SEMIANNUAL REPORT OF THE SIERRA NEVADA BIGHORN SHEEP RECOVERY PROGRAM

Photo by Jonathan Fusaro

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Sierra Nevada Bighorn Sheep Vital Rate Analysis

Animals of different sexes and stage classes have distinct survival and reproductive rates ("vital rates") and as a result, contribute differentially to population performance. Management efforts which target vital rates of the most influential stage classes will have greater potential to redirect a population's trajectory. Thus, to develop effective management strategies for the recovery of endangered species, it is critical to identify vital rates responsible for poor population performance and whose increase will most efficiently change a population's trajectory.

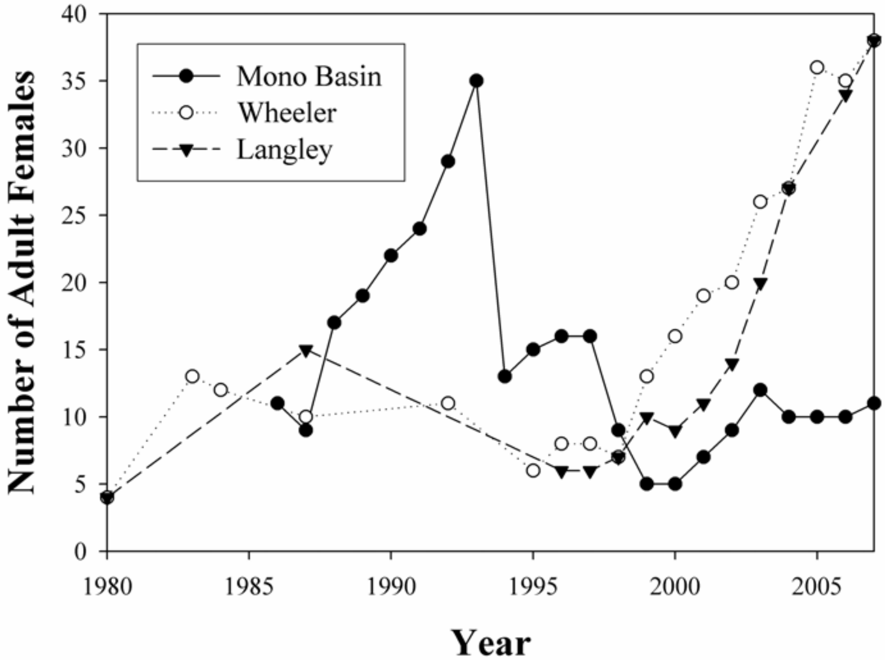
We estimated vital rate values for bighorn sheep in the Mono Basin, Wheeler, and Langley populations based on data collected from 1980-2007 (Fig. 1), accounting for sampling error, variance, and co-variance. We used analytical sensitivity analysis, life-stage simulation analysis, and a novel non-asymptotic simulation approach to (a) identify vital rates that should be targeted for subspecies recovery; (b) assess vital rate patterns of endangered bighorn sheep relative to other ungulate populations; and (c) simulate management scenarios for boosting bighorn sheep population growth rates.

Our vital rate analyses elucidated findings relevant both for the conservation of Sierra Nevada bighorn sheep and for the general application of these approaches to the management of endangered populations. The dominant paradigm for ungulates is that adult female survival has the highest elasticity (the vital rate with the greatest impact on population growth), but its low variation causes it to contribute relatively little to changes in the population performance compared to juvenile survival, which has low elasticity but high variation, making it the primary determinant of population change. In contrast to this paradigm, we found that while elasticity results were consistent across all Sierra bighorn herds and followed classic expectations, vital rates explaining the most variation in population growth differed among herds and contradicted theoretical expectations. For example, in Wheeler and Mono Basin variation was higher in adult survival than recruitment or fecundity, contributing to the pattern that adult survival explained the highest proportion of variation in population growth. Only in Langley did growth rates follow general ungulate life-history expectations, driven by changes in fecundity. These findings demonstrate that decreases in adult survival are primarily responsible for declines and stagnant performance in Sierra Nevada bighorn sheep populations and that adult survival should be the primary focus of monitoring and management activities. Our analysis also showed that populations with seemingly synchronous trajectories, such as Langley and Wheeler (Fig. 1), are driven by entirely different vital rates, indicating substantial variation in the spatial and temporal factors determining bighorn sheep demographic processes.

