

5-YEAR REVIEW

Sierra Nevada Bighorn Sheep (*Ovis canadensis sierrae*)

GENERAL INFORMATION:

Species: Sierra Nevada Bighorn Sheep (SNBS; *Ovis canadensis sierrae*).

Date listed: 2000.

FR citation(s): An emergency listing rule, under the Endangered Species Act of 1973, as amended (ESA) was published and became effective on April 20, 1999 (64 FR 19300). This emergency listing expired on December 16, 1999. The final listing rule was published and became effective on January 3, 2000 (65 FR 20). The entity listed was the Sierra Nevada Distinct Population Segment of the California bighorn sheep (*Ovis canadensis californiana*), which was the recognized taxonomic classification (Cowan 1940) at the time of listing. 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 SNBS as a unique subspecies of *O. canadensis* and modified the nomenclature. On August 5, 2008, we designated critical habitat of approximately 417,577 acres in California and announced a taxonomic revision from a distinct population segment of California bighorn sheep to subspecies, *Ovis canadensis sierrae* (73 FR 45534).

Classification: Endangered.

Lead Field Office: In 2015, the lead field office for the SNBS changed from the Ventura Fish and Wildlife Office to the Reno Fish and Wildlife Office.

BACKGROUND:

Most recent status review: U.S. Fish and Wildlife Service. 2008. Sierra Nevada Bighorn Sheep *Ovis canadensis californiana* (= *Ovis canadensis sierrae*). 5-Year Review: Summary and Evaluation. Ventura, California. 41 pp. (5-Year Review).

FR Notice citation announcing this status review: 83 FR 28251; Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Status Reviews of 50 Species in California, Nevada, and the Klamath Basin of Oregon; June 18, 2018.

ASSESSMENT:

Information acquired since the last status review: This 5-Year Review (short form) was conducted by the U.S. Fish and Wildlife Service's (Service) Reno Fish and Wildlife Office. Data for this review were solicited from interested parties through a Federal Register notice announcing this review on June 18, 2018.

We also contacted Humboldt-Toiyabe, Inyo, Sequoia, and Sierra National Forests; Sequoia/Kings Canyon and Yosemite National Parks; Bureau of Land Management (BLM, Bishop); Animal Plant Health Inspection Service (Wildlife Services); California Department of Fish and

Wildlife (CDFW); other Fish and Wildlife Offices (Ventura, Palm Springs, Sacramento); and existing SNBS Recovery Implementation Team (RIT) members to request any data or information that should be considered in this review. Additionally, a literature search and a review of information in Service files was conducted.

Introduction

This document briefly describes new information that has become available since the last 5-Year Review for SNBS (Service 2008). A more thorough discussion on the status of the SNBS over the succeeding years (until 2018) can be found in numerous reports/publications that have become available since the last review, and many of these reports/publications are cited in this document.

The new information is primarily from annual reports prepared by the Sierra Nevada Bighorn Sheep Recovery Program led by the CDFW. The Sierra Nevada Bighorn Sheep Recovery Program's recovery activities include conducting SNBS population surveys, monitoring survival and habitat use patterns, collecting collar data from numerous individuals, capturing and translocating individuals, and identifying resource selection patterns across the Sierra Nevada. Other activities include modeling the risk of disease transmission from domestic sheep and goats to SNBS, determining effects of fire on bighorn sheep forage and habitat use, determining genetic diversity, and monitoring mountain lion movements, predation rates, and population numbers.

In 2010, the Service and CDFW cooperatively formed the Sierra Nevada Bighorn Sheep RIT (and disbanded the Recovery Team responsible for preparing the Recovery Plan for the Sierra Nevada Bighorn Sheep (*Ovis canadensis californiana*) (Recovery Plan; Service 2007) to assist with the implementation of actions identified in the Recovery Plan. The RIT consists of two separate subteams: a core subteam and a science subteam. The core subteam provides a forum for interagency planning, prioritization, and implementation of recovery actions throughout the range of the subspecies. The core subteam is working on the updates to the risk assessment documents. The science subteam provides a forum for primarily bighorn sheep experts to discuss issues such as translocation needs and predation concerns and prepares plans to address such issues. The science subteam finalized a Translocation Plan in 2015; a Predator Management Plan is being prepared by this subteam as discussed further below.

This document is structured similarly to the 5-Year Review (Service 2008) for this subspecies. Certain sections have been selected, Section 2.3 Updated Information and Current Species Status (Behavior, Metapopulation Structure, Reproduction and Survivorship, Trends in Distribution, and Trends in Abundance and Population) and 2.3.2 Five Factor Analysis (Disease or Predation and Other Natural or Manmade Factors Affecting Its Continued Existence), where new information has been provided. While new information is provided under these various sections, the primary focus of this document is the new information provided under the Trends in Distribution, Trends in Abundance and Population, and Disease or Predation sections.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

Behavior

Segregation

Sexual segregation by SNBS was studied during the winter of 2005-2006 (Schroeder *et al.* 2010). Females foraged in larger groups and closer to escape habitat than males. Males used areas of higher vegetation biomass in less open areas than females. Males were more efficient in foraging in larger groups, while females were more efficient closer to escape habitat. Males traveled farther each day and in more open terrain than females. The two sexes differed in their dietary niches. Management and conservation plans should consider the disparate requirements of each sex of SNBS (Schroeder *et al.* 2010).

