirds. Another point I should make is that only a third of these 150 translocations were what we call persistent or successful. This is a pretty high rate of extirpation or apparent failure, especially given the information we're presented with upfront--that herbivores and game species do better in translocations. The success history with bighorn sheep is not very good. I would say there's a lot that could be done to improve this. One thing I didn't mention is that we have a parallel research project at the master's thesis level. Terese Johnson is doing it. We didn't look at habitat at all; I think that's one obvious omission that people probably noticed. She looked at habitat with a number of translocations in Colorado, so her thesis topic is just habitat. It's a backward look using Tom Smith's habitat model and predicting whether the translocation would be successful or not in populations where we actually have that information. So it's a backwards-looking test, but we do have a parallel effort that's looking at habitat. We ignored that here and I will emphasize this is all correlational, not necessarily cause and effect, analysis.

Speaker Unidentified - Does Jim Karpowitz have anything to say about the San Rafael translocation?

Jim Karpowitz - Not really. It worked. There's lots of sheep there now and we started with a relatively small number.

Francis Singer - Excellent habitat?

Jim Karpowitz - Good habitat.

Speaker Unidentified - Did you look at the presence of lions?

Francis Singer - The answer is no. If you're interested, we'll send you a copy of the manuscript that we're about to submit. It will be much more obvious in the manuscript. Domestic sheep were just such an overriding influence on success to the point that you had to remove that from the model to weed out the other variables.

John Wehausen - I would like to address the fact that you found a negative correlation with supplementation. In California, in Sierra Nevada in particular, we have one population that is successful only because of supplementation. It hasn't reached 100 yet, but it probably will this year. It was absolutely critical that we did that supplementation. We had a number of losses after the initial transplant, and in addition to that supplementation, we controlled lions for 3 years. It didn't take a rocket scientist to figure out that this population was going extinct if we didn't do something about it, and it made all the difference. So supplementation can be very effective in the right circumstances.

Francis Singer - Everyone heard the question I think (question missed in transcription). There could be a correlation here in that the herds that were doing the poorest, for maybe some other reason, domestic sheep, habitat, or whatever, tended to get more supplements. The other reason why I think a lot of veterinarians would caution against supplements is because each time you do it, you're risking a novel pathogen coming in. To just give you my personal opinion, I think I'd be more likely to put some sheep nearby--15 to 20 miles away, but not right on top of the existing sheep--to expand the range, maybe to expand any migratory tendencies.

John Wehausen - Francis, in the case of our supplement, it wasn't likely that novel pathogens would be coming in because the sheep were coming from the same source we'd gotten them from 2 years before.

Speaker Unidentified - I'd just like to comment that it might make a big difference if the original supplement was a small number versus a large number.

John Wehausen - Ours was a fairly large input to start out. I think we put 27 in. We only supplemented with 11, but that 11 made all the difference in the success of that transplant. It was just critical kind.

Francis Singer - Just a personal opinion. .I think it's probably better to transplant as many sheep as you can early, then maybe you're only subjecting yourself to one risk from disease from a novel pathogen versus a program where you're several years apart, maybe four times, then you might have four risks. So get your risks over with at once.

John Wehausen - *I* want to talk about a different subject. We're always up against the question of what stock to use when we're doing a reintroduction and so I'm going to beat this taxonomy stuff into the ground a little further. You've heard a lot of it today. Certainly all states, to some extent, have looked at the question of taxonomy and subspecies in choosing their reintroduction stock.

You heard Rob Ramey's analysis of Cowan's data here a short while ago and learned that Cowan's data does not hold up to modem statistics in terms of Cowan's classification. An interesting thing is that Cowan agrees with Rob. I'd like to read you something from Cowan. The paper that I gave last year about morphometric work, which is in the Transactions, was sent to Cowan for review. That paper found no support for the Peninsular subspecies. Actually it wasn't Cowan's Peninsular subspecies. It predated his taxonomy, but he maintained it. I'd like to read what he wrote in his review of our paper:

> "I have been much interested to read the results of the study by Wehausen and Ramey of the bighorn sheep of California and adjacent areas. It is long past time that a reexamination of systematics of the wild sheep in this fascinating area was undertaken using modem techniques.
>
> Many times in recent years, I have been uncomfortable with the inferences being drawn from my early work. At that time the data base was woefully small and analytical techniques unsophisticated.
>
> Since that time I have done a lot of experimental work with deer, applying diet to test for impacts on growth and morphology, and I endorse the caution of the present authors with regard to possible impacts on cranial anatomy of the food available to the sheep on different parts of their range. I am now very cautious in making the kinds of systematic judgements that I made earlier."

So, there's no support or very little support for Cowan's classification genetically and morphometrically from what we've done so far. Cowan himself doesn't accept it, so where are we? We are in a taxonomic morass now not knowing what to accept. That's one of the reasons that Rob and I are in the thick of redoing morphometric analyses. Since last year when I talked about the Peninsular subspecies, we've done a fair amount more work and moved further east looking specifically at areas in transition from the desert into the Rocky Mountains. I'd like to bring you up to date quickly on what we've been finding. First of all, I want to go back to a slide that I used last year. As Rob pointed out, Cowan's data did support a separation of Rocky Mountain sheep from desert sheep and that's one of the things that we have found too.

One of the neater relationships that we have found concerns horn core length plotted against horn volume of rams. The desert animals all fall up along this pattern here, but here's a Dall sheep down here, very short horn cores relative to horn volume, and here are Rocky Mountain sheep, also falling below desert sheep. There seems to be a fairly clean criterion we can separate them on. We have added a couple hundred more skulls now to what we had then. We've now measured about 600 total, and indeed, Colorado, which is what we concentrated on in terms of Rocky Mountains, does fall in with the Rockies. So we still have at least one clear distinction taxonomically to deal with--that's Rocky Mountain bighorn versus desert bighorn.

In terms of where the desert work is leading, one of the things we found when we first started doing this work was a north/south distinction within the *nelsoni* subspecies, with sheep from the Death Valley region showing differences from those south of 1-15 in California

As we've gone further east, we've been concentrating on some .of the southern parts of Nevada and out to the Canyonlands area What is falling out now is that we seem to have a warm desert and a cold desert band. Canyonlands, when given the choice between warm desert and cold desert, falls in very clearly with cold desert. The shift occurs in southern Nevada. The desert game range already shows clear cold desert affinities. So only the very southern part of Nevada--the River Mountains, the Eldorado Mountains, and so on—falls in with the Mojave Desert and this warm desert band. Everything else seems to go with this cold desert band. We looked specifically at the Grand Canyon for the few skulls we could measure to see where that would fall given an intermediate location, and it came out showing intermediate tendencies, but with some clear affinities toward the cold desert. So what's starting to emerge in terms of desert sheep is that we have this warm desert band extending all the way across into New Mexico and presumably all the way down Baja, and the cold desert band extending from the Death Valley region to Canyonlands, and of course the distinction between the desert and the Rocky Mountains.

An interesting thing about some of these intermediate areas is that Cowan never looked at a single skull from the whole state of New Mexico. When you read him carefully, what he says about how far the Rocky Mountains go down is that he made that determination by logical geographic means and not by any data whatsoever. For the whole state of Utah, he only looked at two specimens; then he assigned the whole state of Utah to Rocky Mountains. But, the genetic data clearly show that Canyonlands are allied with the desert. Morphometrically, we find the same, but cold desert as opposed to warm desert.

Something that correlates extremely well with our morphometric patterns is the change in lambing seasons from a very protracted lambing pattern of the warm desert to the much narrower band of lambing in the cold Great Basin desert. Geographically, these morphometric and lambing season shifts coincide with a change in habitat; mountains get higher. You may think of somewhere like Death Valley as being very hot Mojave Desertlike, but it also has an 11,000 foot mountain on one side of it. I don't know how far north that north desert band will go. We have not dealt with that question yet.

This is how far our taxonomy revision work has progressed. As it applies to reintroductions, it suggests that many past actions considered reintroductions might have really been introductions because they were based on an incorrect taxonomy. This is mostly the case relative to differences between warm and cold desert sheep within what Cowan defined as the *nelsoni* subspecies.

