2012-2013 Annual Report
of the Sierra Nevada Bighorn Sheep Recovery Program

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Summary of Progress

This report documents conservation and monitoring activities carried out between May 1 2012 and April 30 2013 by the California Department of Fish and Wildlife's (CDFW's) Sierra Nevada Bighorn Sheep Recovery Program (the Recovery Program). The Recovery Program is charged with restoring state- and federally-endangered Sierra Nevada bighorn sheep (Sierra bighorn) in accordance with the delisting goals specified in the Recovery Plan (USFWS 2007). These goals recommend the occupation of 12 herd units with a total of 305 females. The Recovery Program regularly monitors bighorn distribution, abundance, and demographic rates. Our efforts also include habitat enhancement, monitoring for causes of mortality and the presence of disease, captures to deploy radio collars, and translocations to restore populations to historic ranges and to augment existing herds.

At the end of the 2012 survey season we estimate that the Sierra bighorn population comprised at least 217 females in 10 herd units, including a newly-reintroduced population at Olancha Peak. If the trends observed over the last decade continue, Sierra bighorn may reach recovery goals within a decade.

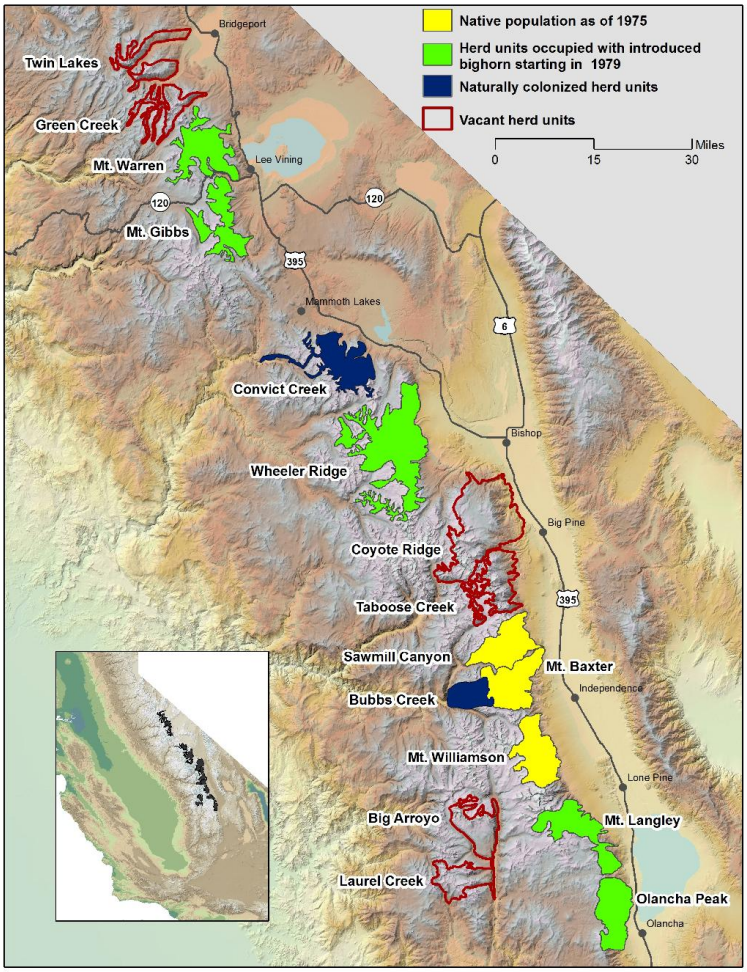

Figure 1. Locations of 16 historic herds of Sierra bighorn. All occupied herd units (filled polygons) are listed in recovery goals except Bubbs Creek. One herd unit, Olancha Peak, was reoccupied with translocated bighorn during this reporting period. Three vacant herd units (Laurel Creek, Big Arroyo, and Taboose Creek) must be occupied in order for Sierra bighorn to be delisted.

