Sierra Nevada Bighorn Sheep
Ovis canadensis californiana
(=Ovis canadensis sierrae)

5-Year Review:
Summary and Evaluation

Photo courtesy of Cody Schroeder – California Department of Fish and Game

U.S. Fish and Wildlife Service
Ventura Fish and Wildlife Office
Ventura, California

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1. GENERAL INFORMATION

1.1 Reviewers

Lead Regional or Headquarters Office: Region 8, California and Nevada, Diane Elam, Deputy Division Chief for Listing, Recovery, and Habitat Conservation Planning, and Jenness McBride, Fish and Wildlife Biologist; (916) 414-6464

Lead Field Office: Ventura Fish and Wildlife Office

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Cooperating Field Office(s): Nevada Fish and Wildlife Office

1.2 Methodology used to complete the review

This review was conducted by staff of the U.S. Fish and Wildlife Service (Service), Ventura Fish and Wildlife Office. This review considered peer-reviewed literature; California Department of Fish and Game, Bureau of Land Management, U.S. Forest Service, and National Park Service reports; and the *Final Recovery Plan for the Sierra Nevada Bighorn Sheep* (Service 2007). We incorporated all comments and information from our files into this review, as appropriate.

1.3 Background:

1.3.1 Federal Register (FR) Notice citation announcing initiation of this review:

The FR notice initiating this review was published on February 14, 2007 (72 FR 7064). This notice opened a 60-day request for information period, which closed on April 16, 2007. During this period, the Service received three comment letters that provided information for use in this 5-year review.

1.3.2 Listing history

Original Listing

Emergency Listing
FR notice: 64 FR 19300
Date Emergency Listed: The emergency listing rule was published and became effective on April 20, 1999. This emergency listing expired on December 16, 1999.

Final Listing
FR notice: 65 FR 20
Date listed: The final listing rule was published and became effective on January 3, 2000.
Entity Listed: Sierra Nevada distinct population segment of California bighorn sheep (*Ovis canadensis californiana*)
Classification: Endangered

1.3.3 Associated rulemakings

The Service designated critical habitat and announced a taxonomic revision for this species on August 5, 2008 (73 FR 45534).

1.3.4 Review History:

The Service has not performed a formal status review containing a five-factor threat analysis for this species since the time of listing.

1.3.5 Species' Recovery Priority Number at start of review:

The Sierra Nevada bighorn sheep has a recovery priority of 3, which identifies it as a distinct population segment with a high degree of threat and a high recovery potential.

1.3.6 Recovery Plan or Outline

Name of plan: Recovery Plan for the Sierra Nevada Bighorn Sheep (Service 2007)

Date issued: September 14, 2007

Dates of previous revisions: No revisions have been made.

2. REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate?

Yes.

2.1.2 Is the species under review listed as a DPS?

Yes.

2.1.3 Was the DPS listed prior to 1996?

No.

2.1.4 Is there relevant new information for this species regarding the application of the DPS policy?

Based on genetic (Ramey 1993, 1995; Boyce *et al*. 1997, Gutierrez-Espeleta *et al*. 1998) and morphological data (Wehausen and Ramey 1993, 2000), Wehausen *et al.* (2005) recognized the listed DPS as a distinct subspecies and published a change in nomenclature for this subspecies from *Ovis canadensis californiana* to *Ovis canadensis sierrae*.

We received an unpublished Nevada Department of Agriculture analysis of microsatellite markers from desert bighorn sheep and a single Sierra Nevada bighorn sheep sample which suggests that bighorn sheep in the Sierra Nevada may be part of a continuous population of Nevada desert bighorn sheep (Nevada Department of Agriculture 2007). Because these results are preliminary and based on a single Sierra Nevada bighorn sheep sample, we cannot consider it as substantial information at this time. Future analysis of more samples and continued research may allow for further consideration of this issue.

2.2 Recovery Criteria

2.2.1. Does the species have a final, approved recovery plan containing objective, measurable criteria?

This species has an approved recovery plan with objectives and measurable criteria for recovery.

2.2.2. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information. For threats-related recovery criteria, please note which of the 5 listing factors are addressed by that criterion. If any of the 5 listing factors are not relevant to this species, please note that here.

Downlisting Criterion A1: Downlisting will require a minimum total of 305 females at least 1 year of age. At least 50 of those females must be in the Kern Recovery Unit, 155 females in the Southern Recovery Unit, 50 females in the Central Recovery Unit, and 50 females in the Northern Recovery Unit. (Factor E)

Discussion: As of 2007, there are 166 females, at least 1 year of age, that occupy three of the four recovery units. There are 0, 108, 45, and 13 females of at least 1 year of age in the Kern, Southern, Central, and Northern Recovery Units, respectively (Service 2007). Recovery efforts have not yet achieved this criterion.

Downlisting Criterion A2: The measures to prevent contact between domestic sheep/goats and bighorn sheep have been implemented and are successful. (Factor C)

Discussion: The recovery plan recommends a strategy for managing the risk of disease transmission between domestic sheep or goats and bighorn sheep. Land and resource management agencies have not implemented all the recommendations of that strategy. Effective alternative strategies that would achieve the same objective have not been proposed.

Delisting Criterion B1: The number of female bighorn sheep required for downlisting by recovery unit (see above) will be maintained as an average for at least 7 years (one generation) without intervention. (Factor E)

Discussion: Recovery for the Sierra Nevada bighorn sheep cannot achieve Criterion B1 until it has first achieved Criterion A1. Because populations have not reached the thresholds that Criterion A1 identifies for downlisting, this species has not achieved Criterion B1.

Delisting Criterion B2: Bighorn sheep of both sexes will be present in a minimum of 12 specifically identified herd units distributed as 2 in the Kern Recovery Unit (Laurel Creek and Big Arroyo), 6 in the Southern Recovery Unit (Olancha Peak, Mount Langley, Mount Williamson, Mount Baxter, Sawmill Canyon, and Taboose Creek), 2 in the Central Recovery Unit (Wheeler Ridge and Convict Creek), and 2 in the Northern Recovery Unit (Mount Warren and Mount Gibbs). (Factor E)

Discussion: As of 2007, the Laurel Creek, Big Arroyo, Olancha Peak, Taboose Creek, and Convict Creek Herd Units are unoccupied. Sierra Nevada bighorn sheep currently occupy the other specific herd units identified in Criterion B2. Consequently, occupation of these remaining herd units is required to achieve this criterion.

Delisting Criterion B3: A population viability analysis projects that all recovery units are viable. Recovery tasks related to monitoring and research have been accomplished, allowing the severity of secondary threats (including vegetation succession, recreational disturbance, and loss of genetic diversity) to be adequately assessed. Threats have either been ameliorated or have been determined not to pose a significant risk to the population. (All factors)

Discussion: A population viability analysis for this species has not yet been completed, and the research activities proposed in the recovery plan for addressing secondary threats have not been accomplished.

Delisting Criterion B4: Regulatory mechanisms and land management commitments have been established that provide for long-term protection of Sierra Nevada bighorn sheep and both their summer and winter habitat. Protection considered long-term can be provided through appropriate institutional practices and cooperative agreements between agencies, landowners, and conservation organizations. Of particular importance is the threat of disease transmission between domestic sheep and bighorn sheep through contact in the Central and Northern Recovery Units (Factor D).

Discussion: While some mechanisms are in place to address some threats in portions of the range, they are not in place to address all threats in all portions of the range as required by criterion B4.

2.3. Updated Information and Current Species Status

2.3.1 Biology and Habitat

Taxonomy

The Service listed the Sierra Nevada bighorn sheep as a distinct population segment, *Ovis canadensis californiana* (65 FR 20), which was the recognized taxonomic classification at the time of listing (Cowan 1940). However, this classification has come under recent scrutiny. Based on new genetic (Ramey 1993, 1995; Boyce *et al*. 1997, Gutierrez-Espeleta *et al*. 1998) and morphological data (Wehausen and Ramey 1993, 2000), and a reanalysis of Cowan's original data (Ramey 1993), Wehausen *et al.* (2005) recognized the Sierra Nevada bighorn sheep as a unique subspecies of *O. canadensis* and modified the nomenclature for this taxon from *Ovis canadensis californiana* to *Ovis canadensis sierrae*.

Habitat

Bighorn sheep (*Ovis canadensis*) most often use open habitats that allow detection of predators at sufficient distances to allow adequate lead-time to reach the safety of precipitous terrain. Optimal bighorn sheep habitat is visually open and contains steep, generally rocky, slopes. Sierra Nevada bighorn sheep avoid forests and thick brush, but will use open woodland habitats on rocky slopes. Large expanses lacking precipitous escape terrain, such as the Owens Valley, are substantial barriers to movement. Sierra Nevada bighorn sheep habitat is patchy, and the population structure is naturally fragmented (Bleich *et al*. 1990a).

Sierra Nevada bighorn sheep utilize a wide range of elevations, from alpine peaks in excess of 4,000 meters (m) (13,120 feet (ft)) to the base of the eastern escarpment as low as 1,450 m (4,760 ft) (Wehausen 1980). Within this elevation range there is a wide variety of vegetation communities, including (from lowest to highest): (1) Great Basin sagebrush-bitterbrush-bunchgrass scrub; (2) pinyon-juniper woodland and mountain mahogany scrub; (3) mid-elevation and subalpine forests, woodlands, and meadows; and (4) alpine meadows and other alpine habitats varying from cliffs to plateaus. Because of the overall aridity of this region, meadow habitats are patchy in distribution and occur only where the water table is high due to factors such as snow accumulation. The Great Basin scrub and alpine communities offer the most desirable habitats for Sierra Nevada bighorn sheep in terms of visual openness. However, many of the mid-elevation vegetation communities have some locations near precipitous rocks with sufficiently sparse plant cover to allow use by bighorn sheep (Wehausen 1980).