The two management scenarios we simulated, predator control (an increase in mean vital rate values) and augmentations (an increase in number of adult females in initial population vectors), illustrated that effective strategies appear to be largely population-specific. For example, from the two scenarios it appears that predator control will be most effective for stimulating the Wheeler population, while an augmentation may be most effective for a short-term boost in performance at Mono Basin. Given the current growth rate of the Langley herd, management actions are not predicted to have an appreciable impact in the short-term.

A full analysis of Sierra Nevada bighorn sheep vital rates* (“Population-specific Vital Rate Contributions Influence Management of an Endangered Ungulate”) *is in press for publication in the journal Ecological Applications.

Figure 1. Population trajectories (as indexed by numbers of adult females) in the Mono Basin, Wheeler, and Langley populations of Sierra Nevada bighorn sheep for years included in the vital rate analysis.



Coyote Ridge Is Occupied!

The Coyote Ridge (unoccupied) herd unit is found on a high flat that extends northeast of the Sierra Nevada crest, located immediately SW of Bishop and NW of Big Pine, and is bounded to the west by Bishop Creek (Figure 2). Some patches of excellent potential bighorn sheep habitat exist around the edges of Coyote Ridge and wind removes much of the snow from the top of Coyote Ridge in winter.

Photos 1and 2. Bighorn ewes first seen in rocky terrain and then moved into brushy sage habitat.

However, some isolated stands of forest and the lack of steep rocky terrain make the central part of Coyote Flat largely unsuitable habitat for bighorn sheep. Coyote Ridge was not included among those required by the Recovery Plan because alpine summer range and low elevation winter range are separated geographically with suboptimal connectivity.

There have been some reports of bighorn sheep sightings in this region over the past few decades. Evidence has included tracks above Thunder and Lightning Lake and an observation of six bighorn including one ram and two lambs on a flat just above Thunder and Lightning Lake by an F-18 jet pilot in late August 1990. A bighorn group at the head of Palisade Creek was observed by Boy Scouts and a geologist familiar with wild sheep observed three bighorn including one ram near Thunderbolt Pass in the summer of 1992 or 1993. These observations all lacked definitive documentation of bighorn sheep, but that changed this past summer. On July 18, 2009, CDFG wildlife biologist Mike Morrison observed and photographed (photos 1 and 2) two female bighorn sheep in Coyote Flat at close range. The ewes were first seen in typical rocky sheep terrain. They then moved lower into brushy sage steppe habitat and continued down to a willow thicket by Coyote Creek.