Migration

A study by Spitz *et al.* (2018) found SNBS are partially migratory as not all animals migrate every year. The animals showed flexible migratory behavior in terms of timing and duration of movements and whether they were resident or migrants with individuals switching between different years. The timing of the fall migration to lower elevations was more variable than spring migration to higher elevations.

Pine Creek Recreation Monitoring

A study was initiated by CDFW in Pine Creek Canyon in October of 2014 to determine if the increases in recreational use by hikers, sightseers, and especially rock climbers were having detectable impacts on SNBS lambing habitat used by Wheeler Ridge ewes (Greene *et al.* 2016). Three infrared trail counters were installed at three climbing trailheads (Barf Canyon, Lamb Canyon, Palisades School of Mountaineering slabs). These sites were chosen because they experience high use in proximity to parturition and lambing sites. In April and May (lambing period) of 2015, these sites were visited more than 500 times per month. Recreationists and SNBS overlapped during the winter of 2014-2015 in Pine Creek, but this may have been a result of the drought conditions allowing above average human use of the area. Continuing to collect this data will provide better understanding of any inter annual variation of overlap between SNBS and recreationists as well as a baseline for determining if increased recreation causes SNBS to shift their use of habitat in the future.

Metapopulation and Structure

Genetics Fecal Sampling

In the late 1990s, extracting and freezing SNBS DNA obtained from their droppings, dried tissue from old skulls, and later blood from sheep captured for radio-collaring began (Sierra Nevada Bighorn Sheep Foundation 2013). An important genetic variable is heterozygosity, which is a

measure of genetic diversity at the individual and population levels; it reflects inbreeding levels. Sierra Nevada bighorn sheep have the lowest genetic diversity of all non-captive populations of bighorn sheep sampled. The genetic diversity is not so low as to preclude demographic recovery of SNBS; however, this low diversity causes concern (Sierra Nevada Bighorn Sheep Foundation 2013). As a result, CDFW's Sierra Nevada Bighorn Sheep Recovery Program began (with the 2013 Olancho Peak translocations) and continues to use genetic sampling to assist in determining which individuals with high heterozygosity should be used in translocations.

Genetics

Johnson *et al.* (2011) studied the genetic variation within SNBS, tested whether inbreeding depression affected vital rates and if inbreeding depression limited recovery, and examined the potential for genetic management to increase population growth rates. The results of their study indicate that genetic variation in four populations (Wheeler, Baxter, Langley, and Mono Basin) of SNBS was among the lowest reported for any wild bighorn sheep population, and that inbreeding depression has reduced adult female fecundity. However, the results of their models indicate that inbreeding depression would not substantially inhibit the recovery of SNBS populations in the next approximately 8 bighorn sheep generations (*i.e.*, 48 years). Furthermore, simulations of genetic rescue within the subspecies did not suggest that such activities would appreciably increase population sizes or growth rates during the period modeled (10 bighorn sheep generations, 60 years). Only simulations that augmented the Mono Basin population with genetic variation from other subspecies, which is not currently a management option, predicted significant increases in population size.

Translocation Plan

In 2015, the CDFW finalized a translocation plan for SNBS (entitled, 2015 Translocation Plan for Sierra Nevada Bighorn Sheep: A Focus on Strategic Planning) (Few *et al.* 2015). This translocation plan addressed the need to translocate SNBS to reoccupy historical habitat and to ensure the persistence of this subspecies. Translocations for the next 10 to 20 years are presented in 2 phases. Phase 1 of the translocation plan will ensure the long-term viability of the herds and recovery units and that the recovery criteria are met. Phase 2 of the translocation plan will increase the connectivity within and among recovery units. Future translocations will take into consideration disease risk, genetic diversity, as well as historical information regarding sightings and habitat use/availability. The CDFW is authorized to capture and relocate SNBS, among other activities, under a section 10(a)(1)(A) permit issued by the Service.

Reproduction and Survivorship

Lamb Survival

There was a low lamb:ewe ratio in the Langley herd unit in 2017, and as a result there were no yearling females in 2018 (Sierra Nevada Bighorn Sheep Foundation 2018). Preliminary results from a research project (Forshee 2018) on the early days and months of SNBS lambs has shown that of the 125 lambs that were tracked throughout the range, 60 percent survived their first summer (Sierra Nevada Bighorn Sheep Foundation 2018). Forshee (2018) found the strongest

factor predicting lamb survival was the distance from steep rocky escape habitat that the mothers traveled during the first month. The ewes that traveled the furthest from escape cover were the ones most likely to lose their lambs to predation. Neonates become less vulnerable to predation as they age, were most vulnerable if born before the peak birth time in April, and if lactating ewes selected habitat farther away from escape cover (Forshee 2018). The predictive resource selection function models should assist managers in identifying habitat that is more likely to provide lambing needs for lactating SNBS ewes (Forshee 2018). Understanding the availability of high quality neonate rearing habitat will be important to the recovery of SNBS populations (Forshee 2018).