Because of their extreme visual openness and steep rocky nature, alpine environments in the Sierra Nevada provide large expanses of habitat broken only by canyons containing

forests and willow stands, which bighorn sheep tend to avoid. In contrast, low-elevation winter habitat has been limited to small areas where topographic and visual features are suitable (Riegelhuth 1965; McCullough and Schneegas 1966; Wehausen 1979, 1980). Steep, open, and rocky terrain on south to southeast facing slopes in open steppe vegetation communities defines these areas. The boundary between the eastern escarpment of the Sierra Nevada and the alluvial fans of the Owens Valley defines the lower elevation limit of winter range (McCullough and Schneegas 1966; Wehausen 1979, 1980). High-elevation habitat in the Sierra Nevada has been noted for its aridity relative to other alpine habitats because precipitation is scant and unpredictable during the summer season when temperatures permit plant growth (Major and Bamberg 1967). As a result, the vegetation depends substantially on snowmelt for moisture. Snow and resulting soil moisture show great spatial variation (Major 1977). Vegetation patterns vary concomitantly with moisture, ranging from meadow patches to areas almost devoid of plants (Major and Taylor 1977).

Behavior

Bighorn sheep exhibit a variety of behavioral adaptations to avoid predation. One such adaptation is group living (Hamilton 1971, Alexander 1974); groups provide more eyes and ears, allowing members to spend less time surveying for predators and more time feeding. Studies of this phenomenon have shown that increased in-group size up to six (or more) bighorn sheep confers an advantage in the proportion of time allocated to feeding (Berger 1978; Risenhoover and Bailey 1985). The selfish herd concept of Hamilton (1971) suggests that yet greater group sizes may confer further behavioral comfort. Such comfort may be an important factor enabling bighorn sheep to utilize habitats with greater risks of predation, notably low-elevation winter ranges in the Sierra Nevada where mountain lions are more abundant and open habitat is often encroached upon by pinyon-juniper communities.

Bighorn sheep commonly exhibit seasonal changes in habitat use that reflect various resource needs. Because of relationships between elevation and temperature (Major 1977) and the influences of those variables on plant growth (Wehausen 1980), altitudinal migration in high mountain ranges like the Sierra Nevada allows bighorn sheep to maximize nutrient intake (Hebert 1973, Wehausen and Hansen 1988, Wehausen 1996). In past years, Sierra Nevada bighorn sheep used low-elevation ranges, where temperatures are more moderate and forage is more plentiful, extensively in winter and early spring; alpine ranges in summer and fall; and some intermediate ranges during transition periods (Wehausen 1980). These seasonal migration patterns changed during the second half of the 1980s, when Sierra Nevada bighorn sheep stopped using the low-elevation winter range (Wehausen 1996). Wehausen (1996) identified increased mountain lion predation on low-elevation winter ranges as the best explanation for this change in use. He proposed that with the reduced size of Sierra Nevada bighorn sheep herds and the increased presence of mountain lions, Sierra Nevada bighorn sheep had ceased their use of low-elevation winter range. Recent observations indicate that they are again using low-elevation winter ranges in some portions of their range (Mount Langley, Mount Baxter, Sawmill Canyon, and Wheeler Ridge Herd Units) (Wehausen and Stephenson 2006).

Male and female bighorn sheep commonly live in separate groups during much of the year, and often occupy different habitats (Geist and Petocz 1977; Wehausen 1980; Bleich *et al*. 1997). In the Sierra Nevada, both sexes may share common winter ranges, but they show progressive segregation from winter to spring (Wehausen 1980). During summer, the two sexes utilize different habitats, with females restricted largely to alpine environments along the crest and males often at somewhat lower elevations in subalpine habitats west of the crest (Wehausen 1980). Males again join females during the breeding season in late fall. Bighorn sheep have developed conservative philopatric behaviors (reluctance to disperse from their home range) that make them slow to colonize unoccupied habitat (Geist 1967, 1971).

Metapopulation Structure

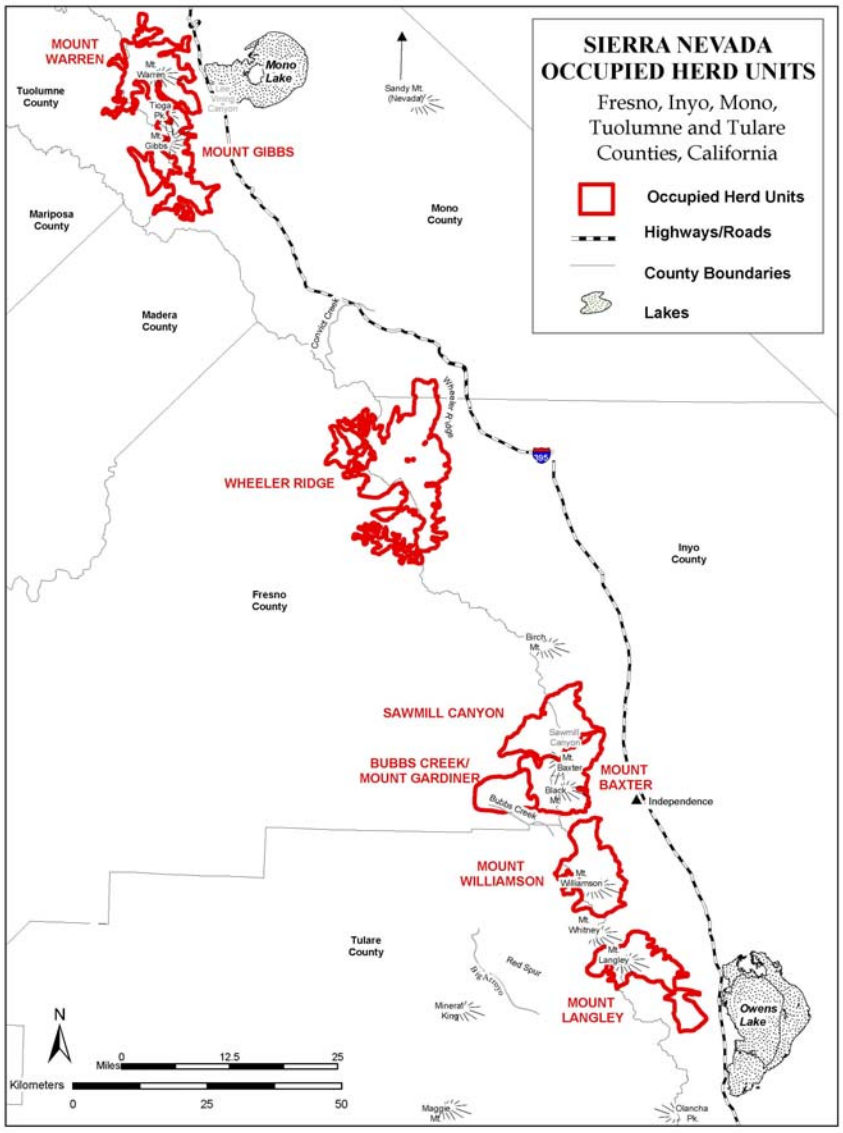
The naturally fragmented distribution of Sierra Nevada bighorn sheep results in distinct herds. At the time of listing the overall metapopulation of Sierra Nevada bighorn sheep consisted of five subpopulations (Lee Vining Canyon, Wheeler Ridge, Mount Baxter, Mount Williamson, and Mount Langley (65 FR 20). Wehausen (2000) further subdivided the Lee Vining Canyon and Mount Baxter populations into smaller groups. Given the distance traveled by rams during the rut, it is possible that genetic exchange occurred among the separated groups within these two subpopulations. By 2005, there were eight separate subpopulations (Mount Langley, Mount Baxter, Sawmill Canyon, Bubbs Creek, Mount Williamson, Wheeler Ridge, Mount Warren, and Mount Gibbs (see Figure 1) (Wehausen and Stephenson 2005b). This increase was due to the discovery of the Bubbs Creek subpopulation in 2002 and recharacterization and regrouping of some bighorn sheep into different subpopulation groups based on new information about the population interaction of bighorn sheep in certain areas.

These geographically separated herds can be grouped into a metapopulation, which are networks of interacting herds (Schwartz *et al*. 1986; Bleich *et al*. 1990a, 1996; Torres *et al*. 1996). Long-term viability depends not on individual herds, but rather on the health of the entire metapopulation. Consequently, both genetic and demographic factors are important to population viability. Increases in inbreeding (mating among relatives) and genetic drift (random changes in gene frequencies) accompany decreasing population sizes and can lead to decreasing levels of heterozygosity (a measure of genetic diversity) that may have negative demographic effects through inbreeding depression (reduction in fitness due to mating among relatives) (Soulé 1980) and loss of adaptability. There is growing evidence that the level of heterozygosity affects the disease resistance of a population (Carrington *et al*. 1999; Coltman *et al*. 1999).

A small amount of genetic exchange among herds via movements by males can counteract inbreeding and associated increases in homozygosity (having two identical forms of a gene) that might otherwise develop within small, isolated populations (Schwartz *et al*. 1986). Males have a much greater tendency than females to explore new ranges, which they may do in search of other females with which to breed (Bleich *et al.* 1996). If geographic distances between groups of females within metapopulations are

FIGURE 1 - Sierra Nevada bighorn sheep herds.

