Appendix F

The Demise of Mountain Sheep: A Brief History of California's Bighorn Sheep Populations and Department Efforts in the Sheep Hole Mountains

In the decades following the California gold rush, a rapid loss of mountain sheep populations occurred (Wehausen et al. 1987). Unregulated market hunting and grazing of domestic livestock are implicated in this decline, as are certain diseases that are associated with livestock, particularly with domestic sheep (Buechner 1960). Despite legal protection of the species by the California Legislature in 1873, populations failed to increase in size, or to recolonize vacant habitats. Moreover, the extirpation of mountain sheep populations continued; 45 of 104 mountain sheep populations thought to exist prior to 1850 are extinct in California (Wehausen et al. 1987), but a number of them have been successfully restored through translocation (Bleich et al. 1990*a*, Torres et al. 1994, Epps et al. 2003).

Although management efforts may have resulted in some population increases, little natural recolonization has occurred. Mountain sheep conservation strategies currently emphasize three approaches: (1) isolation from domestic sheep (Desert Bighorn Council 1990); (2) habitat improvement, primarily through the construction of wildlife water developments (Bleich and Pauli 1990), and (3) the establishment of this species on formerly occupied ranges (Bleich et al. 1990*a*).

Early management of mountain sheep in California centered primarily on protection from losses to shooting; indeed, mountain sheep were afforded protection by the California legislature in 1873, when it became illegal to kill them. In the decades following enactment of protective legislation, few efforts were made to enhance conditions for that species. During the 1940s, following passage of the Pittman-Robertson Act (Federal Aid in Wildlife Restoration Act), the California Department of Fish and Game began an effort to enhance habitat for mountain sheep throughout the Mojave and Sonoran Deserts. Beginning at that time, a heavy emphasis was placed on maintaining the availability of water at natural sources, and on enhancing the availability of water where it had become unavailable as a result of human activities or drought. During the 1950s and 1960s, CDFG personnel worked throughout the deserts of California to ensure the availability of water at locations where it formerly had occurred, consistent with the notion that water is an important component of habitat for those specialized ungulates.

Increasing public interest in mountain sheep occurred during the late 1960s, and the California Legislature provided funds for the first statewide assessment of the population of mountain sheep in California. Those investigations were carried out over a period of approximately 5 years, and resulted in the preparation of a series of reports that addressed the status of mountain sheep in various geographic areas of the state and, ultimately, in the preparation of a statewide management plan for the species (Weaver 1973). Within each geographic area, a series of recommendations for the development of water sources was provided; the primary emphasis for doing so was to

ensure continued availability of water in areas occupied by mountain sheep, and to expand the distribution of mountain sheep into areas where water was a factor limiting their distribution. Included in the overall management plan (Weaver 1973) were recommendations for the restoration of mountain sheep to ranges that they historically had occupied, but from which they had been eliminated, largely as a result of human activities.

An intensive effort to develop water sources at locations identified as a result of the statewide survey began in 1973, has been an important activity since that time, and had been carried out with the support and cooperation of the Bureau of Land Management, National Park Service, and Department of Defense (Bleich 2005). In 1983, the first translocation of mountain sheep in a desert environment occurred in California, as a result of the enhancement of an ephemeral, but historically used water source, as recommended by Weaver (1973) and consistent with California's mountain sheep management plan (California Department of Fish and Game 1983). During that effort, mountain sheep were moved from Old Dad Peak, San Bernardino County, to the Eagle Crags on China Lake Naval Weapons Center, San Bernardino County. Management actions by the Department of Defense had eliminated a factor (wild burros) that was thought largely to have played an important role in the loss of mountain sheep in the Eagle Crags. An additional operation that year established mountain sheep on vacant range in the San Gabriel Mountains, Los Angeles County. Subsequently, other populations of sheep were reestablished, some in isolated locations where interchange with nearby populations was unlikely (Bleich et al. 1996).

In the mid 1980s, forward-thinking wildlife biologists began to view the distribution of mountain sheep in the context of a metapopulation (Schwartz et al. 1986), rather than as a series of isolated populations that occupied a series of disjunct mountain ranges. In essence, a metapopulation is a population of populations inhabiting disjunct patches of suitable habitat isolated from one another, but that are linked together by movements of individual animals between those areas of suitable habitat. Within a metapopulation, individual populations may exhibit independent dynamics and differ in genetic structure. Connectivity (i.e., movement of animals) between the populations contributes to genetic diversity, and provides opportunities for colonization of vacant habitats should a population become extirpated. Metapopulations can persist only if the rate of colonization is equal to, or exceeds, the rate of extirpation of populations comprising the metapopulation.