Trends in Distribution

The Recovery Plan (Service 2007) identified 16 herd units in areas historically occupied by SNBS, which were grouped into 4 recovery units based on natural breaks in habitat distribution. Occupation of 12 specific herd units out of the 16 is considered essential for recovery of the subspecies because habitat characteristics make these units the most likely areas where recovery will occur (Service 2007). These 12 essential herd units are: Laurel Creek, Big Arroyo (Kern Recovery Unit); Olancha Peak, Mount Langley, Mount Williamson, Mount Baxter, Sawmill Canyon, Taboose Creek (Southern Recovery Unit); Wheeler Ridge, Convict Creek (Central Recovery Unit); and Mount Warren, Mount Gibbs (Northern Recovery Unit).

A minimum of 305 yearling and adult females must be achieved throughout the 4 recovery units (50 in the Kern Recovery Unit, 155 in the Southern Recovery Unit, 50 in the Central Recovery Unit, and 50 in the Northern Recovery Unit) (Service 2007). Achieving these geographic and numeric measures need to occur before considering the downlisting of SNBS. Measures to prevent contact between domestic sheep/goats and SNBS also need to have been implemented and successful before considering the downlisting of this subspecies (Service 2007).

As indicated in the 5-Year Review (Service 2008), SNBS were distributed among the following 8 herd units in 2005: Mount Langley, Mount Williamson, Mount Baxter, Bubbs Creek, Sawmill Canyon, Wheeler Ridge, Mount Gibbs, and Mount Warren. All of these herd units are considered essential for SNBS recovery, except for Bubbs Creek.

Between 2005 and 2016, natural expansions, multiple reintroductions, and augmentations occurred throughout the 4 recovery units to improve the distribution of SNBS across the Sierra Nevada. Through natural range expansion, Convict Creek herd unit was discovered to have become occupied in 2008 (Sierra Nevada Bighorn Sheep Foundation 2017). The first SNBS reintroduction to occur in 25 years occurred in 2013 when 10 uncollared, pregnant females from the Sawmill Canyon herd unit and 5 collared rams (with high heterozygosity) from various herd units were reintroduced to the Olancha Peak herd unit (Sierra Nevada Bighorn Sheep Foundation 2013). In 2014, 10 ewes and 4 rams were translocated to the west side of the Kern River to occupy the Big Arroyo herd unit (Sierra Nevada Bighorn Sheep Foundation 2014). In 2015, 11 SNBS were reintroduced to the Laurel Creek herd unit (Greene *et al.* 2016) and 5 ewes were translocated to Alger Creek drainage to establish a new deme in the southern portion of the Mount Gibbs herd unit, expanding this herd unit's range (Greene *et al.* 2016). The resulting ewe movements also demonstrated the variability of movements by these animals after being

translocated to a new area (Greene *et al.* 2016). Additionally in 2015, the natural colonization of the Taboose herd unit was confirmed; in 2015, 2 ewes were caught and collared and will assist in determining habitat use (Sierra Nevada Bighorn Sheep Foundation 2015).

In 2015, CDFW requested support from the Service for reintroducing SNBS into Yosemite National Park's Cathedral Range and establishing it as a new herd unit (T. Stephenson, CDFW, *in litt.* 2015). Though this area was not identified in the Recovery Plan (Service 2007), the Northern Recovery Unit needs an additional herd unit to meet recovery criteria as indicated in the Recovery Plan. The science subteam of the RIT supported this effort. Historical detections of SNBS, excellent summer range, and separation from domestic sheep suggest that SNBS would do well in this area. This area also has the potential for connectivity with the Mount Gibbs herd unit, which could provide genetic exchange. The Service supported this reintroduction effort (A. Pitts, U.S. Fish and Wildlife Service, *in litt.* 2015). Subsequently, in 2015, 10 ewes and 3 rams were reintroduced into Yosemite National Park's Cathedral Range to create the Cathedral Range herd unit (Runcie *et al.* 2015, Sierra Nevada Bighorn Sheep Foundation 2017). Additionally, CDFW suggested future SNBS reintroductions to the Black Divide in Sequoia and Kings Canyon National Parks (T. Stephenson, CDFW, *in litt.* 2015). This area also was not identified as a herd unit in the Recovery Plan (Service 2007). The area has excellent habitat (a large contiguous area of predicted winter range west of the Sierra Nevada crest and abundant alpine summer habitat) (Few *et al.* 2015) as well as separation from domestic sheep. Although neither the Cathedral Range nor Black Divide herd units were mentioned in the Recovery Plan (Service 2007), the Service supports the conservation effort and will appropriately evaluate SNBS occupancy of the possible total 18 herd units when downlisting is considered in the future.