***Note: Sand Mountain and Lee Vining Canyon are not depicted here. Sand Mountain is within the Mount Baxter Herd Unit. Lee Vining Canyon is located between the Mount Warren and Mount Gibbs Herd Units.**



not great, gene migration via males occurs readily (Epps *et al.* 2005). In the absence of such a metapopulation structure, populations will be isolated and may benefit from genetic enrichment via induced migration by individuals translocated between herds (Epps *et al.* 2006).

Substructuring also can occur within single herds of bighorn sheep (Geist 1971; Holl and Bleich 1983; Festa-Bianchet 1986; Wehausen 1992; Jaeger 1994; Andrew *et al*. 1997; Rubin *et al*. 1998). Such substructuring is defined by separate home range patterns in different subgroups of a single herd. Although more evident in females, it can occur in both sexes. Because separate female groups often reflect maternal lines (Festa-Bianchet

1986), differences in (maternally inherited) mitochondrial DNA profiles between them may be detectable (Bleich *et al*. 1996; Boyce *et al*. 1999). Population substructuring has been recognized in Sierra Nevada bighorn sheep (Wehausen 1979). Bleich *et al*. (1996) suggested that separate female groups are the fundamental building blocks of bighorn sheep metapopulations.

The other important long-term process in metapopulation dynamics is the balance between rates of natural extinction and colonization among constituent subpopulations. Colonization rates must exceed extinction rates for a metapopulation to persist (Hanski 1991). This balance has not occurred for Sierra Nevada bighorn sheep since about 1850 due to the high rate of local extinctions, resulting in an increasingly fragmented distribution. In addition to fragmentation resulting from past local extinctions, the reintroduction program during 1979-88 (Bleich *et al*. 1996) and the more recent collapse of all herds together resulted in small, isolated groups of bighorn sheep. These small groups showed a greater propensity to winter at high elevations, resulting in greater vulnerability to extirpation due to small population size and difficulty surviving severe winter climates.

Reproduction and Survivorship

Bighorn sheep generally give birth to single young, but there is a low incidence of twins (Buechner 1960). Sierra Nevada bighorn sheep give birth during short periods in late spring and early summer (Wehausen 1980); the birthing season can begin as early as the second half of April, and end as late as early July (Wehausen 1991), with most births occurring in May and June (Wehausen 1996). Timing of births correlates with the nutritional regime of females; later birthing appears to be a consequence of lower annual nutrient intake (Wehausen 1996). The gestation period for bighorn sheep is approximately 174 days (Shackleton *et al*. 1984, Hass 1995). The breeding (rutting) season in the Sierra Nevada, therefore, occurs during late fall and early winter (mostly November and December), when they are usually still at high elevations.

Nutrient intake can also influence birth rates (Wehausen 1984), including the frequency with which adult females produce young and the age at which young females first bear offspring. Two years of age is the youngest that females in the Sierra Nevada give birth, and their age at first lambing may be as high as 4 years under poor nutritional circumstances, as has been recorded for Dall's sheep (*Ovis dalli*; Bunnell and Olson 1981). Measuring the actual proportion of females producing young is difficult because of possible unrecorded losses soon after birth. The upper range of summer ratios of lambs to females recorded shortly after the birthing season in the Sierra Nevada has been 75-83:100 (Wehausen 1980; Chow 1991), while the lowest reported value was 30:100 (Wehausen 1980).

Survivorship of lambs can also vary with environmental and nutritional factors. For the Mount Baxter and Sawmill Canyon herds in the Sierra Nevada (see Figure 1) during 1965-79, 73 percent of the variation in winter lamb to female ratios ware explained by variation in precipitation 8 to 12 months prior to conception (Wehausen 1980). That model suggested that variation in the production of young, rather than offspring survival, was the primary variable affecting winter recruitment ratios during that period. However,

with decreasing use of winter ranges during the 1980s, lamb survival declined considerably in that herd (Wehausen 1996). Thus, lamb survival may also be sensitive to habitat use patterns and associated environmental factors.

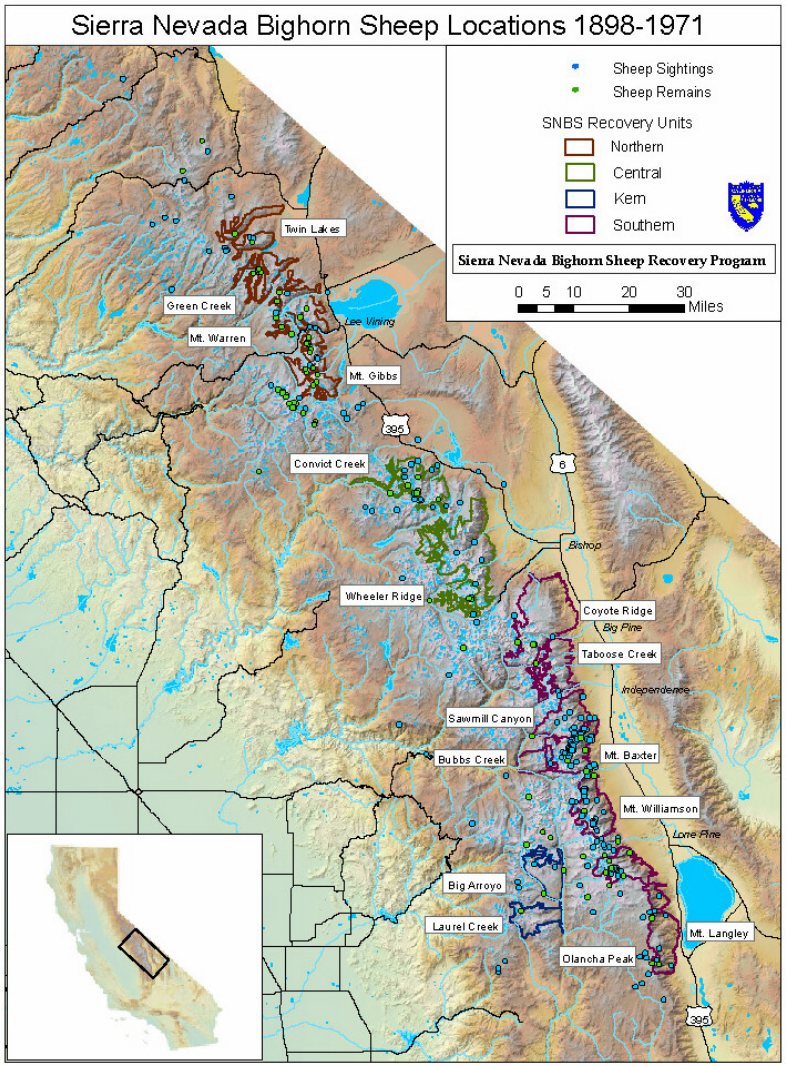
In 2000, lamb survival and yearling recruitment had increased substantially. Excluding the Mount Williamson Herd (Figure 1), for which no data were collected, the number of yearlings estimated in 2000 was 94 percent of the number of lambs estimated in 1999. While Wehausen (2000) points out that this value is not an actual survivorship estimate, it points to extremely high lamb survival between 1999 and 2000. In addition, surveys in 2000 estimated that the lamb population was 20 percent higher than 1999, indicating an increase in reproductive output. Adult survival in the Mount Langley, Black Mountain, Wheeler Ridge, and Lee Vining Canyon (see Figure 1) populations was 92 percent between 1999 and 2000 (Wehausen 2000). All of these signs point to increasing reproductive output, lamb survival, yearling recruitment, and adult survival between 1999 and 2000. By 2004, surveys were documenting the decline in lamb and yearling recruitment that had become evident in some herds (Mount Langley and Wheeler Ridge) (Wehausen and Stephenson 2004, 2005b). Wehausen and Stephenson (2005b) attributed this decline in recruitment and overall decline in population growth rate to density dependence (i.e., some herds were approaching carrying capacity). However, increased use of winter range is likely to increase the winter carrying capacity of some populations and allow for additional recruitment and growth in those populations. Prior to the recent use of low-elevation winter range, population size, recruitment, and survivorship were greatly restricted by the carrying capacity of high-elevation habitats during the winter. Because the low-elevation habitats have greater winter carrying capacities, the use of these areas will eliminate this restriction.

Trends in Distribution

Sierra Nevada bighorn sheep herds once occupied numerous locations along and east of the alpine crest of the Sierra Nevada from the Sonora Pass area south to Olancha Peak. They also occurred in similar habitat west of the Kern River as far south as Maggie Mountain, with concentrated use in the regions of Mineral King, Big Arroyo, and Red Spur (see Figure 1 and 2) (Jones 1950). Additional evidence suggested that herds used non-alpine habitat farther south near Walker Pass (Jones 1949; Garlinger 1987; Wehausen *et al*. 1987). Whether those southernmost herds were taxonomically the same as those that occurred farther north in the Sierra Nevada or were desert bighorn sheep (*Ovis canadensis nelsoni*) is unknown.

Of 16 areas in the Sierra Nevada that likely had separate herds (see Figure 2) (excluding the southernmost non-alpine region), only nine persisted to the beginning of the 20th century. By 1948, the number of areas thought to support this species had dropped to five (Convict Creek, Birch Mountain (Taboose Creek), Mount Baxter, Mount Williamson, and Mount Langley) (see Figures 1 and 2) (Jones 1950). Jones (1950) documented Sierra Nevada bighorn sheep in three of these areas and postulated their existence in two other regions based on sign and reported observations.