Rob Ramey - What I'd like to talk about briefly is the perspective that biologists 100 years from now will take on our efforts. So I think it's really important that we look ahead and think about what we're doing very, very carefully. In reintroducing mountain sheep, are we interested on one side of the spectrum in sort of a pure conservation/preservationist goal of trying to put back the closest genetic stock to what was originally in that area or, at the other end of the scale, are we creating a zoo for hunting opportunities? I think it's very incumbent upon us to decide where we fit in between those two goals. I personally feel that, in the long-run, indigenous populations are going to increase in value to us, partly because of this pure conservation ethic, but also because those populations may represent unique, locally adapted traits. An example would be lambing season.

I think that when we are preparing to do translocations, and it hasn't been done all that much in the past (more than 10 years back), that probably the best and most conservative strategy we can take is to try to take stock from the nearest possible source for reintroduction. If we cannot get enough animals to successfully get that reintroduction going, then we should look to the next closest stock. I think that's the only way we're going to ensure the sort of preservation of some unique, indigenous populations.

Taking an alternate view, Doug Humphreys already told us about Texas having mixed sheep from a wide range of areas. I think it's important that we watch and see what happens with translocations like that. So another step that I think we should take in this process of reevaluation, which both Jim Bailey and Francis Singer have taken on, is to create a comprehensive database of all translocation data. I have a lot of that in the back of my dissertation, but that's something that should be put in a database and updated. That is the only way we are going to be able to complete an objective analysis of what we've done, and that will help direct us in the future.

There's also been a lot of speculation in relation to the merits of genetic diversity of animals in reintroductions. A lot of it is speculative. There have been some papers on conservation in the literature that suggest that numbers may be more important than some perceived notion of having high genetic diversity in populations. So, when I hear people talk about the potential for augmenting an indigenous population that may be at some perceived low number with additional animals to increase genetic vigor--that sets off alarm bells for me because really we don't have any data that suggests that there's is a sort of genetic effect. It is speculation at this point. To try to measure the effect of high heterozygosity or high levels of genetic variation with some sort of indication of population success I think is going to be very difficult at best. Soon, hopefully we'll have some data both from Jack Hogg (University of Montana) and also from Walter Boyce on the effects of genetic variation on individual reproductive fitness and longevity. I think that's the place we'll probably look to for information to guide us.

Finally, taking this long-range view of translocations, I think that trying to establish metapopulations, or at least trying to establish groups of populations that are going to make it through the various difficulties they will face, is a very reasonable goal rather than just looking at the magic number of 100. I would much rather have five populations of 50 sheep out there than one population of 100, because we all know that populations go up and down for a variety of reasons, primarily disease. So, this will allow us insurance in the future. A corollary to that is, if we do have some indigenous population, for example like in the San Andres and in New Mexico, then maybe we should take on the strategy they have or that California has used in the Sierra Nevada. We have something that's relatively unique to an area, so we've tried to reestablish sure groups of those animals in other nearby mountain ranges. I think that is probably the most practical way to go for the long-range viability of sheep.

Amy Fisher - Just adding to what you said about taking the long-range view and doing the right thing once transplants are made--I think most of you are aware of this--it's very difficult to ameliorate any problem that occurs. One of the worst things that New Mexico did was to put Rocky Mountain sheep into desert habitat in the Gila and Turkey Creek areas in the 1960s. Someone thought we did that because we wanted to; we did it because we didn't have desert sheep to transplant. It was politically the most expedient thing to do to satisfy outside pressures. Beware of doing things simply because of political expediency. We're getting a lot of pressure in New Mexico to transplant sheep to ranges adjacent to the San Andres. As I mentioned in my status report, this would simply spread scabies throughout the state. I would rather lose my job than have a biologist 100 years from now say, "Wow, back in 1993, New Mexico had a chance to eradicate scabies or at least investigate the potential of it and they didn't do it. They spread scabies when they had a chance to do something about it."

Jim Bailey - Well first of all, Rob Ramey let me go last, so I have to say more. Rob, I thought maybe you contradicted yourself, so you get a chance to explain. You said we should watch populations where we've mixed gene pools, such as Texas, very closely. Later you said you didn't think we were going to learn anything if we did that. You said we aren't going to be able to correlate genetic diversity with population success or something like that. So, what should we watch in Texas?

Rob Ramey - I doubt whether we'll see anything, but that doesn't mean we won't see something. Trying to correlate some level of genetic variation with fitness of a population I think is difficult at best, but maybe we will see something. So what I'm saying about Texas, just like Francis Singer's gone through, and both of you have gone through--the data on translocation and looking for effects, maybe we will be able to spot an effect there. I'm just saying what we've done in the past shouldn't just be forgotten. We should watch and maybe we'll learn something from it. It may be difficult to find any effect, but that doesn't mean we shouldn't be looking for it.

Jim Bailey - We did this with pheasants in Illinois a long time ago. We threw in different races of pheasants in a place where pheasants were having a tough time. The theory was that natural selection would select the best genetic type for that habitat. So, is there a chance that if this happens with mixed populations in Texas, we would see a gradual increase in population success. Is there going to be enough time to measure that sort of change?

Amy Fisher - I said that it is Rob's point that we just don't know enough about genetics to justify mixing herds and supplementing herds with rams based on a genetic argument. I've always kind of agreed with Rob that we don't, so I tend to resist that argument. If you want to do it for other reasons, I think that's great. I think you should just lay your cards on the table and explain why you're doing things. If it's for invigorating the herd with maybe a different horn configuration, say it. Don't say you're doing it for genetics. Does anyone have anything that supports supplementary ram transplants?

Speaker Unidentified - Where you weren't able to transplant these sheep because of the scabies mite being scattered all over your state, what is the possibility of using "pour on" like the ranchers are using on their cattle? We might use it as a water-- as a place to take a scrub--and putting this on would take care of lice, mites, ticks, and a lot of internal parasites. Then, once they were cleaned up, go ahead and transplant them.

Amy Fisher - Well, I wish it was that easy. It's really rather a complex deal and I don't think I really have time to get into it, but if I say that logistically I think we could do it, there's other r cations--political and jurisdictional--that are hanging us up, I believe.

Francis Singer - I'd like to respond to Amy's earlier question. The analysis that we did threw out three factors that had implied genetic diversity in them correlated to success or persistence of populations. One was increasing founder size, where the implication is that you're bringing in more genetic diversity with a larger founder group. A second one was indigenous versus dilution as a source. Nancy Fitzsimmons had verified that you do get more genetic diversity, at least in the state of Wyoming, with indigenous--usually they were large indigenous populations--versus something that had already been transplanted. The third was mixing sources, which did come out statistically significant. So the implication is there--again, that was correlational--that genetic diversity does do some good. I think there's a very interesting management challenge or question here. In all likelihood, maybe we need to look at that. When sources were mixed in the transplant, they were probably larger and maybe there's other ways. Mixing does sound a little bit dangerous to get more genetic diversity. It's better to get a bigger founder group, rather than just getting more animals from a single source.

Jim Bailey - My understanding, and Rob you were probably going to say a little more about this than I, is that with a relatively small number of animals, you get, if it's a random sample, a large proportion of the genetic diversity out of a herd. So, once you're over 20 or 30, if you go to 40 or 50, you're not going to gain a great deal more genetic diversity unless you transplant from a diierent herd that has different genes in it.

Rob Ramey - In terms of Nancy Fitzsimmons' work--you may not be familiar with it--she looked at the genetic diversity of Rocky Mountain bighorn sheep herds, both indigenous and transplanted sheep. She found an effect in foreign blood parameters for a reduction in horn growth rates for introduced, diluted, and transplanted populations, which is an interesting result. One thing she didn't find was a reduction in measurable genetic variation from indigenous source populations to the transplants, so it was not a significant effect.