In 2015, occupation of the 12 essential herd units met the geographic distribution needed as a recovery requirement as indicated in the Recovery Plan (Service 2007), but the specific numeric goals for each of the 4 recovery units was not met (Greene *et al.* 2016; Sierra Nevada Bighorn Sheep Foundation 2016). By 2016, SNBS occurred in 14 herd units (Greene *et al.* 2016). The specific numeric goals were not met for all of the four recovery units; however, in 2016, specific numeric goals had been met for the Southern and Central Recovery Units (Greene *et al.* 2016). Bubbs Creek and Cathedral Range herd units, while not essential for recovery, contain a number of SNBS and assist in increasing SNBS numbers and distribution throughout their range.

Even with the severe winter conditions of 2016-2017, SNBS continue to occur in 14 herd units; these included Mount Warren, Mount Gibbs, Cathedral Range, Convict Creek, Wheeler Ridge, Taboose Creek, Sawmill Canyon, Mount Baxter, Bubbs Creek, Mount Williamson, Big Arroyo, Laurel Creek, Mount Langley, and Olancho Peak (Greene *et al.* 2017).

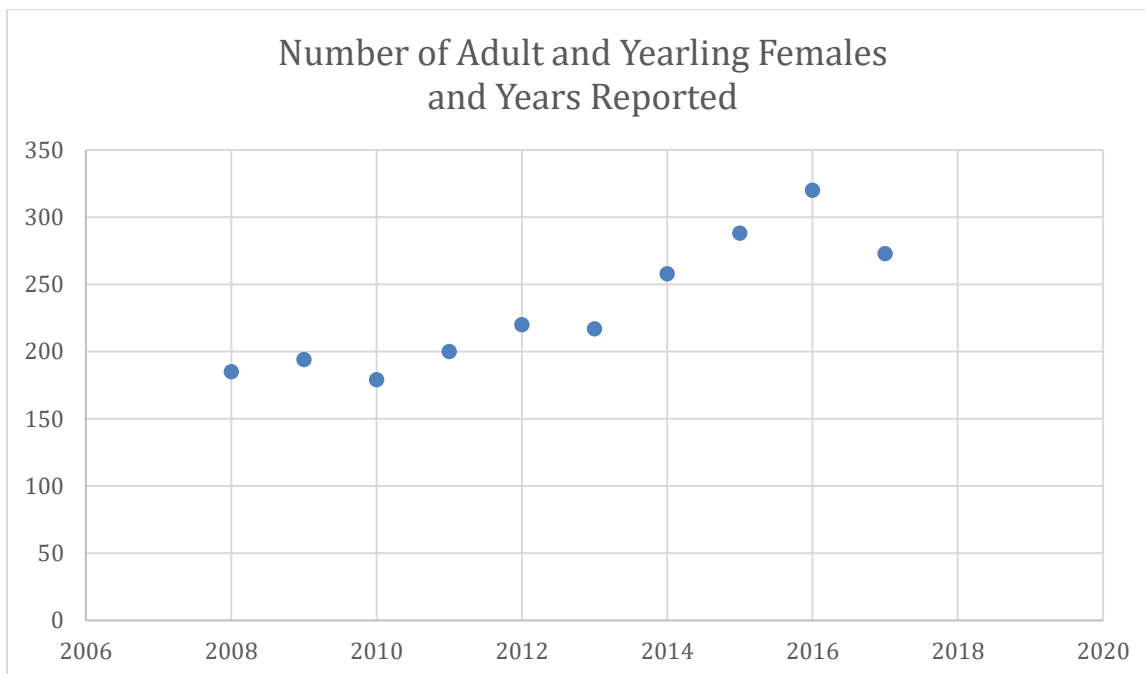
Trends in Abundance and Population

The 5-Year Review (Service 2008) reported a 2006-2007 (July 2006-June 2007) conservative minimum estimated total SNBS population size as over 400 individuals (Wehausen *et al.* 2007). Since then, the estimated SNBS population has grown considerably throughout its range. Estimated population sizes have been reported over subsequent years as a subset defined by adult and yearling females or as a total population size. Maintaining collars on 30 to 35 percent of SNBS females within each herd unit assists in conducting accurate population surveys,

monitoring reproductive success, and identifying mortality (Greene *et al.* 2016). While the focus of this effort is on females as they drive population dynamics, some males are also collared to monitor disease risk and genetics; the data collected assists in understanding habitat selection, seasonal migration, home range use, and survival (Greene *et al.* 2016). The following information provides yearly estimates for SNBS by one or both of these two measures from 2008-2018.

Between 2008 and 2014, the SNBS population demonstrated minor fluctuations between particular years but an overall increase in females (adults and yearlings) was reported throughout the range (Table 1). These female population numbers included 185 adult and yearling females reported by Wehausen *et al.* (2008); 194 adult and yearling females (with a total population close to 400) reported by Wehausen *et al.* (2009); 179 adult and yearling ewes reported by Wehausen *et al.* (2010); about 200 females reported by Stephenson *et al.* (2011); at least 220 and 217 females reported by Few *et al.* (2012, 2013), respectively; and at least 258 females reported by Runcie *et al.* (2014).