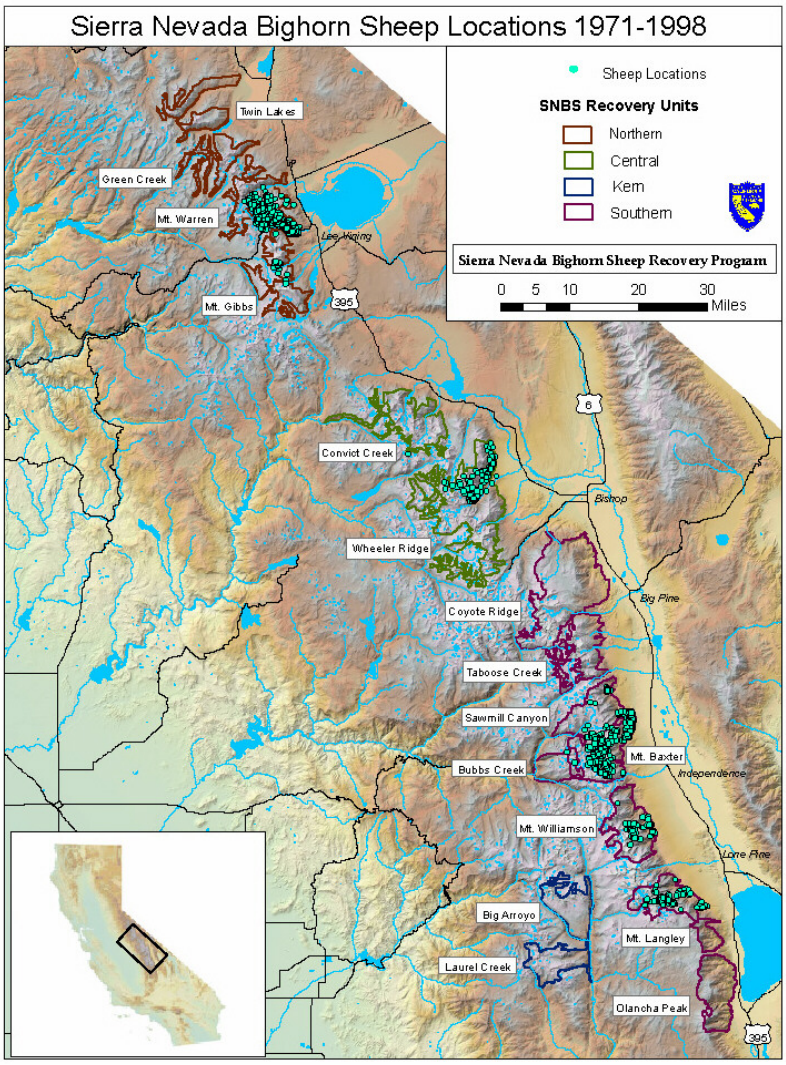
FIGURE 2 – Compiled Sierra Nevada bighorn sheep locations 1898 to 1971



By the 1970s, Sierra Nevada bighorn sheep only remained in the Mount Baxter and Mount Williamson areas, but the Mount Baxter herd represented two demographically distinct herds (Mount Baxter and Sawmill Canyon; Wehausen 1979, 1980). Because of their large size and productivity, the California Department of Fish and Game used the Mount Baxter and Sawmill Canyon herds as sources of reintroduction stock from 1979 to 1988, to reestablish populations at Wheeler Ridge, Mount Langley, and Lee Vining Canyon (see Figures 1 and 3) (Bleich *et al*. 1990b).

FIGURE 3 – Compiled Sierra Nevada bighorn sheep locations 1971 to 1998

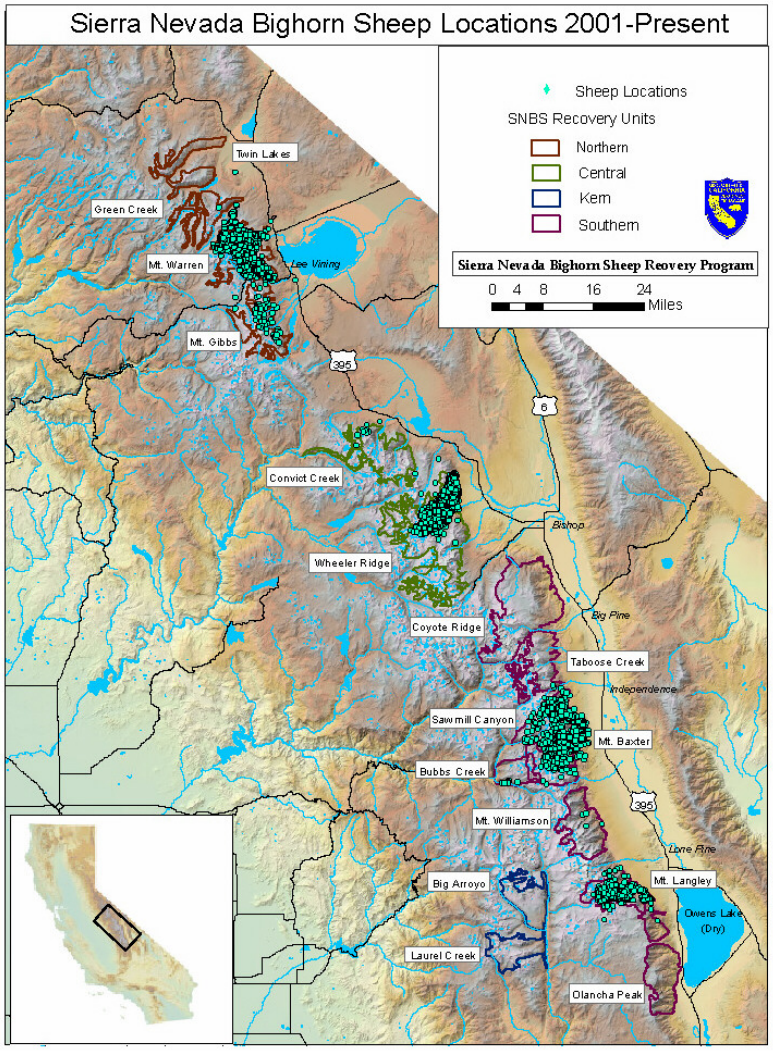
*** Note: Although the data depicted here covers 1971-1998, this is approximately the distribution of Sierra Nevada bighorn sheep at the time of emergency listing in 1999.**



At the time of emergency listing in 1999, Sierra Nevada bighorn sheep were distributed among the Mount Langley, Mount Williamson, Mount Baxter (composed of Black Mountain, Sand Mountain, and Sawmill Canyon herds), Wheeler Ridge, and Lee Vining Canyon (Mount Gibbs, Tioga Crest, and Mount Warren herds) populations (see Figures 1 and 3) (Wehausen 1999). Surveys performed following reports from climbing guides, identified a new herd in the Bubbs Creek area in 2002 (see Figure 1 and 4) (Wehausen and Stephenson 2004, 2005b). As of 2005, Sierra Nevada bighorn sheep are distributed among the Mount Langley, Mount Williamson, Mount Baxter, Bubbs Creek, Sawmill Canyon, Wheeler Ridge, Mount Warren, and Mount Gibbs herds (see Figures 1 and 4) (Wehausen and Stephenson 2005b). The *Final Recovery Plan for the Sierra Nevada Bighorn Sheep* classifies these herds and the habitat that they use into separate herd units (Service 2007). We use this herd unit designation in the Five-Factor Analysis (below) to

FIGURE 4 – Compiled Sierra Nevada bighorn sheep locations 2001 to Present

* Note – Locations identified in Convict Creek Herd Unit are from one rut season movement by a ram from the Mount Gibbs area. The Convict Creek Herd Unit is no longer occupied.



discuss the herds and their associated home ranges. For the purposes of this review, the term herd and the term deme are interchangeable. We use the term subpopulation when discussing these groups in the context of metapopulation discussions.

Abundance and Population Trends

The total population of Sierra Nevada bighorn sheep prior to settlement is unknown, but it probably exceeded 1,000 individuals (Service 2007). Population losses apparently began shortly after the immigration of Europeans to the Sierra Nevada in the mid-1800s, and those losses continued through most of the twentieth century (Wehausen *et al*. 1987). Specific causes of most population losses in the Sierra Nevada are unknown. Market

hunting for mining towns may have played a role in some areas. A die-off in the 1870s west of the Kern River was attributed to scabies (Jones 1950), presumably contracted from domestic sheep. Die-offs from pneumonia contracted from domestic sheep may have been the most important cause of losses, but have not been documented. Beginning in the 1860s, and extending into the twentieth century, large numbers of domestic sheep were grazed seasonally in the Sierra Nevada (Austin 1906, Vankat 1970).

During the initial phase of reintroduction efforts, populations in the Sierra Nevada increased from 250 in 1978 to almost 300 in 1985. In the late 1980s, bighorn sheep in many parts of the Sierra Nevada began to abandon use of low-elevation winter ranges, which corresponded with a period of decline in population size to just over 100 in 1995, with a reproductive base of about 50 females (Wehausen and Stephenson 2005a).

Sierra Nevada bighorn sheep numbers have increased dramatically since the low in 1995. The first four years had somewhat slow and inconsistent overall increases due to further losses in the Mono Basin area (Mount Gibbs, Mount Warren, Tioga Crest herds) and delayed recovery in some other herds. At the time of emergency endangered listing in spring 1999, there were a minimum of 117 Sierra Nevada bighorn sheep, but additional data suggested that the actual total was probably somewhat higher (Wehausen 1999). Subsequent data increased that minimum to 122 individuals (Service 2007).