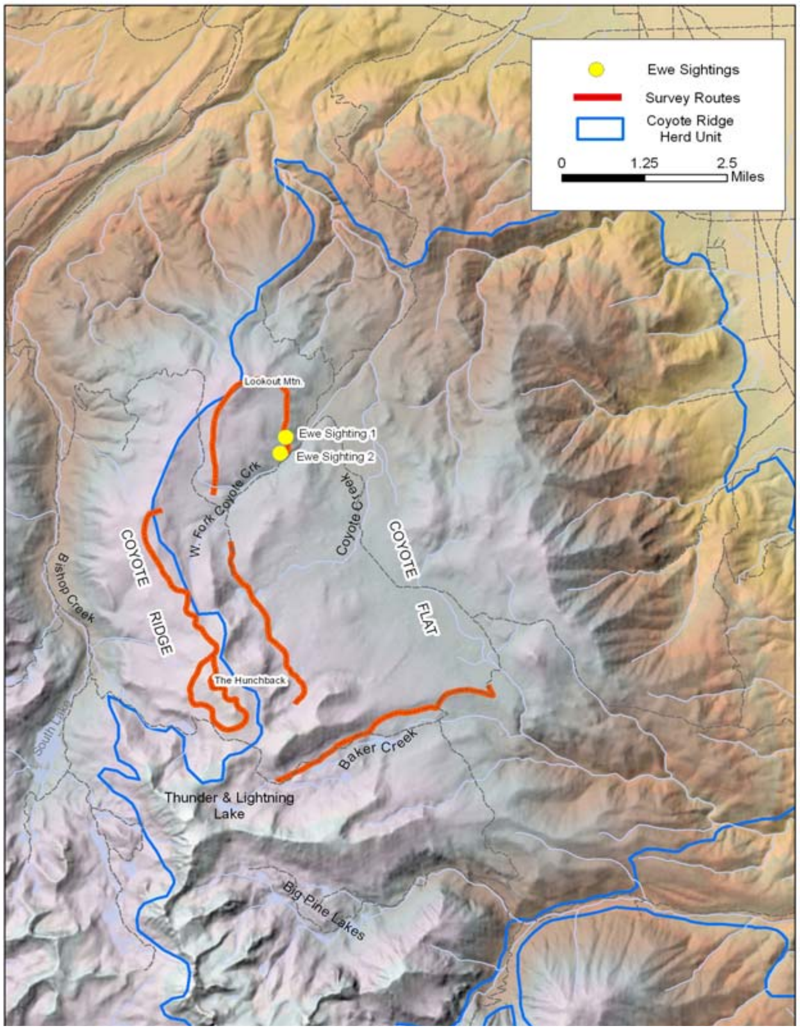


Figure 2. Location of the ewes and subsequent survey routes.

The documented sighting was followed by two surveys conducted by CDFG personnel (Figure 2). From the first survey, two bed sites were observed just to the west of Lookout Mountain and four relatively fresh pellet samples were collected. During the second survey no bighorn were observed, but eight fecal samples were collected near the Hunchback. Genetic analysis indicates that the fecal samples collected were deer. Further surveys will be conducted during the next year.

Another Successful Capture

During October 30 –November 1, 2009, we captured 32 Sierra bighorn by helicopter netgun. Captures are conducted to deploy collars for monitoring survival, reproduction, cause-specific mortality, population size, habitat selection, movements, and distribution, to assess nutritional status, and conduct disease surveillance. Furthermore, we want to determine population estimates by using mark-resight methods. In order to acquire reasonable confidence intervals with small populations, mark-resight requires that approximately 35% of the adult female population be collared based on statistical power analysis. Due to recent mortalities, we needed to collar additional ewes in the Mt. Langley, Mt. Baxter, Sawmill Canyon, and Mt. Williamson herd units in order to maintain the required number of marks in each herd unit. Two exceptions to our sampling plan were Bubbs Creek and Coyote Flat, each having no collared animals to date. Both Bubbs Creek, west of the crest, and Coyote Ridge were targeted for their first two collar deployments. Over time, their sample sizes can be increased to meet the 35% goal as well.

Monitoring risk of disease transmission is primarily accomplished by collaring bighorn males, since these animals are more likely to make long distance forays and to encounter domestic sheep. Our goal was to complete collaring of all males in the Mono Basin herd units, Mt. Warren and Mt. Gibbs, while the population remains small enough for this to be achievable and there remains a risk from adjacent domestic sheep grazing allotments. Satellite downloadable collars are the best tool for disease risk monitoring. For herd units without significant disease risk, a smaller sample of males is being collared in order to better define the outer limits of their habitat. This applies to herds in the Southern Recovery Unit.

In the Mt. Warren herd unit, the site of translocations in the spring of 2009, our intention is to closely monitor both native and translocated animals for demographic rates and habitat use to assess the effects of the translocated animals. In order to achieve this, additional native animals were collared to increase sample sizes. We anticipate that this will also aid in population surveys in the Mt. Warren herd. Finally, some collared animals in the Mt. Baxter and Wheeler Crest herd unit were still wearing GPS collars on which the blow-off mechanism had failed. Each of these animals was targeted for recapture if they still wore the collar. All animals captured were fitted with a GPS collar to collect spatial data for a limited time (18-24 months) and a VHF collar for monitoring demographic data (survival and reproduction; 60 months).

By completion of the capture effort, we accomplished most of our goals. The collared ewe sample size was increased in most herds as needed for mark-resight. In addition, most of the Mono Basin rams were collared, two rams at Mt. Langley were collared, two ewes were collared in Bubbs Creek and additional native ewes in the Mt. Warren herd were collared. Animals with failed blow-off mechanisms on their GPS collars were captured and collars retrieved. The only significant goal with no progress was locating and collaring sheep at Coyote Ridge. (see table)