Table 1. Number of Adult and Yearling Females during the Years Reported (2008-2017) Throughout the Range of the Sierra Nevada Bighorn Sheep.



In 2015, it was estimated that at least 288 adult and yearling SNBS ewes inhabited the Sierra Nevada with a total population size of over 600 (Few *et al.* 2015) (Table 1). The SNBS population continued to increase during the 2015-2016 year (Greene *et al.* 2016) (Table 1). While rams were also counted during ground surveys, the focus was on females as they have a greater influence on population trajectories (Greene *et al.* 2016). The number of adult and yearling females was estimated at 320 among 14 herds (Greene *et al.* 2016). While this number surpassed the downlisting goal of 305 females and occurred in the required herd units, work is

still needed to reach the more specific numeric goals for each of the 4 recovery units to meet the downlisting distribution requirements as discussed in the Recovery Plan (Service 2007). The total SNBS population in 2016 was estimated at 667 (320 yearlings and adults ewes; 107 lambs; and 240 rams based on a ram:ewe ratio of 0.75) (Greene *et al.* 2016).

In 2017, the total SNBS population size was estimated at 675 (317 yearling and adult ewes; 120 lambs; and 238 rams based on a ram:ewe ratio of 0.75) (Greene *et al.* 2017). However, this number does not include the impacts of the winter (Greene *et al.* 2017). The winter of 2016-2017 produced record snowfall surpassing the winter of 1969 (Sierra Nevada Bighorn Sheep Foundation 2017). It was the second wettest year on record for the Sierra Nevada; some areas received more than 600 inches of snow (Greene *et al.* 2017). With the severe winter conditions of 2016-2017, it was estimated that adult and yearling ewes totaled 273 (Greene *et al.* 2017) (Table 1). The CDFW estimated that a little more than 100 females died (about 30 percent of the known female population). However, the end-of-year counts, which included recruitment, indicated a net loss of 56 ewes (Greene *et al.* 2017). Most female mortalities were related to the severe winter conditions (*e.g.*, avalanches, malnutrition) but 17 deaths were due to mountain lions. Nine uncollared and 48 collared ram mortalities were also documented during this period (Greene *et al.* 2017). Collared rams died from unknown causes, avalanches, malnutrition, mountain lion and bobcat predation, and rock falls. There were also 10 mortalities of unknown sex from mountain lion predation and unknown causes. These mortalities resulted in the greatest loss of individuals and loss rangewide ever documented in a single year (Greene *et al.* 2017). Specific mortality data is likely to be biased to include more low elevation events because they are easier to access and investigate (Greene *et al.* 2017). Additionally, the Mount Langley herd experienced high levels of predation in 2017 by mountain lions (*Puma concolor*) (Sierra Nevada Bighorn sheep Foundation 2017). The Mount Langley herd has been serving as a source herd for translocations; the decline in this herd may preclude its use as a source herd for some years in the future (Sierra Nevada Bighorn Sheep Foundation 2017). While the 2016-2017 year ended a 19-year increasing trend for estimated SNBS population numbers, it is thought the total estimated SNBS population in 2018 was above 600 animals (Sierra Nevada Bighorn Sheep Foundation 2018).

Table 2 provides a reconstructed range of abundance for SNBS during 2006-2016 by herd unit (Greene *et al.* 2016, Appendix B).

Table 2. Reconstructed Sierra Nevada Bighorn Sheep Range of Abundance for 2006-2016 by Herd Unit (Greene *et al.* 2016, Appendix B).

Herd Unit	Year	Minimum Ewes	Lambs	Minimum Rams	Minimum Total
Olancha Peak	2012-2016	10-16	0-8	3-8	14-29
Laurel Creek	2014-2016	7	0	4	11-12
Big Arroyo	2013-2016	9-10	0-5	4-5	14-18
Mt. Langley	2006-2016	33-48	8-27	19-67	67-128
Mt. Williamson	2007-2016	8-14	2-7	4-10	16-28
Bubbs Creek	2006-2016	9-17	1-9	5-12	0-28
Mt. Baxter	2007-2016	30-46	13-34	13-41	57-117
Sawmill Canyon	2007-2016	12-45	4-17	5-19	21-75
Wheeler Ridge	2006-2016	34-58	11-20	22-39	71-114
Taboose Cree	2014-2016	3	0	17	20
Convict Creek	2011-2016	4-14	2-8	1-12	8-34
Cathedral Range	2014-2016	10	0-2	2-3	13-14
Mt. Gibbs	2006-2016	4-22	1-10	1-14	9-46
Mt. Warren	2006-2016	9-21	4-12	7-13	23-40
Grand Minimum Total Range					344-703

Mortality

During 2006-2015, the cause of death for 50 percent of collared animal mortalities (male and female across the various herd units) was determined; avalanche deaths varied from 0 to 38 percent during the winter of 2010, predation varied from 6 to 61 percent, mountain lions were responsible for 94 percent of predation mortality, 4 percent of predation by bobcat, and 2 percent of predation by coyote (Greene *et al.* 2016). Some types of mortalities can be easier to detect and access; it is unlikely the unknown mortalities are well represented by the known mortalities, and determining cause of death continues to be a high priority (Greene *et al.* 2016). As stated earlier, specific mortality data is likely to be biased to include more low elevation events because they are easier to access and investigate (Greene *et al.* 2017).