Six years after emergency listing, the minimum number of yearling and adult females had increased by 265 percent from 55 to at least 146 (Wehausen and Stephenson 2005a). The minimum number of lambs in 2004 was 66. With the addition of adult males, the total population in 2004 was approximately 325 to 350 (Service 2007). Census data from 2005-2006 estimates the current minimum population size at approximately 386 individuals (Wehausen and Stephenson 2006). With the addition of new lambs in 2006 in the Mount Langley, Mount Baxter, Sawmill Canyon, and Wheeler Ridge herd units, the total 2007 population size is likely over 400 individuals (Wehausen et al. 2007).

2.3.2 Five Factor Analysis (threats, conservation measures, and regulatory mechanisms)

a. Present or threatened destruction, modification or curtailment of its habitat or range:

In the final listing rule for the Sierra Nevada bighorn sheep (65 FR 20), the Service did not consider destruction, modification, or curtailment of habitat or range as a substantial threat. The Inyo and Humboldt-Toiyabe National Forests, Bureau of Land Management (Bishop Resource Area), Sequoia and Kings Canyon National Parks, and Yosemite National Park manage the majority of habitat for the Sierra Nevada bighorn sheep (Service 2007). The types, extent, and intensity of permitted activities on lands managed by these agencies have not increased since the time of listing. Most of the Sierra Nevada bighorn sheep habitat that these agencies manage is within designated wilderness areas (73 percent), which greatly restricts the types of activities that could potentially affect habitat features. There are privately

owned lands within Sierra Nevada bighorn sheep habitat in the Green Creek, Mount Warren, and Wheeler Ridge Herd Units, but they encompass an extremely small fraction of the total habitat available to the Sierra Nevada bighorn sheep. As was the case at the time of listing, there is no substantial destruction, modification, or curtailment of habitat or range that would affect the status of this species.

b. Overutilization for commercial, recreational, scientific, or educational purposes:

There is no evidence that commercial, recreational, scientific, or educational activities currently pose significant threats. We have not documented any evidence of poaching of Sierra Nevada bighorn sheep. The California Department of Fish and Game performs live captures of bighorn sheep and fits them with radio collars to collect movement and location information for a variety of studies. Capture efforts have killed two bighorn sheep rams since the Service emergency listed this species in 1999 (CDFG 2005). It is unlikely that this level of mortality has any substantial effect on the Sierra Nevada bighorn sheep. This mortality rate of two bighorn sheep in the 7 years since listing is considerably lower than any other threat where mortality has been observed, with the exception of roadkills, which results in a similar level of mortality. In addition, the benefits that these capture efforts have on our ability to address issues, such as disease and genetic diversity, far outweigh the minimal losses that have occurred.

c. Disease or predation:

Disease

Disease transmission from domestic sheep

The potential for the transfer of virulent disease organisms from domestic sheep to Sierra Nevada bighorn sheep was a factor in listing this species. Contact between these two species has the potential to result in transfer of disease-causing pathogens that could result in major die-offs of Sierra Nevada bighorn sheep. Diseases transferred through contact with domestic sheep are suspected to have played a major role in the disappearance of certain bighorn sheep herds in the Sierra Nevada beginning around 1870 (Wehausen 1985).

Pneumonia, caused by *Pasteurella* alone, or in combination with other pathogens, is the most significant disease threat for bighorn sheep (Bunch *et al*. 1999). Sheep in general are susceptible to pneumonia and bighorn sheep appear particularly susceptible. Although die-offs of bighorn sheep due to disease have occurred that are unrelated to domestic sheep (Miller *et al*. 1991), the history of bighorn sheep in the United States provides numerous examples of major die-offs following contact with domestic sheep (Goodson 1982; Foreyt and Jessup 1982; Singer *et al*. 2001; Coggins 2002).

Pneumonia epizootics can extirpate entire populations (Martin *et al*. 1996). Although researchers have never empirically proven transmission of disease from domestic sheep to bighorn sheep under range conditions, numerous independent trials in captive bighorn sheep have resulted in mortality of bighorn sheep due to respiratory disease following contact with domestic sheep (Onderka and Wishart 1988; Foreyt 1989, 1990, 1994; Callan *et al*. 1991). In addition, inoculations of bighorn sheep with *Pasteurella* from the respiratory tract of healthy domestic sheep (Onderka *et al*. 1988; Foreyt *et al*. 1994; Foreyt and Silflow 1996) has resulted in respiratory disease and death of the bighorn sheep, but not of domestic sheep treated identically. Given the evidence from these captivity and inoculation studies in combination with the field observations of pneumonia-related die-offs mentioned previously, disease contracted from domestic sheep is considered a potentially significant source of mortality that requires management.

Currently, domestic sheep grazing on both private and Federal land occurs adjacent to occupied Sierra Nevada bighorn sheep herd units (Clifford *et al.* 2007). While land management agencies have removed sheep grazing from some of the most high-risk Federal grazing allotments on the Humboldt-Toiyabe and Inyo National Forests since listing, additional allotments and private lands continue to pose a disease risk. The potential for contact between the species occurs when stray domestic sheep enter bighorn sheep habitat, or when bighorn sheep encounter domestic sheep herds. Since listing, the California Department of Fish and Game has documented the presence of wandering bighorn sheep rams on domestic sheep grazing allotments that land management agencies still permit for sheep grazing (Clifford *et al.* 2007). In addition, modeling of potential Sierra Nevada bighorn sheep utilization areas indicates that they are likely to occupy areas that overlap numerous allotments that are open to domestic sheep grazing (Clifford *et al*. 2007). Additional modeling identifies areas on or immediately adjacent to numerous open domestic sheep allotments that Sierra Nevada bighorn sheep are likely to select because of the quality of the habitat (Johnson *et al.* 2006).

Disease transmission from cattle

The impacts of domestic cattle (*Bos taurus*) grazing within bighorn sheep habitat have not been well documented. Researchers have reported hemorrhagic disease and pneumonia resulting from bluetongue virus (BTV) infection in bighorn sheep (Robinson *et al* 1967; Noon *et al* 2002). Because of prolonged viremia (presence of viruses in the blood), cattle may be an important reservoir of BTV for *Culicoides* (biting midges) vectors (Osburn 2000) and a potential source of infection for other wild and domestic ungulates in areas climatically suitable for *Culicoides*. Singer *et al* (1997) studied cattle, bighorn sheep, and mule deer (*Odocoileus hemionus*) in an area where the three species used common areas. Only cattle were seropositive to BTV, but deer and bighorn sheep were seropositive for *Babesia* sp., and *Psoroptes* mites were on bighorn sheep. Singer *et al*.

(1997) concluded that cattle, deer, and bighorn sheep did not share similar patterns of exposure to the three pathogens and proposed that cattle did not constitute a health risk for bighorn sheep in that area. Foreyt (1994) reported no adverse effects on healthy bighorn sheep in one co-pasturing study with domestic cattle. In a follow-up study, one of five bighorn sheep co-pastured with cattle developed a fatal pneumonia and died on day 6 post introduction (Foreyt and Lagerquist 1996). Although cattle may carry *Pasteurella* spp. that are pathogenic to bighorn sheep, researchers hypothesize that "the nose to nose contact required for transmission of *P. haemolytica* (renamed *Mannheimia haemolytica*) is less likely to occur between bighorn sheep and cattle" than with domestic sheep. This is because the social interactive behavior between bighorn sheep and cattle is less likely to result in nose-to-nose contact. They recommended further research to determine the compatibility of bighorn sheep and domestic cattle. Based on the limited amount of evidence linking cattle to diseases in bighorn sheep, we do not consider disease transmission from cattle grazed in the eastern Sierra Nevada to be a major threat to Sierra Nevada bighorn sheep at this time.

Disease transmission from domestic goats

Domestic goats can be unapparent carriers of various pathogens. A recent outbreak of disease in bighorn sheep in Arizona provides strong evidence that contact with domestic goats presents a significant disease risk for bighorn sheep (Heffelfinger 2004, Jansen *et al.* 2006). In October 2003, 4,800 domestic goats were legally imported into Arizona from Texas to an unfenced grazing allotment about 5 miles north of bighorn sheep habitat in the Silver Bell Mountains, Pima County. In early November, a number of stray goats were occupying bighorn ranges. Despite efforts to remove the domestic goats, by December, contact between the two species had resulted in an outbreak of infectious keratoconjunctivitis (inflammation of the eye) resulting in complete blindness in 33 bighorn sheep. During capture and treatment of these bighorn sheep, contagious ecthyma (CE or soremouth) was also detected in 19 animals. Of 81 bighorn sheep thought to inhabit the Silver Bell Mountains, there were 14 known mortalities from malnutrition, predation, and other factors that were exacerbated by blindness in some animals. In addition, there were three stillborn lambs and three lambs that died post-partum from infected ewes. Thirteen bighorns recovered, but five remain unaccounted for.

There is currently no domestic goat grazing on Federal grazing allotments that would be in likely areas of contact with Sierra Nevada bighorn sheep, but the Forest Service and the Bureau of Land Management have not specifically prohibited domestic goat grazing on these allotments. In addition, private lands in areas that have a high risk of contact may have domestic goats. The Inyo National Forest has prohibited domestic goat packing in key Sierra Nevada bighorn areas on the Inyo National Forest (Forest Order No. 04-02-07), and the Sequoia and Kings Canyon National

Park does not list domestic goats as allowable stock within the park (NPS 2006). Similar prohibitions are not in place on the Humboldt-Toiyabe National Forest or in Yosemite National Park. Consequently, the potential exists for disease transmission between domestic goats and Sierra Nevada bighorn sheep in some areas.