	PreCapture		Fall (Plan)		Fall (Actual)		PostCapture	
Herd Unit	Males	Females	Males	Females	Males	Females	Males	Females
Wheeler Ridge	15	16/37%	0	1	1	1	12*	16/37%
Mt. Gibbs	2	4/57%	0	1	2	1	4	5/71%
Mt. Warren	3	8/53%	8	4	3	3	7	11/72%
Mt. Baxter	1	7/18%	0	5	1	5	2	11/28%
Mt. Langley	1	9/21%	0	6	2	6	2	15/35%
Mt. Williamson	2	3/21%	0	2	0	2	2	5/35%
Sawmill Canyon	2	8/30%	0	1	0	3	2	8/30%
Bubbs Creek	0	0	0	2	0	2	0	2/16%
Coyote Ridge	0	0	0	2	0	0	0	0
Totals	26	50	8	24	9	23	31	73

note: 3 older vhf collars have failed post capture

Mt. Warren Translocation Status

We continued to monitor the status of the translocation effort to the Mt. Warren herd unit that occurred in April 2009. We were able to observe the 6 adult females on numerous occasions during July – December 2009. Five lambs remained with the 6 ewes well into the autumn suggesting that escape terrain was optimal to ensure the survival of lambs. As desired, the ewes migrated to alpine summer range comparable to that used by bighorn sheep native to this herd. The translocated ewes were observed at various times in groups with the native ewes. To date, we consider this translocation to be a success as it is furthering the potential for recovery in the Northern Recovery Unit.

Colonization of Convict Creek Herd Unit

Mount Stanford lies within the Convict Creek (unoccupied) herd unit just north of Rock Creek and Mono Pass and is identified in the Recovery Plan as bighorn habitat. The current known distribution of bighorn sheep in the Wheeler Ridge herd does not include Mt. Stanford (Figure 3). However, in 1989 a backpacker encountered and photographed 11 rams near Rosy Finch Lake which, interestingly, lies very close to Bighorn Lake on the north side of Mono Creek near Mt. Izaak Walton. This is part of the range of the extinct Convict Creek herd. A radio collar evident on one of those rams in that photo identified them as from the Wheeler Ridge herd. The 1989 sighting was 10 years after the first bighorn were released at Wheeler Ridge, but only 3 years after translocation of 4 sheep from the Mount Baxter herd to Wheeler Ridge. During the last 5 years, three additional locations indicating use of this habitat north of Wheeler Ridge have been obtained through flight locations of radio-collared sheep (Figure3). In the spring of 2009, a hiker, who frequents that area, reported seeing bighorn in the Mt. Stanford area in recent years.

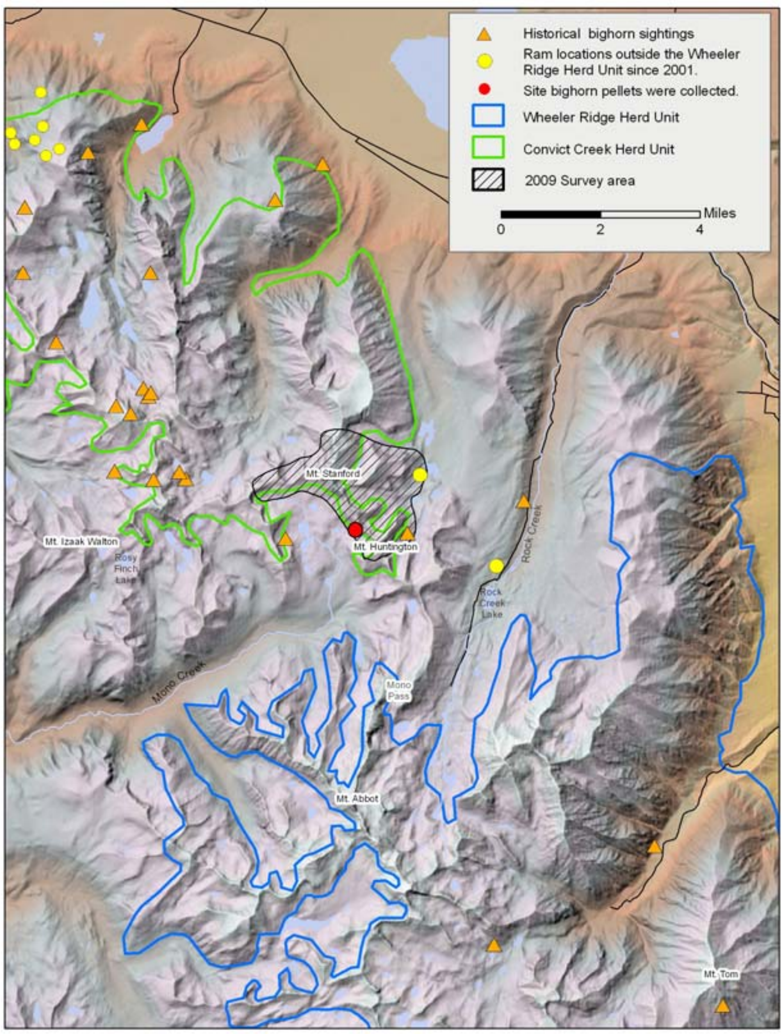


Figure 3. Bighorn locations both historic and current showing use of the area near and within the Convict Herd Unit.