Conservation Activities

Translocations

In March 2013 we carried out the first reintroduction of Sierra bighorn to a vacant herd unit in 25 years, establishing a founding population of 10 ewes and 4 rams at Olancha Peak. All 10 translocated ewes were pregnant and came from the Sawmill Canyon herd unit. The 4 rams were previously-collared animals chosen because genetic analysis revealed that they had high heterozygosity values, indicating high levels of genetic diversity. Two of the rams were from Mt. Langley and 2 were from Sawmill Canyon. Sierra bighorn were captured via helicopter net-gun, assessed and radio-collared at a processing site, and transported by truck to the Falls Creek drainage of the Olancha Peak herd unit, where they were released.

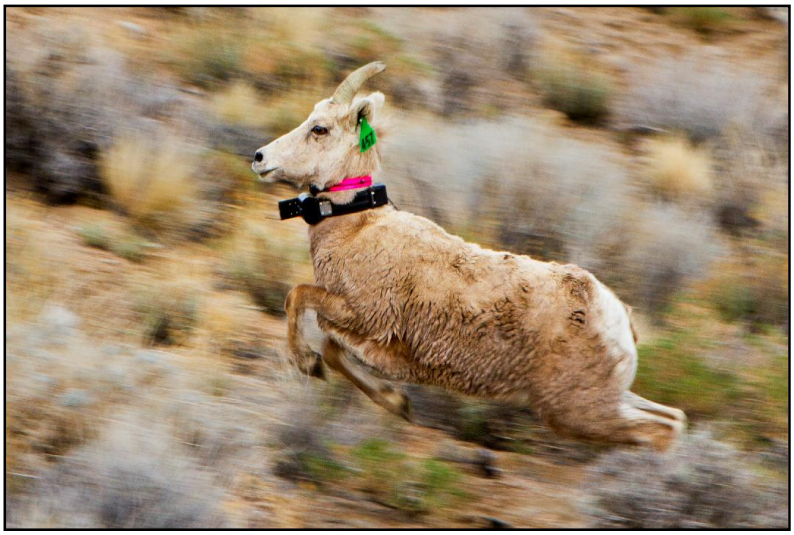

Figure 2. Ewe S274 is released at Falls Creek.

In addition, 6 collared ewes from Mt. Langley with high levels of genetic diversity were recaptured for translocation to the Mt. Gibbs and Convict Creek herd units. The Mt. Gibbs herd, which declined to a reproductive base of just 1 female in the mid-1990s, has historically suffered from the lowest level of genetic diversity known in the Sierra. This low genetic diversity may be a factor in the continued small size of this herd and its limited reproductive success. The 3 collared ewes were added to the population in an effort to boost its genetic diversity and test this hypothesis. The Convict Creek herd was colonized by a small number of females from Wheeler Ridge; only 3 ewes were identified genetically when this herd was first documented in 2009. We expect that the translocation of 3 collared ewes will add to the genetic diversity of this small population and aid in population monitoring.

The translocation efforts were carried out in collaboration with the Inyo National Forest, Yosemite National Park, Sequoia and Kings Canyon National Parks, and the Sierra Nevada Bighorn Sheep Foundation. A large number of volunteers from other agencies and organizations participated in the event.

Habitat Enhancement

No habitat enhancement projects took place during this reporting period.

Disease Management

Severe respiratory disease in bighorn can result from nose-to-nose contact with domestic sheep, whose normal respiratory tract flora can cause devastating pneumonia

in bighorn (Lawrence et al. 2010; Wehausen et al. 2011). Domestic sheep grazing near bighorn habitat greatly increases the risk of a disease outbreak among Sierra bighorn, threatening recovery of the subspecies.

In November 2012, Recovery Program leader Tom Stephenson met with the Mono County Board of Supervisors to discuss options to minimize the risk of disease transmission from permitted domestic sheep grazing allotments at Conway Ranch and Mattly Ranch. The options under discussion ranged from removing domestic sheep from Conway Ranch entirely to installing a 10-foot double fence around domestic sheep grazing areas on the ranch. No decisions were reached.