Predation

In the Sierra Nevada, mountain lions (*Felis concolor*) have been the primary predator of bighorn sheep, accounting for 96 percent of losses attributed to predation with the remaining losses attributed to coyotes (*Canis latrans*) and bobcats (*Felis rufus*) (Table 1; Service 2007). Of 147 bighorn sheep deaths recorded in the Sierra Nevada from 1975 to 2000, a minimum of 54.5 percent could be attributed to predation; the actual percentage could be considerably higher due to numerous mortalities for which no definitive cause could be assigned (Table 1; Service 2007).

Table 1. Causes of known bighorn sheep mortalities in the Sierra Nevada by population, 1975-2000. Sources include Andaloro and Ramey (1981), Chow *et al*. (1993), Wehausen (1996) and many unpublished records.

Herd	Predation			Avalanche/ Accidents	Post Release Exposure	Highway Collision	Not Known
	Lion	Coyote	Bobcat				
Langley	7						4
Williamson	5						2
Baxter	50			1			27
Wheeler	3			15			2
Mono Basin	12	2	1	3	5	1	7
Totals	77	2	1	19	5	1	42
Percent	52.4	1.4	0.7	12.9	3.4	0.7	28.6

During the 1990s, Sierra Nevada bighorn sheep incurred major losses while remaining at high elevations during the winter. This was a change in habitat selection that Wehausen (1996) suggested was a response to increased mountain lion predation on winter ranges. Those losses were a key factor that put these sheep in danger of extinction.

Data on mountain lions indicate that their population along the eastern Sierra Nevada declined markedly in the 1990s, especially toward the end of that decade, and hit a low in 1999 (Service 2007). Following the emergency endangered listing of Sierra Nevada bighorn sheep, CDFG initiated a program of focused control of mountain lions. In 2000, that program began placing telemetry collars on mountain lions near bighorn sheep ranges and closely monitoring them in an effort to be as selective as possible in the removal of mountain lions for the benefit of bighorn sheep. On average,

CDFG has removed one mountain lion per year to protect Sierra Nevada bighorn sheep under that program.

Sierra Nevada bighorn sheep in the Mount Langley, Mount Baxter, Sawmill Canyon, and Wheeler Ridge Herd Units have expanded use of low-elevation winter ranges since listing in 2000. Populations in the Bubbs Creek and Mount Williamson Herd Units also show some use of low-elevation winter ranges. We do not know how much of this change we can attribute to mountain lion removals and how much is due to other factors. CDFG is currently controlling this threat through monitoring and selective removal of mountain lions, which is likely contributing to the increased use of winter range by some bighorn populations. As bighorn populations in other portions of the range continue to grow and increase there use of winter range, continued predator control will likely be necessary to ensure that these expansions are successful.

d. Inadequacy of existing regulatory mechanisms:

There are several State and Federal laws and regulations that are pertinent to Sierra Nevada bighorn sheep, each of which contribute to the conservation of the Sierra Nevada bighorn sheep, although in varying degrees.

State Protections

California Environmental Quality Act (CEQA): CEQA requires review of any project that is undertaken, funded, or permitted by the State or a local governmental agency. If significant effects are identified, the lead agency has the option of requiring mitigation through changes in the project or to decide that overriding considerations make mitigation infeasible (CEQA section 21002). Protection of listed species through CEQA is, therefore, dependent upon the discretion of the lead agency involved.

California Endangered Species Act (CESA): The CESA prohibits the unauthorized take of State-listed threatened or endangered species. CESA requires State agencies to consult with the California Department of Fish and Game on activities that may affect a State-listed species and mitigate for any adverse impacts to the species or its habitat.

In 1971, California listed the California bighorn sheep as "rare." The State changed the designation to "threatened" in 1984 to standardize the terminology of the amended California Endangered Species Act (CESA) (Sierra Nevada Bighorn Sheep Interagency Advisory Group 1997). The California Fish and Game Commission upgraded the species' status to "endangered" in 1999 (CDFG 1999 *in* 65 FR 20). Pursuant to the California Fish and Game Code and the CESA, it is unlawful to import or export, take, possess, purchase, or sell any species or part or product of any species listed as endangered or threatened. The State may authorize permits for scientific, educational, or management purposes, and to allow take that is incidental to

otherwise lawful activities. However, the State of California also identifies the Sierra Nevada bighorn sheep as a fully protected species, which precludes the authorization of incidental take.

The policy of the State of California is to protect and preserve all native species and their habitat, such as the Sierra Nevada bighorn sheep, that are threatened by extinction or are experiencing a significant decline (California Fish and Game Commission 1999 *in* 65 FR 20). Since the Sierra Nevada bighorn sheep was listed by the State of California in 1971, the CDFG has undertaken numerous efforts for the conservation of the sheep, including but not limited to: (1) intensive field studies to monitor locations and movement patterns, (2) reestablishment of additional subpopulations in historical habitat, (3) monitoring and controlling mountain lion predation under the authority of A.B. 560, and (4) participation on numerous interagency advisory groups to deal with external threats to bighorn sheep. These efforts have continued since the time of Federal listing.

CDFG has had great success in increasing the distribution and abundance of bighorn sheep, controlling predation, and providing data needed for management of other threats to this species. However, their authority to regulate external threats to these populations, such as grazing, is limited to private lands. The Sierra Nevada bighorn sheep occurs mainly on Federal lands administered by the Bureau of Land Management, Forest Service, and National Park Service. These Federal agencies are responsible for regulating activities on Federal lands that may adversely affect Sierra Nevada bighorn sheep. Consequently, the regulatory mechanisms that CESA provides are not sufficient to protect this species from threats throughout the entirety of its range.

A.B. 560: In 2000, the California State Legislature passed a law to allow the California Department of Fish and Game to control mountain lion populations in the eastern Sierra Nevada in order to reduce predation and promote the recovery of Sierra Nevada bighorn sheep. This legislation and the steps that CDFG has taken to control mountain lions has greatly reduced the threat of predation on Sierra Nevada bighorn sheep in the eastern Sierra Nevada and has likely had an influence on the expanding use of winter range in some areas. However, this legislation only addresses a single threat to the species.

Federal Protections

National Environmental Policy Act (NEPA): NEPA (42 U.S.C. 4371 *et seq*.) provides some protection for listed species that may be affected by activities undertaken, authorized, or funded by Federal agencies. Prior to implementation of such projects with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. In cases where that analysis reveals significant environmental effects, the Federal agency must propose

mitigations that could offset those effects (40 C.F.R. 1502.16). These mitigations usually provide some protection for listed species. However, NEPA does not require that adverse impacts be fully mitigated, only that impacts be assessed and the analysis disclosed to the public. Additionally, NEPA is only required for projects with a Federal nexus, and therefore actions taken by private landowners or on State lands are not required to comply with this law.

Endangered Species Act of 1973, as amended (Act): The Act is the primary Federal law providing protection for this species. Since its listing, the Service has analyzed the potential effects of Federal projects under section 7(a)(2), which requires Federal agencies to consult with the Service prior to authorizing, funding, or carrying out activities that may affect listed species. A jeopardy determination is made for a project that is reasonably expected, either directly or indirectly, to appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution (50 C.F.R. § 402.02). A non-jeopardy opinion may include reasonable and prudent measures that minimize the amount or extent of incidental take of listed species associated with a project. The Service's responsibilities include administering the Act, including sections 7, 9, and 10. Section 9 of the Act prohibits the taking of any federally listed endangered or threatened species. Section 3(18) of the Act defines "take" to mean "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." Service regulations (50 CFR 17.3) define "harm" to include significant habitat modification or degradation which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering. Harassment is defined by the Service as an intentional or negligent action that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. The Act provides for civil and criminal penalties for the unlawful taking of listed species. Incidental take refers to taking of listed species that results from, but is not the purpose of, carrying out an otherwise lawful activity by a Federal agency or applicant (50 C.F.R. § 402.02). For projects without a Federal nexus that would likely result in incidental take of listed species, the Service may issue incidental take permits pursuant to section 10(a)(1)(B). To qualify for an incidental take permit, applicants must develop, fund, and implement a Service-approved habitat conservation plan (HCP) that details measures to minimize and mitigate the project's adverse impacts to listed species. Regional HCPs in some areas now provide an additional layer of regulatory protection for covered species, and these HCPs are coordinated with the related NCCP-State program.

Since the time of its listing, three biological opinions have been issued to address the potential threats to the Sierra Nevada bighorn sheep from a variety of actions. Actions for which the Service has issued biological

opinions for effects to Sierra Nevada bighorn sheep include grazing and packing.

National Park Service (NPS) Organic Act: The NPS Organic Act of 1916 (39 Stat. 535, 16 U.S.C. 1, as amended), states that the NPS "shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations … to conserve the scenery and the national and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." The NPS Management Policies (NPS 2006) indicate that NPS will "meet its obligations under the NPS Organic Act and the Endangered Species Act to both pro-actively conserve listed species and prevent detrimental effects on these species." This includes working with the Service and undertaking active management programs to inventory, monitor, restore, and maintain listed species habitats, among other actions.