2.3.2 Five Factor Analysis (Disease or Predation, Other Natural or Manmade Factors Affecting its Continued Existence)

Disease or Predation

Disease

In 2006, during a Sierra Nevada Bighorn Sheep Recovery Team meeting, a decision was made to redevelop the disease risk assessment portion of Appendix B of the Draft Final Recovery Plan

for the Sierra Nevada Bighorn Sheep (*Ovis canadensis californiana*) (Service 2006). To avoid delaying completion of a final recovery plan, this portion of Appendix B was removed from the final Recovery Plan (Service 2007) and a new disease risk assessment was to be prepared. The Recovery Team assigned a subgroup representing the Recovery Team to develop a technique for assessing the risk of disease transmission between domestic sheep and goats and SNBS. Subgroup representatives included land managing agencies, wildlife management agencies, domestic sheep producers, environmental organizations, and members of the Recovery Team's science subteam. A document entitled, *A Process for Identifying and Managing Risk of Contact between Sierra Nevada Bighorn Sheep and Domestic Sheep*, was prepared in early 2009 (Risk Assessment; Baumer *et al.* 2009).

In February of 2009, a meeting was held among land managing agencies (Forest Service (FS), BLM), CDFW, and the Service, to discuss the above mentioned document. Land managers requested further assistance interpreting and applying the Risk Assessment, which would provide consistency in applying the document among the various agencies and jurisdictions. In April 2009, a document entitled, *Application of the Document Entitled A Process for Identifying and Managing Risk of Contact between Sierra Nevada Bighorn Sheep and Domestic Sheep*, was prepared (Croft *et al.* 2009). A revision of this second document occurred in 2010 (Croft *et al.* 2010).

These documents have been used by land managing agencies to assist in determining the risk of contact between SNBS and domestic livestock (sheep and goats) on allotments. As a result, several domestic sheep grazing allotments near SNBS use areas are categorized as voluntary non-use status or resource protection non-use status by BLM or the FS, respectively. Additional information regarding management actions and disease transmission by other types of livestock (*e.g.*, cattle, goats, llamas) are also included in these documents. The RIT (core team) is working on revising these two documents based on updated model inputs from SNBS data collected since 2009.

In addition, two research articles have been published specific to SNBS disease risk and recovery. Clifford *et al.* (2009) constructed a model assessing how different grazing management strategies affect the risk of respiratory disease transmission from domestic sheep to SNBS and predicting population-level impacts of a disease outbreak. When grazing management strategies reduced the risk of contact between domestic sheep and SNBS to less than 2 percent each year, a 50 percent probability of a catastrophic respiratory outbreak during the next 10 SNBS generations was predicted by the model. If an outbreak occurred in the near future, the model predicted the smallest SNBS population would have a 33 percent probability of quasi-extinction. To eliminate all risk of contact and potential disease transmission, domestic sheep cannot be grazed on allotments that overlap with areas utilized by SNBS. Difficult decisions will need to be made where conflicts exist (Clifford *et al.* 2009).

Cahn *et al.* (2011) evaluated the potential impact of disease on the probability of achieving specific population size and persistence goals, as outlined in the SNBS Recovery Plan. They also sought to heuristically evaluate the efficacy of management strategies aimed at reducing disease risk to or impact on modeled bighorn populations. Through modeling efforts they found that results from the projection model indicated that management strategies need to be population

specific. The population with the highest growth rate was more robust to the effects of disease. By contrast, the population with the lowest growth rate would require management intervention beyond disease management alone, and the population with a moderate growth rate would require management sufficient to prevent severe disease outbreaks. Because severe outbreaks increased adult mortality, disease can directly reduce the probability of achieving recovery plan goals. Although mild disease outbreaks had minimal direct effects on the populations, they reduced recruitment and the number of individuals available for translocation to other populations, which can indirectly reduce the probability of achieving overall, rangewide minimum population size goals. Based on simulation results, reducing the probability of outbreak by continuing efforts to manage high-risk (*i.e.*, spatially close) allotments through restricted grazing regimes and stray management to ensure recovery was recommended. Managing bighorn and domestic sheep for geographic separation until SNBS achieve recovery objectives would enhance the likelihood of population recovery.

A number of other journal articles have been published since the 5-Year Review (Service 2008) and further indicate/demonstrate that disease (*i.e.*, primarily pneumonia) and its presence within a bighorn sheep herd whether transmitted to bighorn sheep from domestic livestock (primarily domestic sheep) or not remains a serious concern and can be devastating to bighorn sheep populations for years; managing this issue continues to be very difficult regardless of bighorn sheep species (George *et al.* 2008, Cassaigne *et al.* 2010, Lawrence *et al.* 2010, Wehausen *et al.* 2011, Cassirer *et al.* 2013, Besser *et al.* 2014).