In the summer of 2009, CDFG recovery program personnel made a coordinated sweep of the area from Rock Creek to the north as far as Pioneer Basin and to the east to Steelhead Lake looking for evidence of bighorn (Figure 3).

The most promising finding was a set of fresh tracks and some droppings at timberline between Mount Stanford and Mount Huntington in a small meadow system high on the east side of Pioneer Basin. Based on genetic analysis, the droppings were from female bighorn sheep. Further surveys of this area can be expected.

The droppings were used by John Wehausen to design a simple genetic test to distinguish deer from bighorn sheep. He tested the 3 fecal samples, which proved to be from bighorn sheep. Equally notable is that an additional genetic test found those samples to be female. Having a reliable test to distinguish droppings of deer from bighorn sheep is likely to prompt more exploration of areas currently not known to have bighorn sheep in the Sierra Nevada, as well as some desert ranges of California.

Disease Monitoring: White Mountain Bighorn Sheep

In 2005, desert bighorn sheep (Ovis canadensis nelsoni) in the Silver Canyon area of the White Mountains were reported to be suffering from respiratory disease. We initiated this work because of the proximity of the White Mountains to the Sierra Nevada, concerns about the effects of disease amongst all bighorn, and growing interest in this population. In other bighorn populations affected by respiratory disease, such as the Hells Canyon population, severe die-offs have occurred, often killing entire herds or severely depressing population sizes. In recent history, the White Mountain bighorn sheep population has been monitored almost exclusively by conducting aerial and ground surveys to count animals. After discovering respiratory disease in this population, the need for more intensive monitoring of the White Mountain population was realized.

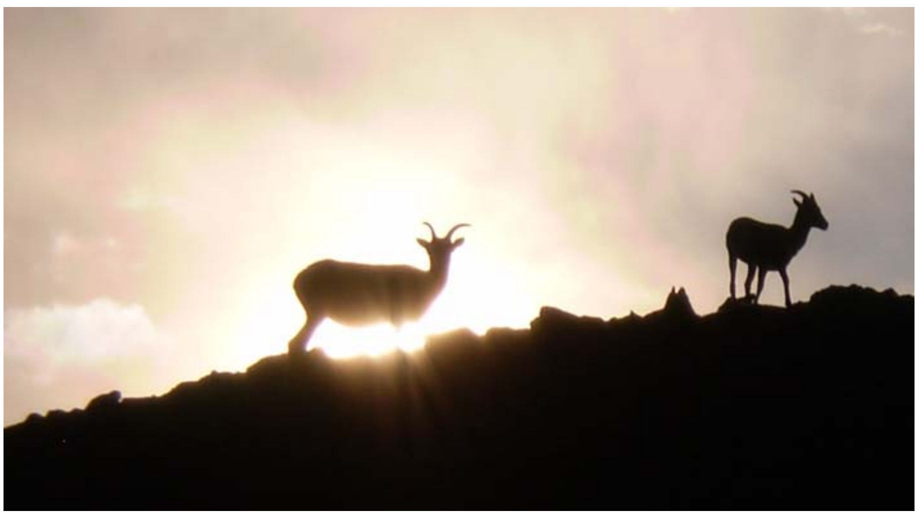


Photo 3. Bighorn sheep observed around sunset on White Mountain Peak.

We designed a study to investigate the extent of disease spread throughout the range and its possible demographic effects in the White Mountain population. Our study plan was constructed carefully using power simulations and statistical modeling to determine sample sizes and schemes to meet our study objectives. Initial focus was placed on gaining updated and more accurate basic information such as population size and growth rate, adult survival, and animal movements. The main aspect of the study was to monitor survival of lambs that belonged to collared ewes and document visual observations of sick animals. This would allow us to track the spread of disease and to document lamb deaths throughout the study period, thus shedding light on the severity of the disease outbreak in this population.