National Forest Management Act (NFMA): The National Forest Management Act (36 C.F.R. 219.20(b)(i)) has required the Forest Service to incorporate standards and guidelines into Land and Resource Management Plans, including provisions to support and manage plant and animal communities for diversity and for the long-term, range-wide viability of native species. Recent changes to NFMA may affect future management of listed species, particularly rare plant occurrences, on National Forests. On January 5, 2005, the Forest Service revised its National Forest land management planning under NFMA (70 FR 1023). The 2005 planning rule changes the nature of Land Management Plans so that plans generally are strategic in nature and may be categorically excluded from NEPA analysis, and thus not subject to public review. Under the 2005 planning rule, the primary means of sustaining ecological systems, including listed species, will be through guidance for ecosystem diversity. If needed, additional provisions for threatened and endangered species may be provided within the overall multiple-use objectives required by NFMA. The 2005 planning rule did not include a requirement to provide for viable populations of plant and animal species, which had previously been included in both the 1982 and 2000 planning rules. On March 30, 2007, however, the United States District Court in *Citizens for Better Forestry et al. v. USDA* (N.D. Calif.) enjoined (prohibited) the USDA from implementing and using the 2005 rule until the Forest Service provided for public comment and conducted an assessment of the rule's effects on the environment, including listed species.

On April 21, 2008, the Forest Service published a final 2008 planning rule and a record of decision for a final environmental impact statement examining the potential environmental impacts associated with promulgating the new rule (73 FR 21468). The 2008 planning rule also does not include a requirement to provide for viable populations of plant and animal species on Forest Service lands. As part of the environmental analysis, a biological assessment was prepared to address the 2008 planning

rule's impact to threatened, endangered, and proposed species and designated and proposed critical habitat. The assessment concluded that the rule does not affect, modify, mitigate, or reduce the requirement for the Forest Service to consult or conference on projects or activities that it funds, permits, or carries out that may affect listed or proposed species or their designated or proposed critical habitat. On August 8, 2008, the Forest Service published an interim directive and requested public comment on its section 7 consultation policy for developing, amending, or revising Land Management Plans under the 2008 planning rule. Thus, the impact of the 2008 rule to listed species is unknown at this time.

Federal Land Policy and Management Act of 1976 (FLPMA): The Bureau of Land Management also is required to incorporate Federal, State, and local input into their management decisions through Federal law. The Federal Land Policy and Management Act of 1976 (FLPMA) (Public Law 94-579, 43 U.S.C. 1701) was written "To establish public land policy; to establish guidelines for its administration; to provide for the management, protection, development and enhancement of the public lands; and for other purposes." Section 102(f) of the FLPMA states that "The Secretary shall allow an opportunity for public involvement and by regulation shall establish procedures…to give Federal, State, and local governments and the public, adequate notice and opportunity to comment upon and participate in the formulation of plans and programs relating to the management of the public lands." Therefore, through their management plans, the Bureau of Land Management is responsible for including input from Federal, State, and local governments and the public. Additionally, Section 102(c) of the FLPMA states that the Secretary shall "give priority to the designation and protection of areas of critical environmental concern" in the development of plans for public lands. Although the Bureau of Land Management has a multiple-use mandate under the FLPMA which allows for grazing, mining, and off-road vehicle use, it also has the ability under the FLPMA to establish and implement special management areas such as Areas of Critical Environmental Concern, wilderness, research areas, etc., that can reduce or eliminate actions that adversely affect species of concern.

Based on the above, the Forest Service, Bureau of Land Management, and Park Service have authority to manage the land and activities under their administration to conserve the Sierra Nevada bighorn sheep. Since listing, Federal agencies have taken steps to enhance habitat through prescribed burning, and they have retired domestic sheep allotments in some areas. In addition, they have participated in the creation and implementation of the 2001 Interagency Domestic Sheep Management Strategy to try to eliminate the risk of disease transmission between domestic sheep and Sierra Nevada bighorn sheep. However, location and movement data combined with modeling of preferred Sierra Nevada bighorn sheep habitat and likely utilization areas indicate that additional allotments still pose a risk of contact (Clifford *et al.* 2007; Johnson *et al.* 2006). Because these allotments are open and pose a potential risk to Sierra Nevada bighorn sheep, the

provisions of section 7(a)(2) provide for jeopardy analysis and implementation of terms and conditions to minimize take that would not be required if the species were not listed.

In 1971, the State of California, in cooperation with the Forest Service, established a sanctuary for the Mount Baxter and Mount Williamson subpopulation of Sierra Nevada bighorn sheep and called it the California Bighorn Sheep Zoological Area (Zoological Area) (Wehausen 1979; Inyo National Forest Land Management Plan 1988). The Forest Service set aside about 16,564 hectares (41,000 acres) of National Forest land for these two herds. At the time, many felt that human disturbance was causing the decline of the species. The sanctuary was designed to regulate human use in some areas (Hicks and Elder 1979), and reduce interactions with domestic sheep by constructing a fence below the winter range of the Mount Baxter subpopulation along the National Forest and Bureau of Land Management boundary (Wehausen 1979). The Inyo National Forest also eliminated goat packing in these areas. The National Park Service also gave adjacent national park lands a restrictive designation to reduce human disturbance (Wehausen 1979). The Inyo National Forest continues to manage the Zoological Area; it encompasses land designated as wilderness and Sierra Nevada bighorn sheep habitat (Inyo National Forest 1988 and R. Pedoff, pers. comm. 1999 *in* 65 FR 20).

e. Other natural or manmade factors affecting its continued existence:

Small population size and fragmented distribution

At the time of its final listing, the Sierra Nevada bighorn sheep population was very small, with only about 125 adults among five geographic areas (Wehausen 2001), and little probability of interchange among those areas. Additionally, multiple independent groups of females, defined by distinct home range patterns, existed in some of those areas and resulted in yet smaller population units (Wehausen and Chang 1997; Wehausen 2001). Evidence has suggested that many of these contained five or fewer females (Wehausen 2001). Thus, small population effects alone made these bighorn sheep vulnerable to extinction. Since listing, population size has increased to more than 400 (Wehausen *et al.* 2007), but the effect that small population size has on genetic variation and vulnerability to demographic effects continues to be a substantial threat (Service 2007).

Demographic processes are especially important considerations in the conservation of small populations (Gilpin and Soulé 1986). Variation in birth, death, immigration, and emigration rates, as well as the age and sex structure of populations, can cause fluctuations in population size that make small populations especially vulnerable to extinction. For example, a large size can buffer a population against a few years of low birth rates, recruitment, and immigration, coupled with high mortality, but a small

population would likely die out without a continued influx of new individuals.

The complex topography and the vegetation structure of the Sierra Nevada, coupled with their intrinsic biology and behavior has resulted in Sierra Nevada bighorn sheep having a metapopulation structure (Bleich *et al*. 1990a). This metapopulation is composed of multiple subpopulations that interact intermittently to varying degrees, depending on site-specific geography, movement characteristics of males (occasional) and females (rare), and random chance. Hanski and Gilpin (1991) cautioned that species subject to accelerated habitat and/or population fragmentation must be managed carefully, as they may not necessarily be able to function as a metapopulation in equilibrium. This situation is likely exacerbated in the Sierra Nevada because the metapopulation is largely linear in geographic distribution and composed of small subpopulations, resulting in fewer subpopulations that can serve as sources of colonists.

Loss of genetic variation is a special concern among small populations because heterozygosity is lost more quickly in small populations than in large ones (Meffe and Carroll 1994). In the past, occasional, long-range movements north or south along the Sierra Nevada, especially by males, likely helped to maintain gene flow, but it is unclear to what extent such movements now occur. The current, fragmented distribution of the subpopulations of these animals likely reduces their connectivity. In small herds of bighorn sheep, random natural variability in population parameters can be an overriding determinant of population survival that immigration of both sexes can mitigate. If small herds become isolated and stay small, they potentially face an increased loss of genetic variability, in addition to the risks to persistence associated with stochastic demographic events (e.g., several consecutive years of low reproduction and/or high mortality within a small herd). Even if gene flow is maintained among female groups throughout the Sierra Nevada, the overall small population size (approximately 400 individuals in 2007 is still a concern. Because of the small, overall population size; fragmented distribution of subpopulations; and the likely low levels of genetic exchange among subpopulations, the loss of genetic variation continues to be a concern despite the increases in population size since listing.

Fire

In the summer of 2007, the Inyo Complex Fire burned a large portion of the Mount Baxter winter range. Additional fires have occurred historically in the eastern Sierra Nevada and are likely to occur in the future. We do not know how the Inyo Complex Fire or other historic or future fires affect the use of these areas by bighorn sheep in the Mount Baxter or other herd units. Reduced forage could potentially result in bighorn sheep staying at higher elevations during the winter following a fire. However, the reduction in

pinyon/juniper woodland in these areas may open up habitat and increase the quality and quantity of winter range.

Heavy winters and avalanches

Due to their small population size, Sierra Nevada bighorn sheep are also subject to extirpation by naturally-occurring, random, environmental events (e.g., prolonged or particularly heavy winters and avalanches). Bighorn sheep herds in the Sierra Nevada ceased regular use of low-elevation winter ranges during the 1980s. Sierra Nevada bighorn sheep that remained at high elevations during the winter suffered extreme cold, deep snow, and avalanches in heavy winters. Remaining at high elevation during winter also resulted in notably lower nutrient intake (Wehausen 1996).