Jim Karpowitz - I wanted to make a statement. Yesterday we talked about transplants in relation to disease and today we're talking about transplants in relation to genetic mixing. I thought back over the 20 years in Utah that we've transplanted bighorn sheep. Most of our transplants have been done with in-state stock. We've moved sheep in which we've seen scabies in their ears. We've moved sheep with runny noses. We've brought sheep in from Nevada and we've brought sheep in from Arizona. Had we not done that, there would be no bighorn sheep in Utah now. That was the alternative. The native populations on the east side of the Colorado River, the north and south San Juan units, and the Needles units are essentially gone. The Potash/Island in the Sky herd remains, but had we not removed sheep from that herd, I think it would have followed the same fate of the San Juan herds. We now have 1500 to 2000 desert bighorns in southeastern Utah. Had we had this real cautious, don't move them until you're sure everything's okay philosophy, we wouldn't have any sheep.

Walter Boyce - I agree with what you just said, but I want to mention a couple of things. Many of the advances on the medical front were achieved by means that are no longer acceptable to us. We used to use mental patients as our experimental guinea pigs. We learned a tremendous amount by doing that. We used prisoners. We did all sorts of things you can no longer do today and tremendous advances were made. But as we move forward and we have more and more refined tools and more options available to us, I think it really behooves us to take advantage of all of those options and at least consider them seriously.

Steve Torres - I have a question in regard to genetic diversity, which we all seem to be launching into a little bit. One, it's still unclear to me how well it's measured, and two, whether it manifests itself. Is the panel suggesting that it manifests in a 10-year period, in subtle differences in founder size, because I think that's real important to consider? Additionally, I think something of interest in your analysis, Francis, that I think is real valuable is whether you might also include a variable of distance from neighboring bighorn sheep populations, and whether that has any effect since we're also talking about the reestablishment of local, regional populations.

Francis Singer - We did look at that. That was on my list of factors that weren't correlated. Again, I have to emphasize this is a correlational data set. We thought that would probably come out significant and I think it is important. Also, one of the variables that came out in logistic regression and didn't in the Cox model was whether or not the population was considered a subpopulation--part of a metapopulation with limited interchange. So statistics are statistics, I guess. I think what you're saying probably is important.

Jim Bailey - I was asked to be here, I guess, largely because several years ago we produced a publication in which I tried to review the past management of Rocky Mountain bighorn sheep in Colorado. I had data at that time through the late 1980s. I tried to see what we could glean from all the information we had, and what, if anything, we'd learned. So I'm going to try to update that with some recent information out of Colorado, and secondly, add some data that I found in the Oregon management plan for bighorn sheep.

One of the first things I looked at in the old report was bottlenecked herds—herds that had gotten down to, at some time, less than 50 sheep, and whether or not they did recover. This isn't much of a big deal, but there's a few more year's information here. We looked at 18 herds that were bottlenecked. Six of them have gone extinct. Six of them still have less than 50 sheep, but are still there. In one case, in Mesa Verde, since 1956 apparently, that population is still struggling along. Four of the herds have partially recovered and two now have more than 100 sheep. So, if you look at total and partial recovery, about one-third of the herds do in fact recover. It's a small sample size. I'm not sure what it tells us. I think that we could rationalize that some of the herds went extinct, not because of small population sizes, but because environmental problems that made the herds become small in the first place persisted and caused the herds to go extinct. From this, I think the genetic effects are uncertain, but it does demonstrate that at least some herds can recover once they've gotten below that magic number of 50 sheep.

More important to what we've been talking about is some information on the genetic diversity of transplants. What I looked at in the original report, and this is what Francis alluded to, is that we've got some transplants that are mixed stocks. They come from more than one and sometimes three different herds. We've got single transplants corning out of one population, and we've got what I call dilution transplants. A lot of these come from the Trickle Mountain herd in Colorado. What we had was 15 sheep taken in the 1950s out of the Tarryall herd. Those 15 founders established the Trickle Mountain herd, which did very well. Then another sample of the gene pool, 15 to 20 sheep were taken to establish an additional transplant. So, let's say that in 15 sheep you've got 90 percent of the gene pool (possibly more than that, but that's a nice round number) in the first transplant. Then you have 90 percent in the first sample and 90 percent in the second sample, so 0.9^2 gives you about 81 percent of the genetic diversity remaining in the second transplant. Then, some of these sheep were put into a pen in Basalt to establish a population that was used as a source of further transplants. These further transplants were double-dilution transplants, now with about 73 percent of the original genetic diversity. We had 24 Colorado transplanted herds that I used in the original paper (Colorado Division of Wildlife Spec. Rpt. 66). However, there were five mixed-source transplants that were too new to evaluate at that time. I've put them into today's new analysis. Another thing that has changed is that one of these herds was supplemented with about three rams in 1990.

The same kind of activity has occurred in Oregon. California bighorns from British Columbia were used to establish a population at Hart Mountain, I believe, or else it was the Sheldon Refuge. That herd was used as a source population to establish some dilution transplants. Later, these herds were used as sources for double-dilution transplants. Using the Colorado and Oregon results, we now have a larger sample size (47 transplants) with better representation in the extremes than I had in the original analysis.

What about the success of these four kinds of transplants? Forty-four percent of the nine mixed-source transplants grew to at least 100 sheep, as did 40 percent of the 15 single-source transplants and 32 percent of the 19 dilution transplants. None of the four double-dilution transplants grew to 100 sheep. One of these, Derby Creek, is the largest herd from a double-dilution transplant, currently estimated at 60-80 sheep. However, this is the population that was supplemented with additional rams, so it's now a questionable double-dilution transplant. There has been some infusion of genes there. This is interesting. The results could be biased if later dilution and double-dilution transplants tended to be into poorer transplant sites. This could occur if Colorado and Oregon emphasized the best-looking sheep ranges first, then transplanted into the less likely ranges. However, the trend supports the idea that genetic diversity is important in determining transplant success.

One of the conclusions that I dwelled on in the original report is that we haven't learned very much from our management activity. My suggestion was that if we're going to obtain knowledge of what works and what doesn't work, we're going to have to rigorously test our management hypotheses with management experiments. This is still true. It applies to most of our wildlife management. The values of water developments have not been rigorously demonstrated. The effects, if any, of fertilizing ungulate winter ranges have not been demonstrated by measured changes in herd demographics.

Today, a common rhetoric is that we will monitor populations following applications of management techniques. I call this the "manage and monitor" approach. With this approach, we haven't learned very much and we aren't going to learn very much. We are going to have to manage with some kind of experimental design. Management will have to be implemented using the methods of research; but it's adaptive management, not research. Administrators who do not understand adaptive management will be leery of this. Management must consider the requirements for controls, randomization, and replication. Otherwise the results from the "manage and monitor" approach are going to be quite confounded, and we're going to be left with ambiguous results such as we have today.

I want to switch gears and speculate about the genetic concerns in transplant projects. These ideas are intended only to stimulate discussion. Our concern is that there may be genetic differences between a transplant stock and the recipient herd stock, or between two stocks that we might mix in one transplant. We might know that there are genetic differences between the stocks, but if Rob Ramey hasn't been around recently, we probably don't know that. We might presume that there are genetic differences because the two stocks come from different environments. The environmental differences may be quite large, as between Canada and New Mexico. There may also be genetic differences between alpine, high elevation herds and low elevation herds. When we presume there are genetic differences between stocks, we worry that local genetic adaptations may be lost or that we may not be using the best genetic stock for achieving a successful transplant. There may also be learned adaptations that may influence transplant results, but that's another issue. So we should use similar genetic stock, or stock from a similar environment, in most of our transplants. But is mixing genetic stocks or environmental backgrounds of stocks never justified? Absolutes simplify management decisions; but they may not recognize the complexity of problems.

In speculating on this issue, consider a 2 X 2 matrix of bighorn "stocks"--recipient populations to be supplemented, or groups of bighorn from separate sources to be transplanted. These stocks may be small or large. They also may be indigenous or they may consist of all or some nonindigenous bighorn. Thus we have four types of stocks in this 2 X 2 matrix.

We might add sheep to a large, indigenous population. There may be no need for this type of transplant, but it may occur to remove excess rams from a captive population or to expand a herd range by transplanting sheep onto its periphery. In this case, I suggest we are not going to reduce the adaptability of the recipient herd. We are not going to swamp this large, indigenous herd with new genes, and it's possible that we could add unique genes that may increase the adaptability of the herd.