Since the 5-Year Review (Service 2008), additional activities have assisted in reducing the risk of disease transmission between domestic sheep and SNBS. In 2016, CDFW acquired approximately 2,000 acres of property to create the Green Creek Wildlife Area (Greene *et al.* 2016). This area was historically grazed by domestic sheep, but CDFW discontinued this type of use on the property, reducing the potential risk of disease transmission. Adjacent Federal public land allotments no longer allow domestic sheep grazing to support SNBS recovery in this area. The Humboldt-Toiyabe National Forest is conducting a review of four Federal allotments, formerly grazed by domestic sheep, to determine if these allotments are appropriate for grazing by cattle.

In 2017, the grazing lease for Conway and Mattly Ranches, allotments administered by Mono County and located near Lundy Canyon and the Mount Warren herd unit, came up for renewal. Augmentation to this SNBS herd unit were discontinued in 2009 due to the close proximity of SNBS to the allotments (Greene *et al.* 2017). After careful consideration of the risks of domestic sheep grazing to the SNBS in this herd unit, the Mono County Board of Supervisors decided not to renew the lease. This decision assists with further reducing the risk of disease transmission between domestic sheep and SNBS. In addition, future augmentations to the Mount Warren herd unit may resume due to this decision.

Continued concern exists with livestock grazing on Los Angeles Department of Water and Power property located in Little Round Valley, hobby farms at the mouth of McGee Canyon in the Pine Creek area, and near Carroll Creek (Greene *et al.* 2016).

In July 2018, the Inyo National Forest signed an order (Inyo National Forest Order No. 05-04-50-18-05 Goat Prohibition) to prohibit the possession or storage of goats on the Inyo National Forest west of U.S. Highway 395 to protect the SNBS (T. Randall-Parker, FS, *in litt.* 2018). Contact between goats, including pack goats, and SNBS could result in disease transmission to SNBS and the possibility that an epizootic could occur within the SNBS herd. While goat grazing is not authorized within the Inyo National Forest's livestock grazing allotments, recreational pack goat use is allowed on the Inyo National Forest. It is believed that actual use is quite low.

Predation

In 2013, a draft Predation Plan was prepared but never finalized. The RIT science subteam continues to work on developing a predator management plan to address predation threats to SNBS. The appropriate management of mountain lions within the range of SNBS has become more urgent as 2016-2017 saw a substantial increase in the number of SNBS killed by mountain lions. One needs to manage predation of SNBS to a sustainable level. This can be achieved by determining allowable mountain lion predation limits, monitoring population sizes of both SNBS and mountain lions as well as predation events, and proactively managing mountain lions if allowable mountain lion predation limits are reached. The CDFW has authority under Fish and Game Code Section 4801 to remove or take a mountain lion that the CDFW perceives to be an imminent threat to threatened, endangered, candidate, or fully protected sheep species (Greene *et al.* 2017).

During 1999 and 2010, 22 mountain lions were removed that were preying on SNBS (Greene *et al.* 2017). Mountain lion predation of SNBS was comparatively minimal between 2011 and 2016 and no mountain lions were removed (Greene *et al.* 2017). In the 2015-2016 year, there was a notable increase in the number of SNBS killed by mountain lions as they killed males and females in seven herd units at higher numbers than had been seen since 2010 (Greene *et al.* 2016). In 2016, CDFW resumed monitoring of mountain lions in the Southern Recovery Unit (but due to lack of resources precluded a complete count in this unit) and determined that their numbers had increased compared to previous years (Greene *et al.* 2017). Eleven unique mountain lions were documented with many photographs of unmarked mountain lions that could not be distinguished from others due to the inability to determine their sex (Greene *et al.* 2017).

Greene *et al.* (2017) reported as of May 2017, that there were 118 overwinter mortalities in 2016-2017 mostly caused by avalanche or malnutrition due to heavy snow. Of these 118 SNBS mortalities, 25 were caused by mountain lions. More specifically, 2 to 3 adult mountain lions killed 18 SNBS (including 13 females) in the Langley herd unit. Prior to 2017, the Mount Langley herd unit had 51 female SNBS and was a source herd for translocations. However, this high level of predation on this herd will result in delay to future reintroductions necessary for achieving recovery goals (Greene *et al.* 2017). In April 2017, two mountain lions (one male, one female) were lethally removed in Langley herd unit. After these removals, one more SNBS was killed in late April, 2017 (Greene *et al.* 2017).

Johnson *et al.* (2013) used location, demographic, and habitat data to assess whether mountain lion predation on SNBS was a consequence of their winter range overlap with mule deer. Sierra

Nevada bighorn sheep populations with greater spatial overlap with deer experienced higher rates of mountain lion predation; this is consistent with apparent competition hypothesis (Johnson *et al.* 2013). Sierra Nevada bighorn sheep killed by mountain lions were located primarily on deer winter ranges, though those areas were only a portion of the SNBS winter ranges. Johnson *et al.* (2013) thought the variation in sympatry between SNBS and deer populations was driven largely by differences in habitat selection among the SNBS herds. Although this competition may limit some SNBS populations, it is not the primary factor limiting all populations; this suggests that the dynamics of different herds are highly distinctive.