After the realization that populations of mountain sheep existed in a metapopulation structure (Schwartz et al. 1986), conservationists began to think more deeply about the ramifications of the probabilities of extinction, habitat fragmentation, and metapopulation persistence in the context of population restoration (Bleich et al. 1990*b*, Bleich et al. 1996, Singer et al. 2000). Following these advances, the proximity of translocated populations to extant populations became a primary consideration in the decision making process (Singer et al. 2000). Thus, traditional wildlife management practices (including wildlife water developments) that would enhance the probability of persistence of extant populations, as well as newly translocated populations, became

an integral part of an overall conservation strategy for mountain sheep in desert environments (Schwartz et al. 1986). Further, investigators emphasized that concerns about genetic problems paled relative to the importance of protecting and enhancing habitat, and to reestablishing mountain sheep on historically occupied ranges (Schwartz et al. 1986, Bleich et al. 1990, Bleich et al. 1996).

Every effort to reestablish mountain sheep has important implications for the maintenance of biodiversity and ecosystem function in mountain ranges from which sheep previously have been extirpated. More importantly, however, those efforts have important implications for the persistence of mountain sheep in a metapopulation structure, and for the persistence of the species as a whole in the Mojave and Sonoran deserts of the southwestern United States (Bleich et al. 1996). With that realization, investigators embarked on a strategy for reestablishing mountain sheep on historical ranges that emphasized the restoration of connectivity to extant populations (Bleich et al. 1990) and expanding the distribution, and expanding areas of usable habitat within mountain ranges (Bleich and Pauli 1990). Such a strategy would increase the number of sheep comprising extant populations if sheep were unable to occupy all parts of a mountain range that otherwise were suitable but lacked a critical component and, thereby, decrease the likelihood of stochastic events eliminating a small population. Further, such a strategy would result in a larger number of potential emigrants to proximate mountain ranges, thereby increasing the potential for recolonization events to occur in the event of an extirpation. Central to all of this was the notion of establishing populations on historical ranges, which would provide additional potential for gene flow and population persistence in a metapopulation context.

In 1985, and again in 1987, mountain sheep were translocated to the Sheep Hole Mountains to enhance the potential for movement of mountain sheep among the Bullion, Coxcomb, Iron, and Calumet mountains, and to reestablish the presence of a large, native ungulate that historically had been an important component of the biodiversity and ecosystem function of that range (Bleich et al. 1990*b*, 1992). Indeed, detailed aerial telemetry investigations (Bleich et al. 1992) indicated that mountain sheep translocated to the Sheep Hole Mountains moved to and from all of those ranges, with the exception of the Iron Mountains. Recent evidence (Epps 2004) has confirmed the presence in the Coxcomb Mountains of haplotype E (the most common haplotype at Old Dad Peak, which was the source of animals translocated to the Sheep Hole Mountains), and that result substantiates the potential importance of the Sheep Hole Mountains to the Central Mojave Metapopulation (Epps et al. 2003). When combined with movements to and from the Calumet and Bullion Mountains (California Department of Fish and Game, unpublished data), the finding of haplotype E underscores the importance of the Sheep Hole Mountains to the conservation of mountain sheep, and biodiversity in general, in the south-central Mojave Desert.

In 1985, a single water source (Suds Hole) was present in the Sheep Hole Mountains; following intensive telemetry investigations and subsequent habitat modeling, a second water source (Bear Claw) was developed in the central portion of the mountain range, and mountain sheep subsequently began to use the central portion of that mountain

range more frequently; that effort has resulted in a wider distribution of mountain sheep in the Sheep Hole Mountains, and a subsequent increase in the total number of sheep occupying that range. The density of mountain sheep likely has remained unchanged, but because a greater proportion of the mountain range can be occupied by mountain sheep, there has been a substantial increase in the number of sheep inhabiting that range. Additional suitable habitat is found in the southern and western part of the Sheep Hole Mountains, and in the Calumet Mountains. Those geographic areas currently support mountain sheep on a seasonal basis; permanent occupancy of those ranges would enhance the probability of movements among the Sheep Hole, Calumet, Coxcomb, and Bullion mountains, and enhance the probability of connectivity with the Iron Mountains, which clearly support movement to and from the Old Woman Mountains to the north (Bleich et al. 1996, Epps 2004). Further, a larger population in the Sheep Hole Mountains decreases the probability of a stochastic event, such as drought, leading to the extirpation of that population.