In contrast, a large herd may have a small indigenous component because it has been supplemented with dissimilar sheep in the past. In this case, I think it would be unwise to move additional dissimilar stock that would further swamp the indigenous genes.

More often, we deal with supplements into small recipient herds, or with small numbers of sheep in transplant stocks. Small indigenous herds are losing genetic diversity through random, rather than "natural" selection (genetic drift). Inbreeding may cause additional loss and there may be depression of reproduction and survival. Such herds are in trouble and deserve attention to any environmental limiting factors, as well as consideration of a supplemental transplant. But how do we select a transplant source? A large transplant with a dissimilar stock of bighorn would swamp the indigenous genes and should be avoided if possible. But if the herd suffers from loss of genetic diversity, would it make sense to occasionally move small numbers of dissimilar sheep into this herd? Such small transplants would reduce the risk of swamping the indigenous gene pool and would enhance genetic diversity. This strategy will require patience and along-term commitment. If marked ewes, and no rams, are transplanted into a small inbred herd, we might measure success by comparing the reproductive successes of resulting inbred vs. outbred ewes.

Lastly, what about a small population that is nonindigenous, having resulted from a past transplant. The extreme of this problem existed in Texas, where we started with zero indigenous bighorn. Conventional wisdom is that we should transplant stock from a similar environment on the assumption that we would have some preadapted genetic material. But that assumption, and our ability to identify truly similar environments, are questionable. Another strategy would be to use several transplants with somewhat diverse genetic backgrounds, providing an opportunity for natural selection to operate on a diversity of genetic material. This would take much time and many sheep. If we can afford both, it allows the local environment to choose the transplant stock by natural selection, rather than basing that choice on our best knowledge, which may be wrong.

Not being a population geneticist, I have stuck my neck out with these suggestions. Behold the turtle, he only makes progress when he sticks his neck out. My point is that, given the primitive nature of our knowledge of the genetics and adaptations of various stocks of bighorn sheep, it is premature to conclude that we should never mix gene pools and always transplant sheep between habitats that we view as being the most similar. The problem is not that simple. In selecting stocks of bighorn sheep for transplants, I suggest we consider the size and indigenous status of each stock that we mix.

Tom Bunch - I appreciate being here and participating with you on this panel discussion. I want to briefly cover two areas of research that I've been involved in and hopefully to draw some inferences from that research that might have management implications. I was not here yesterday, so I hope that I won't be redundant on some of the things that were discussed yesterday that deal with disease.

The first topic I want discuss with you briefly is pneumonia. I think that most of us who have worked with disease, particularly in desert bighorn sheep, would agree that there's no disease that has killed more desert bighorn sheep, considering all diseases together, than pneumonia. Pneumonia, particularly *Pasteurella* pneumonia, has been and will continue to decimate entire populations of desert bighorn sheep. During the last 10 years, there's been a lot of research attempting to relate a virus, or in the case of Pasteurella pneumonia, a biotype, serotype, or with the DNA techniques, a genotype to equate the virulence with the onset of pneumonia. Five or so years ago, I think it was at Las Cruces, Terry Spraker discussed the role of stress and there's no doubt that stress plays an important part in pneumonia. Within the last few years, Bill Foreyt and others made reports which suggested that exposure to domestic sheep can be a significant factor in the pneumonia complex. We've found the same with exotic wild sheep. There's also reports that when you bring desert bighorn sheep together from different geographic localities and mix them in confinement, it often leads to Pasteurella pneumonia. Also, I've heard suggestions coming out of these meetings from time to time, and it's not new, that desert bighorn are inbred, thus reducing their natural immunity to disease.

Now I used to be a firm believer in thinking that there's more to the pneumonia complex than Pasteurella multocida or hemolytica, and that's true. There are other things that are involved such as viruses on occasion and stress. What I did a few years ago, and it becomes very difficult studying disease in wild sheep or studying sheep in general because you don't have the control over the situation, the factors that are involved, or at least the type of control you would want. What we attempted to do was to take desert bighorn rams that were captive-reared, in some cases handraised, and expose them one at a time to a group of our mouflon-cross sheep (a wild-type sheep developed in Texas for game ranching purposes) to look at what would happen under those conditions. We monitored the animals from the time of exposure to the time of death. We measured vital signs. We took blood samples, nasal swabs, sinal samples, and during the necropsy, we took tissue samples. Richard Mott, a virologist from the Texas Medical Veterinary Diagnostic Laboratory Systems, worked with us using the most current methodologies in tissue culture combined with electron microscopy to look for an agent other than Pasteurella pneumonia that led to the death of these animals. I realize that if you don't find a virus, it doesn't mean that it's not there. But, with our best effort--exposing six sheep in six different trials--we could never substantiate anything other than Pasteurella pneumonia.

This leads to the second area of research, which has raised some of the issues here just recently. This was a hybridization program. Now there's no question, I think all of us will agree, that desert bighorn are inbred; but, so are a lot of wild populations. Some rodent populations are extremely highly inbred and are able to handle that inbreeding, which doesn't result in high mortality from disease. Most of our livestock species (an area I'm involved in and my primary assignment at Utah State University) are the result of inbreeding and selection. We have more than 850 breeds of domestic sheep throughout the world and those are a result of inbreeding and selection. Our premier dairy cow in the United States, the Holstein, is the result primarily of the development of artificial insemination. You can trace their history back to a relatively small number of sires. The question then that we raised was can we upgrade or can we outbreed--now the ultimate of outbreeding is hybridization--can we hybridize desert bighorn sheep and develop a higher level of immunity to Pasteurella pneumonia?

With the experience I've had with both wild and domestic sheep, I knew they were interfertile. We cross mouflon and domestic sheep without a problem. In Iran years ago, we crossed the Urial with domestic sheep; they're interfertile. At Sybille (Sybille Wildlife Research and Conservation Education Unit) back in the early 1970s, they crossed Rocky Mountain bighorn with domestic sheep. So, I knew the two breeds were interfertile. At least I thought they were. So the questions I asked myself as I approached this were: Are the two breeds interfertile? What will the hybrids be like? Are they viable? And, are the hybrids more resistant to pneumonia? Yes, the two species are interfertile, but they're not compatible. Most of the lambs that were born were less than three pounds and died within 24 hours after birth. Many of the lambs were stillbirths resulting from spontaneous abortion. The hybrids were a very unique cross. The females had a phenotype like a desert bighorn ewe, the males had a phenotype as well like the desert bighorn. Are the hybrids resistant or more resistant to Pasteurella? Yes and no. If the lambs were left with their dams or their mothers, they would be dead within 6 weeks from acute Pasteurella pneumonia. If we bottle-raised them, with a lot of tender, loving care, then we were able to maintain a degree of compromise with the pneumonia; off and on these animals would have to be treated for Pasteurella pneumonia. The only difference is that if we aggressively treated them, most of the time we could pull them out of pneumonia. With the desert bighorn, no matter how aggressively we treated their pneumonia, we couldn't change the course of the disease.

So what are the management implications as I see them? I believe there's wisdom in keeping exotic wild sheep away from populations of desert bighorns as much as possible. Exotic wild sheep will intermix with desert bighom and could very well be the primary factor leading to an outbreak of Pasteurella pneumonia. I don't currently see where outbreeding, particularly hybridization as we did and as I indicated represents the extreme form of outbreeding, will be an immediate answer in developing a more resistant desert bighorn.

One of the areas of research at the University that I've been involved with the last *2* or **3** years is genetic engineering of livestock. At the present time, even though the technology is in place, I don't see any magic bullet out there that can be applied to the desert bighom sheep's Pasteurella pneumonia problem. We simply do not know enough yet about the gene/disease interaction, although the potential is there. We recently developed a mouse that's highly susceptible to a retrovirus. We genetically engineered that particular mouse and it's developed a high degree of resistance to the virus. So the potential is out there, although I don't see it in the near future. Therefore, I would recommend that whenever and wherever the situation occurs, that managers should greatly reduce these high risk factors to pneumonia, such as exposure to both domestic and exotic wild sheep. I don't see a solution to the problem at the present time through altering genes or through vaccination. Those who have dealt with vaccination and trying to control disease in wildlife populations through vaccination know it's very difficult--not impossible, but difficult. So I think the primary method of management here as we look at *Pasteurella* pneumonia is to be conservative, to remove the high risk factors. In many cases, that's going to mean maintaining isolation from these high risk factors as much as possible.