To begin the disease investigation we captured 23 females and 4 males in March 2009 in the northern subpopulation. We monitored these collared animals, along with previously collared sheep, to track the survival of their lambs from June until October. Lamb survival markedly decreased over the study period. However, because of limitations to the study that resulted in small sample sizes and large variance, the survival estimate lacked statistical resolution. We therefore analyzed lamb recruitment (the lamb to ewe ratio for both collared and uncollared females in the population) as a way to monitor lamb survival for the entire population. This measure gave us more statistical confidence. Both estimates (lamb survival 0.10 (95% CI = 0-0.28) and recruitment 0.29 (95% CI = 0.17-0.40) were below 'normal' lamb survival and recruitment values of 0.30 and 0.43 observed in other desert bighorn populations. Adult female survival remained high at 97 percent. Judging by these below normal lamb survival and recruitment rates, coupled with visual observations of sick lambs outside Silver Canyon, we concluded that respiratory disease is not limited to the Silver Canyon herd in the White Mountains. The disease outbreak has spread throughout the White Mountain population and is significantly affecting lamb survival. Consequently, population size of bighorn sheep in the White Mountains appears to be declining.

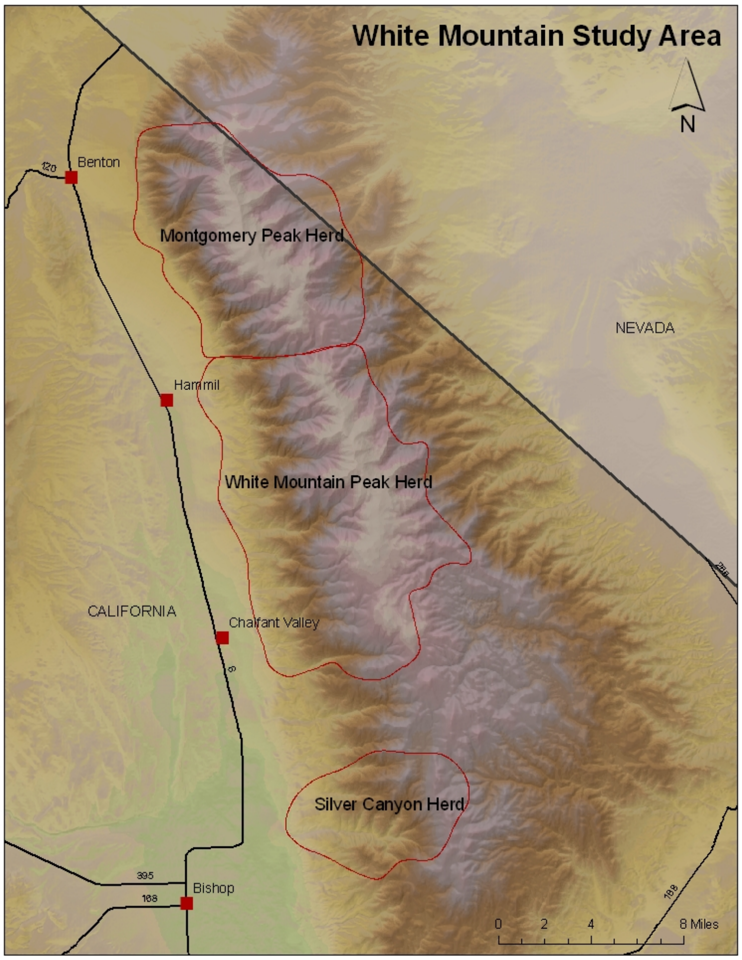


Figure 4. Map showing the White Mountain bighorn sheep study area and the three within the study area. The White Mountain and Montgomery Peak herds have been termed the northern subpopulation and the Silver Canyon Herd is the southern subpopulation.

Because of the high elevation (>11,000 ft) at which most White Mountain bighorn live during lambing season there is virtually no opportunity to treat disease in this herd. This illustrates the essential need to protect bighorn herds from exposure to disease. Domestic sheep and goats pose the greatest disease threat and hence must be managed to avoid any contact with bighorn sheep.

A more detailed discussion of the study can be obtained from the CA Dept. of Fish and Game, Bishop CA, titled *Monitoring Population Dynamics and Spatial Patterns of Distribution and Movement in Relation to Disease Spread in Bighorn Sheep of the White Mountains of California: 2009 Summary.*

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