Mountain sheep have disappeared from approximately 50% of the ranges that they occupied during historical times; those extirpations have occurred largely as a result of anthropogenic influences (Buechner 1960). Human activities, which have been so important in those extirpations, also have the potential to restore and maintain populations of these large specialized ungulates, which are a valuable component of wilderness areas. Human activities have had such an influence on desert ecosystems that management of large, vagile animals on a tiny geographic basis, such as designated desert wilderness areas, is not a viable option (Bleich 1999). Further, conservation of wildlife and its importance to ecosystem function and overall biodiversity were not primary considerations is wilderness legislation and, as a result, wildlife conservation and wilderness management objectives frequently conflict with each other. Nonetheless, wildlife conservation is of overwhelming importance to the American people (Bleich 1999, 2005), and efforts to restore and enhance wildlife populations, particularly those of large, charismatic megavertebrates are important conservation objectives. In the absence of such efforts, continuing ecosystem change, whether from continuing loss of habitat as a result of anthropogenic actions (Bleich 1999), or from forces not yet fully understood (e.g., global warming; Epps et al. 2004) the frequency of extirpations can be expected to increase. The persistence of mountain sheep in such a changing environment will be contingent on continuing, active management to expand populations and enhance populations, and to reestablish and then maintain connectivity between extant populations (Bleich et al. 1996).

Literature Cited

Bleich, V. C. 1999. Wildlife conservation and wilderness management: uncommon objectives and conflicting philosophies. North American Wild Sheep Conference Proceedings 2:195-205.

Bleich, V. C. 2005. Politics, promises, and illogical legislation confound wildlife conservation. Wildlife Society Bulletin 33:66-73.

Bleich, V. C., and A. M. Pauli. 1990. Mechanical evaluation of artificial watering devices built for mountain sheep in California. Pages 65-72 in G. K. Tsukamoto and S. J. Stiver, editors. Wildlife water development. Nevada Department of

Wildlife, Reno.
Bleich, V. C., J. D. Wehausen, K. R. Jones, and R. A. Weaver. 1990a. Status of bighorn sheep in California, 1989 and translocations from 1971 through 1989. Desert Bighorn Council Transactions 34:24-26.
Bleich, V. C., J. D. Wehausen, and S. A. Holl. 1990*b*. Desert dwelling mountain sheep: conservation implications of a naturally fragmented distribution. Conservation Biology 4:383-390.
Bleich, V. C., M. C. Nicholson, A. T. Lombard, and P. V. August. 1992. Preliminary tests of a mountain sheep habitat model using a geographic information system. Biennial Symposium of the Northern Wild Sheep and Goat Council 8:256-263.
Bleich, V. C., J. D. Wehausen, R. R. Ramey II, and J. L. Rechel. 1996. Metapopulation theory and mountain sheep: implications for conservation. Pages 353-373 in D. R. McCullough, editor. Metapopulations and wildlife conservation. Island Press, Covelo, California.
Buechner, H. K. 1960. The bighorn sheep in the United States, its past, present, and future. Wildlife Monographs 4:1-174.
Desert Bighorn Council. 1990. Guidelines for management of domestic sheep in the vicinity of desert bighorn habitat. Desert Bighorn Council Transactions 34:33-35.
Epps, C. W., V. C. Bleich, J. D. Wehausen, and S. G. Torres. 2003. Status of bighorn sheep in California. Desert Bighorn Council Transactions 47:20-35.
Epps, C. W. 2004. Population processes in a changing climate: extinction, dispersal, and metapopulation dynamics of desert bighorn sheep in California. University of Berkeley, California. Ph.D. dissertation.
Epps, C. W., D. R. McCullough, J. D. Wehausen, V. C. Bleich, and J. L. Rechel. 2004. Effects of climate change on population persistence of desert-dwelling mountain sheep in California. Conservation Biology 18:102-113.
Lesicka, L. M., and J. J. Hervert. 1995. Low maintence water development for arid environments: concepts, materials and techniques. Pages 52-57 in D. P. Strickland, editor. Wildlife water development. Water for Wildlife Foundation, Lander, Wyoming.
Pauli, A. M., and V. C. Bleich. 1991. Bighorn sheep management plan: Sheephole Mountains management unit. California Department of Fish and Game, Sacramento.
Schwartz, O. A., V. C. Bleich, and S. A. Holl. 1986. Genetics and the conservation of mountain sheep Ovis canadensis nelsoni. Biological Conservation 37:179-190.
Singer, F. J., V. C. Bleich, and M. A. Gudorf. 2000. Restoration of bighorn sheep metapopulations in and near western national parks. Restoration Ecology 8(4S):14-24.
Torres, S. G., V. C. Bleich, and J. D. Wehausen. 1994. Status of bighorn sheep in California, 1993. Desert Bighorn Council Transactions 38:17-28.
Weaver, R. A. 1973. California's bighorn management plan. Desert Bighorn Council Transactions 17:22-42.
Weaver, R. A., and J. L. Mensch. 1971. Bighorn sheep in southwestern San Bernardino County Federal Aid in Wildlife Restoration, Job Progress Report W-51-R-2. California Department of Fish and Game, Sacramento.
Wehausen, J. D., V. C. Bleich, and R. A. Weaver. 1987. Mountain sheep in California:

a historical perspective on 108 years of full protection. Western Section of The Wildlife Society Transactions 23:65-74.