Jim Bailey - I'm not sure how to interpret what you're saying about outbreeding and disease resistance. You said you had extreme outbreeding and you did not gain any appreciable resistance to *Pasteurella* pneumonia. Now, can we infer anything from that about outbreeding between different strains of bighorn sheep and resistance to other diseases or not?

Tom Bunch - It's certainly possible. We looked at one particular disease. One of the things I didn't mention about the Argali form sheep is that as a wild sheep, they are resistant to pneumonia or at least are able to handle the challenges of *Pasteurella* pneumonia, which would be equivalent to domestic sheep. In the domestic livestock business in Texas, to give you an example of outbreeding or crossbreeding that's made a difference, they've crossbred *Bos tarus*, which is the European-type of cattle, with *Bos indicus*. They wanted to develop a strain of animals in that particular locality that was much more resistant to desert-type areas and also resistant to ectoparasites. It's possible--it's very well possible--that through outbreeding, you could develop resistance to some types of diseases; but, it doesn't appear obvious to me that it's going to work with the *Pasteurella* pneumonia.

Amy Fisher - In addition to Tom's excellent presentation is the realization that there's no good test for finding *Pasteurella* in sheep, which Walter Boyce reminded me of yesterday. This means we cannot rely on a health screening to tell us two different herds are compatible. That's why I get a little scared when people mix herds and depend on the health screening that is available at this time.

Tom Bunch - I just wanted to mention one other thing. I think a lot of times we don't realize with *Pasteurella* pneumonia how serious it can be. In our study at the University, you start developing an eye for animals that show the early symptoms of *Pasteurella* pneumonia. I felt fairly comfortable with that and I knew I had 24 hours, and if I didn't act within 24 hours, these animals were dead. In fact, they died so quickly, it looked like they just went to sleep. A lot of times with the disease, you get debilitation, dehydration, and so forth, but not in this case. It was so quick. From the time of exposure with these rams to the time of death was between 8 and 14 days after initial exposure. So it can be extremely fast. That's the reason why I can't emphasize enough to remove these high-risk situations where our desert bighorn can be exposed. And I strongly feel, and I don't have any data for this, that the desert bighorn are at greater risk because I think they're more susceptible to the *Pasteurella* pneumonias then even Rocky Mountain bighorn.

Walter Boyce - With the exception of Amy Fisher up here, those of us who have been talking about all those considerations that you should think about when doing a transplant don't ever have the option to implement any of these considerations because we're not the managers in charge of the animals. I'd like to ask the various managers in their respective states what drives their philosophy and if perhaps they've heard anything at this meeting that will change their philosophy regarding source stock and transplants. Ray Lee from Arizona would you perhaps comment first?

Ray Lee - Thank you Walter. Actually, there's been a number of interesting things brought up and this afternoon is certainly the time to talk about them. Getting specifically to your question about what drives our transplant program--our program's primarily opportunistic. If we have good source stock or good populations--in the past we've had no shortage of historic habitat that had lost their populations--our drive was to be able to go into those areas where we had good populations and move the source stock out to the nearest possible area.

Primarily, we've taken out of the Peloncillo Mountains, and that being a *mexicana* subspecies, moved them to the southern portion of the state. From the Lake Mead/Lake Mojave Complex, which also has cyclical high population levels, we took sheep from there to move into the *nelsoni* areas in northern Arizona. As the areas have filled within the state, we've looked at supplemental transplants into some of those areas that have perhaps not done quite as well on the first transplant. We tried naturally to take into consideration the things that have been suggested here, 'moving sheep from the most local areas possible and looking at diseases as well. That's one of the things I've personally always been womed about with supplemental transplants. If you have a population there that is doing well, or is not doing well, or is perhaps going one way or the other, to supplement it you always have the possibility of killing it out through your own actions.

Just a couple of other thoughts. When you're looking at moving animals from the genetic diversity aspect, a lot depends on the methods you use to catch the animals. If you do a drop-net capture, for example, typically what you'll do is remove family units. The genetic diversity there is much less despite the fact that you might be moving many more animals. So things like this also need to be looked at as well.

Craig Stevenson - I'm just a field biologist, but basically we're opportunistic also. As far as changing our management strategy, that's kind of tough. I've been talking with Rob Ramey about maybe preserving some of the areas we do have, that we're sure are genetically pure, but I'd have to get George here to give you the history on what we do and why we do it. One of my thoughts is we've been taking southern sheep and moving them up north and we've been putting them into populations that have established ungulate populations, usually mule deer. We're putting lion-stupid sheep up north. They don't know what a lion is and they don't learn until it's too late. One thing that we've been looking at is maybe putting experienced sheep into some of these areas. But, as far as watching genetics, we've been fairly consistent in moving sheep from the Blacks or the Rivers into specific areas and not changing the genetic base at all.

Vern Bleich - I think that some of the things I heard here today were very gratifying. I would argue that we're doing things pretty much correctly in California based on some of Rob Ramey's comments. I appreciate that, however fortuitous it may be. In any event, in terms of driving translocation projects in California, I'd point out that the initial sheep translocations in the Sierra Nevada have been carried out very much in concert with a long-range, long-term conservation and management plan for that subspecies of mountain sheep. It was carefully crafted. It's a true interagency, full-participation document based largely on the initial work Johnny did in the early 1980s or was it the 1970s--I can't remember. That document has proved beneficial to the California Department of Fish and Game, the Forest Service, the Park Service, and the BLM. Even the Los Angeles Department of Water and Power has been a key player in the conservation plan for the Sierra Nevada mountain sheep. We've been very careful there not to import extraneous genetic stock--that is stock not indigenous to the Sierra Nevada. We've extended that guideline to the White Mountains, an area immediately east of the Sierra Nevada where the single translocation we've done was from within that mountain range. It was an attempt to establish a subpopulation of female sheep, an additional subpopulation on historical range in the White Mountains. So we've not been mixing a great deal. With respect to the desert regions of California, we did the first translocations in 1983. At that time we attempted to seize upon the opportunity, as Nevada and Arizona have done, to take advantage of large numbers of sheep in two very productive mountain ranges. We augmented, or at least we think we augmented, a population in the Chuckwalla

Mountains, one in the Argus Range, and one in the Sheephole Range solely with animals taken from Old Dad Peak that John talked about earlier today. It's been a very productive and predictable source of translocation stock. Interestingly, the Chuckwalla Mountains with that augmentation--and mind you it was an augmentation of 45 animals--that population has not done very well as near as we're able to determine. We have some very positive signs with respect to the Sheephole Mountains. It looks as if that population has expanded substantially in size from the initial translocation stock. In the Argus Range, there's some encouraging news there. With respect to mixing populations, we mixed animals from Old Dad Peak and Marble Mountains, placed them in the Whipple Mountains, an area apparently devoid of sheep at that time. Also, we mixed animals from Old Dad Peak and the Marble Mountains and placed them in the Eagle Crags in two separate translocations in the mid-1980s. That population doesn't look like it's doing well at all. So in the Whipples and Eagle Crags--using genetic stock from two sources--the results have not been too encouraging. I don't know what to draw from that, but it's been kind of disappointing. What is driving our translocation program right now is essentially the idea...

(Tape Change)

...populations in the hopes that this will facilitate gene flow between disjunct or island populations of mountain sheep. This stepping stone model is consistent with metapopulation theory. I'm with Rob Ramey. I'd much rather have four populations of 25 sheep, I think, then even one of 200 sheep when you get right down to it. So we're trying to fill in the blanks in the desert and that's currently what's driving much of our management and our translocation strategy.

Walter Boyce - Steve, could you perhaps address some of the taxonomic questions in your comments.

Steve Torres - *In* a way, it fits in if we consider them as metapopulations, particularly the Peninsular Ranges. It only makes sense if we need to augment a population or reestablish it; we take the stock locally. I fully support the regional notion and also the local stepping-stone fashion. A lot of what we're talking about here and why I asked earlier about inbreeding and whether it manifests itself over a 10-year period, and even whether it's something of legitimate concern, depends on what type of population you're trying to reestablish. If you want to reestablish a population, and you're somewhat assured that it's going to be an isolated population, then inbreeding, source stock, and genetic diversity, are all very important considerations.