Other Natural or Manmade Factors Affecting Its Continued Existence

Fires

The Seven Oaks Fire, which occurred in July 2007, provided the first opportunity to evaluate the effects of wildfire on SNBS winter range (Greene *et al.* 2012). Short-term vegetation changes were studied for 2 years following the fire. Forbs dominated burned areas. Green forage (new growth of all forage classes) biomass became equal between burned and unburned areas within 2 years of the burn, although total forage biomass remained greater in unburned areas. Plants in the burn area had slightly higher crude protein but equivalent digestibility and phenology as plants in the unburned areas, and with a shift toward more forb biomass, forage quality likely increased in burned areas. Visibility was greater in burned areas versus unburned areas possibly decreasing predation risk. Wildfire may have benefits for SNBS by increasing forb availability, forage quality, and visibility (Greene *et al.* 2012).

The Horseshoe Fire occurred in 2016 on the Inyo National Forest and was ignited by lightning. This fire burned in designated critical habitat. The area had some conifer cover burn; it was estimated that 200 acres were made suitable for SNBS (B. Gyant, FS, *in litt.* 2018).

The Georges Fire began due to lightening on July 8, 2018, on the Inyo National Forest in Inyo County, California (Cal Fire website accessed March 12, 2019). This fire eventually burned approximately 2,880 acres. This area was in steep, inaccessible terrain. According to B. Gyant *in litt.* (2018), about 1,600 acres of unsuitable SNBS habitat was burned. This area was unsuitable because of heavy conifer cover. As a result of the fire, openings between escape terrain and winter foraging area were created.

Conclusion:

Since the 5-Year Review was prepared for SNBS in 2008, our understanding of various aspects of this subspecies' life history has improved through research. Continued monitoring of SNBS across its range has resulted in documented, significant increases in distribution and population numbers. By 2018, SNBS distribution has improved and has reached the geographic goal of inhabiting the 12 essential herd units as selected in the Recovery Plan (Service 2007). In addition, two nonessential herd units were occupied, surpassing the recovery goal. The estimated total population size was above 600; however, the numeric goals for SNBS females across each of the 4 recovery units have not yet been achieved, thus not meeting the numeric established in the Recovery Plan (Service 2007). The severe winter of 2017, as well as mountain lion predation,

have both had an impact and have reduced ewe (and ram) numbers. Some herds have provided source animals for translocation efforts in the past. A reduction in numbers for these herds may result in translocation delays for several years to come.

Substantial progress has occurred with regards to other recovery actions. Progress includes completion of a translocation plan (Few *et al.* 2015); preparation of disease risk assessments (Baumer *et al.* 2009, Croft *et al.* 2009, Croft *et al.* 2010) (though these need to be updated); reduction of the threat of disease transmission from domestic livestock to SNBS in particular locations; and a Predator Management Plan, which is being drafted as of the date of this document. While progress has occurred in these areas, the Service continues to consider the issues of disease transmission and SNBS management and mountain lion predation and management as serious concerns to SNBS recovery.

We conclude that the SNBS continues to require the protections of the ESA under its current classification of endangered. While important, significant steps toward recovery have been made, small population size, fragmented distribution of subpopulations, and the continued threat of disease transmission from domestic sheep and predation require the continuation of the ESA's protections.

After reviewing the best available scientific information, we conclude that the Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*) remains an endangered species. The evaluation of threats affecting the species under the factors in 4(a)(1) of the ESA and analysis of the status of the species in our Sierra Nevada Bighorn Sheep *Ovis canadensis californiana* (= *Ovis canadensis sierrae*) 5-Year Review: Summary and Evaluation (Service 2008) remains an accurate reflection of the species current status.

RECOMMENDATIONS FOR FUTURE ACTIONS:

1. The Service will continue to work with the CDFW, the Humboldt-Toiyabe and Inyo National Forests, Yosemite and Sequoia and Kings Canyon National Parks and the BLM (Bishop Field Office) to update and implement the Risk Assessment documents.
2. We support CDFW's efforts to address predation concerns and the need to selectively remove mountain lions from SNBS range.
3. We support the RIT science subteam's effort to complete the predator management plan.
4. We support CDFW's continued translocation efforts to augment smaller subpopulations and to establish new populations in unoccupied habitat that is necessary for recovery.
5. We continue to support the National Forests and BLM in efforts to restrict domestic sheep and goat grazing near SNBS habitat.
6. We continue to support the National Forests and BLM in performing controlled burning and other habitat improvement projects on winter ranges for the SNBS.

7. We support CDFW's continued research on potential threats to SNBS related to human-recreation disturbance, wildfire impacts on habitat quality, and use of low-elevation winter range.

Acting Field Supervisor, Fish and Wildlife Service

Approve *Lee Anne Coy* Date 9-27-19

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