Significant losses to one herd occurred because of the severe winter of 1995. Winter losses in the Wheeler Ridge herd that year included 12 sheep that died in a single snow avalanche, with only 18 known to have survived that winter. The population in Lee Vining Canyon suffered excessive losses from particularly inclement weather immediately after individuals were translocated in 1986 (Chow 1991). Beginning in the mid-1990s, a decline in the use of the Lee Vining Canyon winter range became apparent. During the winter and spring of 1995, few bighorn sheep used low-elevation winter range and many sheep disappeared. Repeated thorough counts of this herd the following summer consistently produced only 29 bighorn sheep (Wehausen and Chang 1995), representing a loss of at least 50 individuals. Additional winter declines occurred in 1998 and 1999 (Wehausen and Chang 1998; Wehausen 1999). The Mount Langley herd also appears to have suffered a major reduction in the winter of 1995 due to heavy snowfall. Repeated census efforts beginning in the summer of 1996 accounted for only 6 females and 11 males that survived that winter (Wehausen 1999), in contrast to 42 bighorn sheep counted there in the summer of 1990 (Moore and Chow 1990).

Such threats are highly significant because the subpopulations are small and it is common for all members of one sex to occur in a single group. During the very heavy winters in the late 1970s and early 1980s, there was no notable mortality in the subpopulations because they were using low-elevation winter ranges (J. Wehausen, pers. comm. 1999 *in* 65 FR 20).

With the population increases that occurred after the listing of the Sierra Nevada bighorn sheep, the populations in the Mount Langley, Mount Baxter, Sawmill Canyon, and Wheeler Ridge Herd Units are using low-elevation ranges during the winter (Wehausen and Stephenson 2005b). This appears to have reduced the effect that heavy winters and avalanches have on the status of these populations. The winter's of 2004/2005 and 2005/2006 produced record snowfall in the Sierra Nevada but no severe winter mortality was observed for animals using low- or high-elevation ranges. Populations using low-elevation ranges continued to increase and

those at high elevations remained stable. However, avalanches and heavy winters continue to be a threat for populations that remain at high elevation during winter.

Roadkill

Two subpopulations (Mount Warren and Mount Gibbs) have ranges adjacent to paved roadways, exposing individuals from those subpopulations to potential hazards. Bighorn sheep have been killed by vehicles in Lee Vining Canyon on several occasions (V. Bleich, pers. comm.1999 *in* 65 FR 20).

2.4. Synthesis

At the time of listing, mountain lion predation, the effects of small population size, abandonment of winter range, and the potential for disease transmission from domestic sheep were the primary threats to the Sierra Nevada bighorn sheep. Since final listing in 2000, Sierra Nevada bighorn sheep have begun to recover in some areas with notable increases in population size and distribution. Selective mountain lion control has also proceeded in some areas to reduce predation. It is likely that the combination of predator control and increased population size has aided the recent return of the Mount Baxter, Mount Langley, and Wheeler Ridge populations to their winter range. In addition, the Inyo and Humboldt-Toiyabe National Forests have removed sheep grazing from several allotments that posed a threat of contact between domestic sheep and Sierra Nevada bighorn sheep. However, this species needs additional time to reach population and distribution recovery goals, additional actions are needed to ensure protection of populations from external threats, and regulatory mechanisms need to be in place to ensure continued protection.

There is currently no domestic sheep grazing on the Summer's Meadow, Dunderberg, June Lake (west), McGee, Rock Creek (west), Copper Mountain, and Mono Settlement allotments. Elimination of grazing on these allotments since listing of the Sierra Nevada bighorn sheep has resulted in a reduction in the likelihood of disease transmission near the Mount Warren, Mount Gibbs, and Wheeler Ridge Herd Units. However, not all of the closures are permanent and not all of the closures are due to concerns over bighorn sheep disease issues. In addition, location and movement data coupled with modeling of habitat selection and potential utilization areas indicate that some allotments still pose a threat of potential disease transmission. The *Final Recovery Plan for the Sierra Nevada Bighorn Sheep* (Service 2007) provides a strategy for preventing contact between domestic sheep and Sierra Nevada bighorn sheep. Land and resource management agencies should work together to implement the recommendations of this strategy to ensure that contact does not occur.

Since listing of the Sierra Nevada bighorn sheep, the California Department of Fish and Game has performed selective control of mountain lions on winter ranges in an effort to reduce predation and increase the use of these ranges by Sierra Nevada bighorn sheep. In addition, the Forest Service has performed controlled burning in some areas to improve

habitat quality on winter ranges. Sierra Nevada bighorn sheep in five of the eight occupied herd units are routinely using low-elevation winter ranges, which has increased survival, fecundity, and recruitment. We cannot determine how much of the recent winter range use is attributable to predator control and how much is due to other factors, such as increasing population sizes and increased precipitation. Avoidance of low-elevation winter range still occurs in three populations and may reduce recruitment. Continued winter range habitat improvement, selective predator control, and augmentation to increase small populations are needed to enable better use of low-elevation winter ranges and achieve the benefits of such use.

Sierra Nevada bighorn sheep populations have increased from 125 to over 400 individuals since listing. These increases have likely reduced some of the threat caused by demographic effects in the larger Mount Baxter, Sawmill Canyon, Mount Langley, and Wheeler Ridge populations. However, these subpopulations are still isolated from other subpopulations by large areas of unoccupied habitat, so it is unlikely that they are receiving much natural immigration from other subpopulations that would further buffer them against annual mortalities and increase their overall genetic viability. The remaining populations are isolated and contain far fewer sheep. Recovery efforts require further augmentation of these small units to increase the population size to buffer them against demographic effects and mortality from stochastic events. Once these populations are large enough, they may begin to emigrate to other areas, which would result in establishment of new subpopulations and potential genetic exchange with individuals from other subpopulations. In addition to augmentation of existing populations, repopulation of unoccupied habitat between the current subpopulations is needed. The goal is to establish a genetically healthy metapopulation that is in equilibrium, so that mortalities and emigrations out of any given subpopulation are offset by immigration and recruitment of new individuals into that subpopulation. Because most of the subpopulations are small and the distances and terrain between the subpopulations restrict the flow of individuals, the threats posed by stochastic events, inbreeding, and demographic effects are still present.

In addition to the primary threats discussed above, roadkills and capture-related deaths have resulted in a small amount of bighorn sheep mortality. The mortality from these threats does not result in substantial effects to the overall status of the species. As was the case at the time of listing, there is no substantial destruction, modification, or curtailment of habitat or range that would affect the status of this species. We cannot yet predict what effects will occur due to the recent wildfires on the winter range for the Mount Baxter population.

We conclude that the Sierra Nevada bighorn sheep continues to require the protections of the Endangered Species Act under its current classification of endangered. While steps toward recovery have been made, small population size, fragmented distribution of subpopulations, avoidance of winter range in some areas, the threat of disease transmission from domestic sheep, and the inadequacy of other regulatory mechanisms require the continuation of the Act's protections. Based on the published change in taxonomic classification, we have announced our change of the listed entity from a Distinct Population Segment of *Ovis canadensis californiana* to a separate subspecies under the name *Ovis canadensis sierrae*.

3. RESULTS

3.1. Recommended Classification:

____ Yes, downlist to Threatened
____ Yes, uplist to Endangered
___ Yes, delist
_X__ No, no change is needed

3.2. New Recovery Priority Number: 3c

The recovery priority number for the Sierra Nevada bighorn sheep should be changed from 3 to 3c. It currently has a priority number of 3 for the following reasons: (1) there is a high degree of threat; (2) there is a high recovery potential; and (3) the listed entity, as described, is a distinct population [changing the listed entity to *Ovis canadensis sierrae* would not affect the recovery priority number]. Because many recovery actions pertaining to grazing that are proposed in the *Final Recovery Plan for the Sierra Nevada Bighorn Sheep* will be controversial and will affect the domestic sheep grazing industry in the eastern Sierra Nevada, the "c" designation should be added to the recovery priority number. Changing the listed entity for Sierra Nevada bighorn sheep from *Ovis canadensis californiana* to *Ovis canadensis sierrae* will require that it be designated in the List of Endangered and Threatened Wildlife as a subspecies instead of a DPS.

4. RECOMMENDATIONS FOR FUTURE ACTIONS -

a. The Service should work with the California Department of Fish and Game, the Humboldt-Toiyabe and Inyo National Forests, and the Bureau of Land Management – Bishop Field Office to implement the recommended strategy for preventing contact between domestic sheep and bighorn sheep in Section E of the *Final Recovery Plan for the Sierra Nevada Bighorn Sheep.*

b. The Risk Assessment described in Section E of the recovery plan should be completed and used in accordance with the recommendations in Section E.

c. We support the Inyo and Humboldt-Toiyabe National Forests and Bureau of Land Management- Bishop Field office in continuing to perform controlled burning and other habitat improvement projects on winter ranges for Sierra Nevada bighorn sheep.

d. We support the California Department of Fish and Game in continuing selected removal of mountain lions from Sierra Nevada bighorn sheep winter range.

e. We support the California Department of Fish and Game in continuing translocation efforts to augment smaller subpopulations and to establish new populations in unoccupied habitat that is necessary for recovery.

f. Research should be initiated on potential threats to Sierra Nevada bighorn sheep such as human recreation and the effects of wildfire on habitat quality and use of low-elevation winter range.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Sierra Nevada bighorn sheep

Current Classification: Endangered
Recommendation resulting from the 5-Year Review

____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist**
_X_ **No change is needed**

Appropriate Listing/Reclassification Priority Number NA

Review Conducted By Brian Croft

FIELD OFFICE APPROVAL:
Lead Field Supervisor, Fish and Wildlife Service

Approve Diane K. Noda Date 9/29/08

REGIONAL OFFICE APPROVAL:
Lead Assistant Regional Director, Fish and Wildlife Service

Approve Michael Fris Date 9/30/08