Part of our charter in the Department, of course, and I think in all resource agencies, is to manage for biologically viable long-term populations of bighorn sheep. As part of this, I think the sooner we can have a hands-off approach, the better. Part of establishing a small population that's likely to have interconnectivity further negates some of the concerns with regard to genetic diversity, if indeed they're sharing individuals moving between them. That's part of filling in the missing pieces of the puzzle.

Another thing I think we need to look at in both Francis Singer's and Jim Bailey's interpretations is to be a little careful in the inferences we're drawing. I appreciate, and I'm not putting down the genetic diversity, but I think we've emphasized it a little too much, at least with regard to what's happening in California. Basically, when we introduce a bighorn sheep population, what I look at retrospectively is that there's predation, there's range condition, and there's the availability and the suitability of the range they're on. These are immediate factors that aren't being alternatively tested here. I think that's one thing that most dramatically influences, at least to me, the success of what we're seeing. And, of course, we're not reintroducing next to domestic sheep areas.

A further bias in this retrospective way of looking at things is that there's a time element there that's associated with range condition, precipitation, and other things. So Francis Singer, in this staggered entry of these populations and when they were reestablished, might address the fact that they were done at different times or that different climatic factors were operating then.

So there's many influencing factors and I think, given that when we're establishing a population and it's a founder population, that we must remember fundamental population models, not just population genetic models. Potentially, these sheep populations are at the low asymptote of rate of increase. Now for them sometimes to get out of that, they need a little help, whether it be the good climatic conditions they were introduced under, or whether it be the temporary removal or suppression of predation to which they can increase the rate of increase. There's a whole host of things that I think are really important. I've sort of gone off on several tangents here. That's my style, free-flow conscious. Anyway, basically getting back to the subject. What we're trying to do is establish a regional approach. Vern Bleich and I--and a lot of this is part of the BLM plan, I'll put in a plug for them--they're working with us in the habitat management too. I think a lot of what I'm echoing here I've read out of Weaver's 1983 plan; I want to give Dick some credit. But, we're also looking at, for example, the Orocopia Mountains as a potential way of augmenting the local populations there too as a preferred method, and also that these populations aren't isolated populations. I appreciate Amy's dilemma where she is somewhat forced from not having connectivity between some populations because of a disease process. That limits some of the options you have.

Walter Boyce - Just to throw in one potential word of caution on filling in some of the blanks. Once you establish connectivity between all these populations in a metapopulation, not only have you created a corridor for migration of animals, but you've created a corridor for migration of pathogens. You can indeed set up a scenario where not only can rams rapidly migrate from one population to another, but perhaps disastrous pathogens as well.

Jim Bailey - You've established several metapopulations in the Mojave and Sonoran Deserts. In the future, will you transplant between metapopulations or not?

Steve Torres - ***Ah,*** you're making me think here. Actually, potentially what we're recognizing is a metapopulation. Yes, indeed we may. The Orocopia Mountains are currently on one side of Interstate 10, which is sort of our manmade and now our real barrier between that and the Granite/Palen system. Those populations were local and most likely often shared stock or individuals between them. So, yes, indeed we may consider mixing those metapopulations. Now, if it means going across metapopulation lines, that would be something that would have to be carefully considered and, indeed Walter, the path of exposure is well taken.

Amy Fisher - I wasn't going to jump in unless some things I have weren't brought up. In New Mexico, we've learned a lot from our mistakes and when I got to know you all a lot better, I realized that you've made some mistakes too. You're just more reluctant to acknowledge them. I hear about them after the meeting, during the breaks, and so forth. I'd like to make a plea for a healthy, professional dialogue; we can really learn from each other's mistakes.

I'd like to discuss three other points I've learned from being in this business for 12 years.

First point--conduct habitat evaluations. Don't fall into entrenched positions based solely on your evaluations. I'll tell you a funny story. Many of you know Bill Dunn--a really blunt guy, kind of like me. Bill got up in front of a BLM audience to give the results of his desert bighorn habitat evaluation. One of his sites ranked really low and to sum it up in a nutshell, he said that this site in the Ladron Mountains was simply a pimple on the face of New Mexico. Well, it wasn't too much later--in fact 2 months later--that a transplant to a much better range fell through and guess what? We asked the BLM to transplant to the Ladron Mountains—that pimple on the face of New Mexico. So, be sure that you don't burn any bridges even though your habitat evaluations might rank a place low.

Second point--mitigate and correct limiting factors before transplanting bighorn. I know that's real tough, but a lot of factors can be identified and eliminated. I'll give you an example. We recently transplanted bighorn from the Pecos Wilderness to Wheeler Peak. Wheeler Peak received bighorn in 1968, but that transplant failed for a really simple reason. These sheep were really dependent on salt. When they got to Wheeler Peak, they ended up on the roads seeking road salt and got killed So, by researching what happened to the original transplant, we established salt stations in the transplanted area Jim Bailey, who followed them for 3 months, can tell you that it worked very well.

Third point--conduct intensive postrelease studies. There was a very good paper back in 1981 by Roland and Schmidt in the *Transactions* that extolled us to go ahead and do this. Without postrelease studies, we cannot tell why a transplant succeeds, fails, or stagnates. After this paper came out, there was a spate of postrelease studies. Mine was one. But then, all of a sudden, they seemed to have fallen off. People think, "ah, we kind of really know everything there is to know about transplants, so let's not spend the $15,000 to $20,000 it takes to do it" I tell you, we have learned so much from these studies that I think we get the most bang for our buck from them.

Jim Karpowitz - Most of the desert bighorn transplants in Utah in the past have utilized in-state stock from the Colorado River corridor and we've spread them throughout southern Utah. The animals that we've brought in from out of state have supplemented populations where we've already seen other out-of-state animals show up. For example, in Westwater Canyon, we had desert bighorn from Colorado, originally Nevada stock, move into there and we supplemented them with Nevada stock. Our plans for the Arizona sheep are in an area where we have Arizona sheep moving into Utah.

I have a question for the panel. We have a situation now on the east side of the Colorado River where our large, native, bighorn populations are nearly gone. The North San Juan unit sheep numbered 400 to 500 and now they are down to virtually zero--just a few remnant animals. The likelihood of getting in-state stock to repopulate that area is nil in my lifetime. Do we do nothing or do we consider bringing other Nelson bighorns in from, say Nevada, where they have sheep available that they'll give us to repopulate that area with desert bighorns? It's the largest expanse of continuous desert bighorn habitat in Utah. The desert bighorns proved that 'it was the best habitat. They persisted there until modem times and now have died off. Do we sit back and do nothing or do we repopulate the area with out-of-state bighorns?

Walter Boyce - One question. Can you identify what the most limiting factor is and has that been corrected?

Jim Karpowitz - The most important limiting factor was disease in domestic sheep and it's not entirely resolved, but we wouldn't do anything until it was.

Tom Bunch - I think I'd use a degree of caution because if you still have sheep in that area, there's a good chance that they may have developed some degree of resistance and they could be carriers yet of whatever that disease was. My guess is that it was pneumonia because some of the animals were found along the Colorado River. Often, when sheep develop pneumonia, they'll go to areas where they can become cool--most often near water. I've seen desert bighorn bury their heads in a water trough when they have a high fever. So, I wouldn't jump into this with a lot of money. Initially, because there are some remnant sheep and the interaction could result in the death of the transplant animals that you introduce there. But at the same time, I don't think you should do nothing. I think it's worth the risk on a small scale to start again.

Speaker Unidentified - Is this what they call being between a rock and a hard place? I guess I have to agree with what's been said here. The nearest available, most similar stock is what you would have to go with.

John Wehausen - I'm curious about your comment that the ability of getting native stock in your area is nil within your lifetime. Could you comment as to why that would be since you do have native animals in this area?

Jim Karpowitz - My career lifetime. There's really only a couple of sources: the Potash and the Island in the Sky herd, which now has widespread scabies it looks like, and we've had difficulties in removing sheep from the park. Our other sources are transplanted herds that started with small numbers and have the associated problems, although we've moved some of them too.

John Wehausen - But you do potentially have some of those native, those reintroduced populations, that could serve as some stock?

Jim Karpowitz - Yes, we have used them and they can be used--very small numbers of animals.

John Wehausen - Could you perhaps take rams out of Potash or somewhere like that under certain circumstances and add genetic diversity to those if you wanted?

Jim Karpowitz - We have.

John Wehausen- So, it's not absolutely impossible to use native stock?

Jim Karpowitz - It would be extremely difficult to get enough animals to do any good. We've got so many other places to put the native stock on the west side of the Colorado River that that's where they ought to go. We already have this polluted...

(Tape Problem)

...try to protect, just use native groups in there. Then, there's large areas of southcentral and southwestern Utah where the bighorns are completely extirpated and we maybe feel a little more free to mix and bring in different stocks.

Jim Bailey - Well, with our desert bighorn sheep, we've just been opportunistic on wherever we've gotten them from, Nevada or Arizona. I think maybe we're still in that mode somewhat, although we're starting to get bigger populations. I think we'd just like to take some of our own and try to build with what we've got there now. It's a lot easier probably, financially and for a lot of other reasons.

As far as Rocky Mountain bighorns go, I think we've been pretty opportunistic within the state moving to sites that have been maybe historic bighorn sheep ranges. Since there's nothing there now, we'll take them from probably anywhere in the state. I don't think we've taken any from out of state. In some areas, like Georgetown and around Ft. Collins, where we've got bighorn sheep range that the present herds aren't utilizing, we've been pretty successful moving sheep, local sheep, just a few miles and establishing herds. So that's worked out pretty well.

Doug Humphreys - With the Texas situation, we've had to be completely opportunistic or we just would flat not have any sheep. We're working under good management plans within the state and we're doing more to strengthen those plans, but we've had to do whatever we could to get sheep there. I don't feel, within our department, that it's been a mistake to get sheep back into the state by doing what we've done. It's just a matter now to start working within those bounds and practice good management from where we stand at this point.

Walter Boyce - I think that covers all the states. Am I missing or skipping anybody? The one other group I'd like to hear from is BLM. We have a lot of BLM representatives here and we talked earlier today about coordination and cooperation. Don, do you disagree with anything being said so far by the folks up front in the panel or by the state agencies?

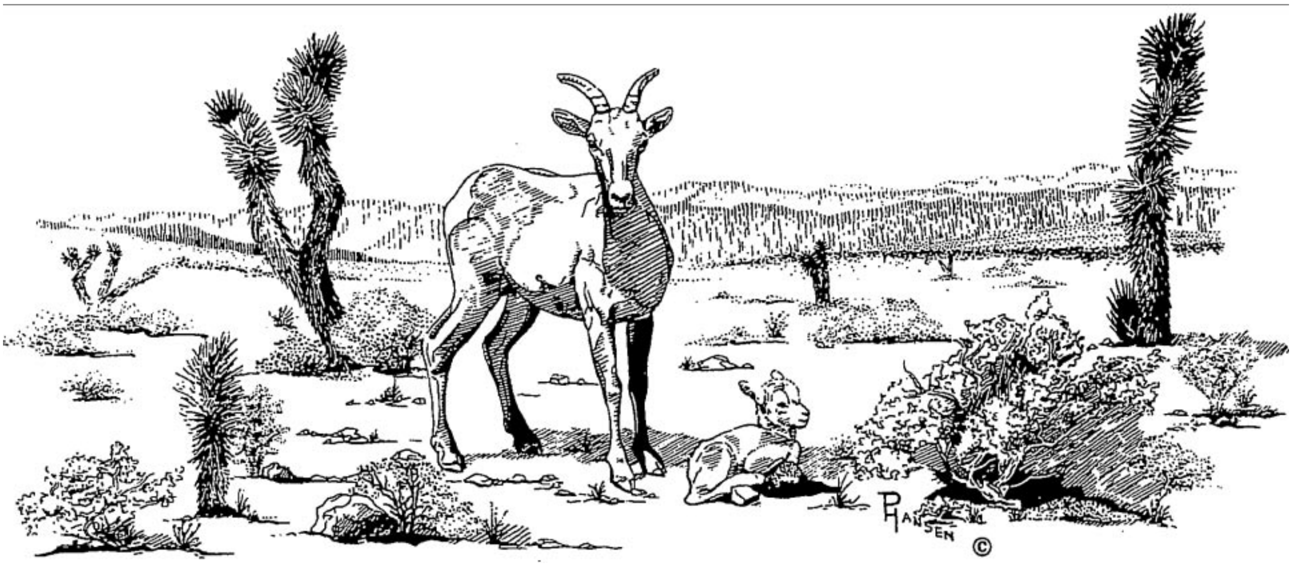
Don Armentrout - No.

Walter Boyce - Does anyone here have any burning comments or questions?

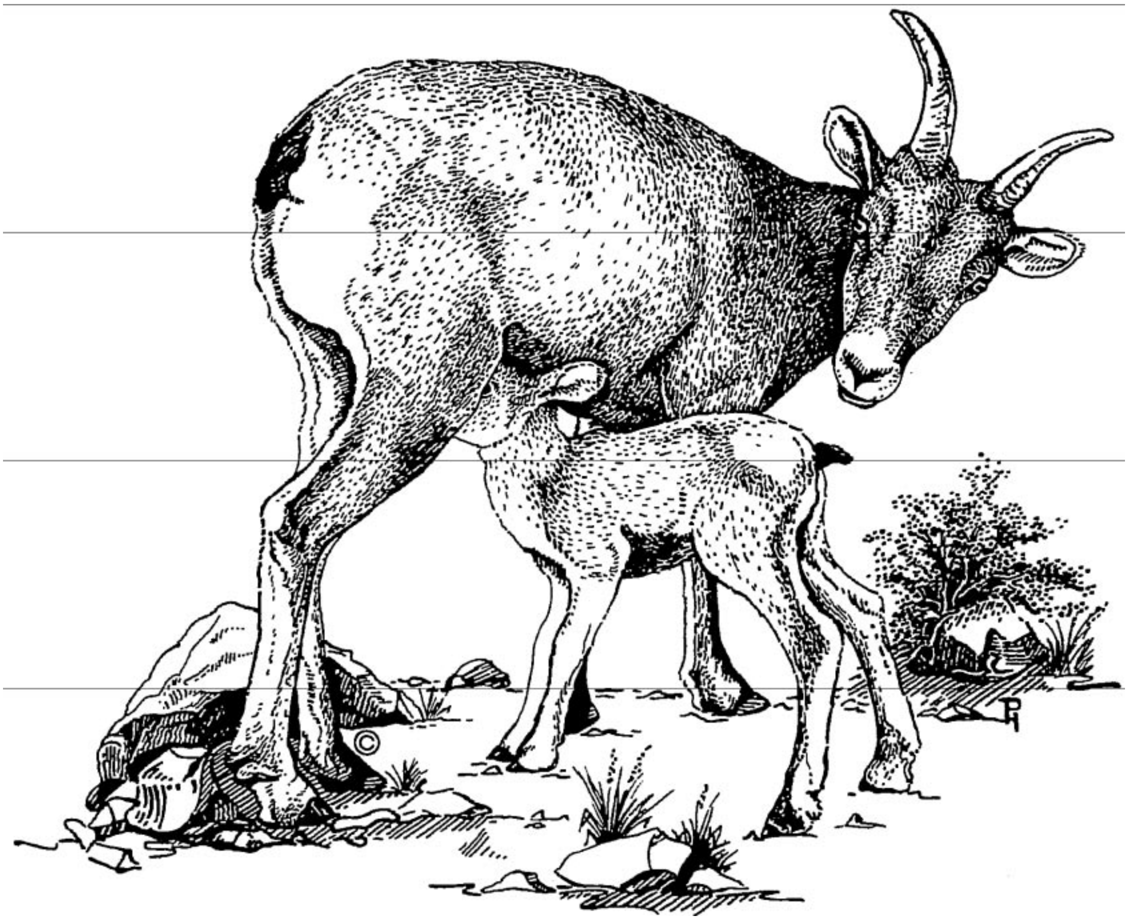
Francis Singer - Just a quick comment. I've been hearing the use of the word metapopulation quite a bit and there's a possibility some people might be misusing it. Usually, it's defined as a series of spatially separated subpopulations with limited interchange of individuals. By definition, the population dynamics of those subpopulations should be independent of each other. The classic example: some subpopulations can go extinct and then be recolonized by the other ones. So, in the model exercises that have been done, these metapopulations persist longer than a single subpopulation. Walter made a comment that a disease could sweep through your whole metapopulation. If you've got that much connection, that's not a metapopulation--it's a single large population. Well, this may be a critical point. It may be to your advantage during your transplant programs to have partial barriers between populations so diseases can't sweep through the whole group.

Rob Ramey - Just so that my comments aren't misinterpreted, I'd like to point out that California really has sort of an ideal situation in that they have a fairly large number of mountain sheep populations still left in the state. There's still some regional integrity. So, my sort of ideal scenario of trying to get sheep from a local area to reintroduce, and to try not to mix too, really sort of works. But you can see with Utah that they're in a situation where they're forced to compromise just simply because they don't have the incredible resource of lots of mountain sheep populations to draw from. So yes, they may have to mix down the road. Texas, at the other end of the scale, had absolutely nothing, and so the closest thing would be New Mexico or Mexican populations. They've had to go to whatever lengths they could. So they weren't in a position to be able to follow this ideal scenario. However, I'd like it to be seen as a predation of opportunities or strategies, and that we try to do what we can with what we have, with our goals set high, and we'll just try to make it work from there.

Walter Boyce - This concludes the panel presentation. I'd like to thank the agency personnel and the other people that I put on the spot, and I'd like to thank the panel participants.



TECHNICAL STAFF ACTIONS



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DESERT BIGHORN COUNCIL

Established to promote the advancement of knowledge concerning the Desert Bighorn Sheep and the long-range welfare of these animals.

26 April 1996

TO WHOM IT MAY CONCERN:

The Desert Bighorn Council was founded in 1957. It is comprised of wildlife biologists (many of whom are ce ed by The Wildlife Society), scientists, administrators, managers. and others interested in the welfare of desert bighorn sheep.

The Council has four primary objectives: 1. Provide for the exchange of information on the needs and management of the desert bighorn through annual meetings and published transactions; 2. Stimulate and coordinate studies in all phases of the life history, ecology, management and protection, recreational and economic values of desert bighorns; 3. Provide a clearing-house of information among all agencies, organizations, and individuals professionally engaged in work on the desert bighorn; 4. Function in a professional advisory capacity, where appropriate, on local, national, and international questions involving management and protection of the desert bighorn.

The Technical Staff of the Desert Bighorn Council was recently requested to review and comment upon *the propagation of desert bighorn sheep (Ovis canadensis) bv interspecies embryo transfer* using domestic ewes (*Ovis aries*) proposed by Texas **A** & M University.

We offer the following points:

** There is the possibility that these crossbreeds would pass domestic livestock diseases to native populations. Wild sheep have been, and continue to be, decimated by diseases introduced by domestic animals. The wildlife Literature fully supports this. The loss of 200+ Rocky Mountain bighorns in 1995-1996, along the Snake River in Idaho, Washington, and Oregon, following contact with a single feral Nubian goat, is a classic example.

** This proposal confuses the issue for acquisition of limited financial resources to restore native species to their historic, or suitable vacant, habitats.

** There are negative genetic implications in this process: it would be possible to end up with an animal that is habituated to humans and has no protective wildness; there is the strong possibility that bighorns would be selected on the basis of horn size, rather than traits that increase their fitness under natural conditions.

** In our opinion, the resulting animal would be a domestic animal, and therefore would not qualify for Boone and Crockett scoring competition.

Based on these points, the Technical Staff is strongly opposed to the concept. Bighorn populations in North America are up as a result of active trapping/transplanting, and reintroduction into historic or suitable vacant habitats of native animals. There is no need for such a program.

William R. Brigham

William R. Brigham
Chairman, Technical Staff

PROGRAM 40th ANNUAL MEETING
DESERT BIGHORN COUNCIL
HOLTVILLE, IMPERIAL COUNTY, CALIFORNIA
APRIL 10-12,1996

TUESDAY, APRIL 9, 1996

7:00 - 9:00 PM	**Registration and Social**

WEDNESDAY, APRIL 10, 1996

7:30 - 8:30 AM **Welcoming Address and Introductions**
Andy Pauli - California Department of Fish and Game

9:00 - 10:00 AM **Keynote Speakers**

Fred Jones, Assistant Chief (Retired)
Game Management Branch
California Department of Fish and Game

Terry Mansfield, Chief
Wildlife Management Division
California Department of Fish and Game

10:00 - 12:00 PM **Session 1: State Status Reports**
Chair - Rick Brigham, Bureau of Land Management, Reno

Arizona	Ray Lee
California	Steve Torres
Colorado	Tom Lytle
Mexico	Ray Lee
Nevada	Pat Cummings
New Mexico	Amy Fisher
Utah	Jim Karpowitz
Texas	Doug Humphreys

12:00 - 1:00 PM **Lunch**

1:00 - 3:00 PM **Session 2: Disease and Genetics**
Chair - John Wehausen, White Mountain Research Station

Genetic Variation of Major Histocompatibility Complex and Microsatellite Loci in Bighorn Sheep

Host Specificity of Psoroptic Mange Mites: Preliminary Results from DNA Sequence Data

Pathogen Exposure Patterns Among Sympatric Populations of Bighorn Sheep, Mule Deer, and Cattle

Evidence of Viral-Induced Pneumonias in Peninsular Desert Bighorn Lambs

Depressed Lamb Survival Syndrome: Some Clues from Comparative Demography

The Temporal Epidemiology of Bluetongue Virus in a Bighorn Sheep Population

3:00 - 3:30 PM **Break**

3:30 - 5:00 PM **Session 3: Special Population Reports**
Chair - Steven Torres, California Department of Fish and Game

Botulism as a Cause of a Bighorn Sheep Die-Off at Old Dad Peak

Die-Off of California Bighorn Sheep in Hells Canyon, Idaho: An Update

7:00 PM ***Special Photographic Presentation: Bighorn Sheep in the Peninsular Ranges***

THURSDAY, APRIL 11, 1996

8:30 - 12:00 PM **Session 4: Populations**
Chair - Vernon C. Bleich, California Department of Fish and Game

The Peninsular Bighorn Sheep Population Health and Demography Study: An Overview of Its Study Design and Major Findings

Reproductive Success of Bighorn Sheep in the Peninsular Ranges of California

Adult Survival and Mortality of Bighorn Sheep in the Peninsular Ranges of California

The Potential Role of Mountain Lions in the Dynamics of Bighorn Sheep Populations

A Conservation Plan for *Ovis canadensis weemsi* on Carmen Island, Baja California Sur, Mexico

Status and Health Parameters of a Population of *Ovis canadensis weemsi*

12:00 - 1:00 PM **Lunch**

1:00 - 3:00 PM **Session 5: Distribution/Behavior/Management**
Chair - Amy Fisher, New Mexico Department of Game and Fish

Effects of Simulated Jet Aircraft Noise on Behavior of Desert Ungulates

The Effect of Scale on Defining Topograhically Suitable Desert Bighorn Sheep Habitat

Habitat Use by Desert-Dwelling Mountain Sheep in the East Chocolate Mountains, Imperial County, California

Water Development Design Concepts for Bighorn Sheep

An Improved Fence for Wildlife Water Sources

3:00 - 5:00 PM **Business Meeting**

6:00 PM **Banquet**

FRIDAY, APRIL 12,1996

7:00 *AM* **Field Trip to Anza Borrego Desert State Park, Indian Canyon**

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DESERT BIGHORN COUNCIL MEETINGS 1957- 1996

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	Jeny 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
1995	Alpine, TX	Doug Humphries	Charles Douglas	Ray Boyd
1996	Holtville, CA	Andi Pauli	Charles Douglas	Ray Boyd