In April 2013 the BLM completed an environmental review analyzing the impacts of 4 alternatives for 2 domestic sheep grazing allotments. These allotments, Dog Creek and Green Creek, are situated between the towns of Lee Vining and Bridgeport at the northern edge of the range of Sierra bighorn. The alternatives under consideration were a modified grazing permit, no action, no grazing, and a crossing permit only. On April 18 2013 the Bishop Field Manager released a finding of no significant impact for Alternative 4, a crossing permit only. On April 23 2013 the BLM issued the operator a temporary crossing permit for the allotments (Lovato 2013). The BLM will regularly carry out compliance monitoring to ensure that no increase in the risk of contact between domestic sheep and Sierra bighorn is incurred.

Predator Management

No predator management occurred during this reporting period.

Sierra Bighorn Population Monitoring

Herd Unit Surveys

Annual ground surveys of Sierra bighorn herds are an important tool used to measure progress toward recovery goals and to evaluate which herds are suitable for use as translocation stock. During these surveys we collect demographic data in an effort to track population trends. We follow 2 different approaches to obtain useful data: minimum counts, which rely on radio telemetry and prior knowledge of habitat use to find bighorn in all areas where they are likely to occur, and mark-resight estimates, which extrapolate the total number of animals in the population from the ratio of collared to uncollared animals seen in an unbiased ground survey. We focus our counts on adult females and associated lambs and yearlings, since this segment of the population is most likely to drive population growth.

Due to variation in behavior and habitat use between herd units, we survey different herds at different times of year. Winter surveys tend to be more successful at the Mt. Baxter and Wheeler Ridge herds, while summer surveys typically produce better counts of the Mt. Langley, Bubbs Creek, Sawmill Canyon, Convict Creek, Mt. Gibbs, and Mt.

Warren herds. We have attempted surveys of the Mt. Williamson herd both in winter and in summer with inconsistent results. Survey results are summarized in Table 1.

Olancha Peak

The Olancha Peak herd unit was established in March 2013, near the end of this reporting period, with 10 pregnant adult ewes and 4 adult rams. All animals were released wearing GPS collars.

Mt. Langley

We made 4 attempts to survey the Mt. Langley herd during the summer of 2012. The last attempt, during September 18-21, yielded the most successful minimum count: 40 adult ewes, 3 yearling ewes, 5 yearling rams, 26 lambs, 26 adult rams, and 3 unclassified animals. Five collared rams and 2 collared ewes (S86 and S92, both observed later in 2013) were not seen. Adding these collars to the count brings the total to 110 bighorn. Given that an earlier survey attempt (August 1-3) counted 5 yearling ewes and 27 lambs, we can assume these additional animals were still present in the population, bringing the total to 113 bighorn: 42 adult ewes, 5 yearling ewes, 5 yearling rams, 27 lambs, 31 adult rams, and 3 unclassified animals.

Six collared ewes were taken from this herd in March 2013 to augment the Convict Creek and Mt. Gibbs herds. One collared ewe died in February 2013.

Mt. Williamson

We did not attempt to survey the Mt. Williamson herd during this reporting period, instead focusing our limited resources on obtaining counts of herds for which we have more consistent long-term data.

Mt. Baxter

Three consecutive trips to the Mt. Baxter winter range on February 11, 12, and 13 2013 resulted in a minimum count of 98 bighorn: 26 adult ewes, 6 yearling ewes, 10 yearling rams, 23 lambs, and 33 adult rams. Two collared ewes (S162 and S50) were not seen during this period; S162 had been seen the previous week and was added to the minimum total, while S50 had not been seen in more than a year and was censored from the count. Given a count of 38 adult and yearling ewes in 2011, it is likely that the February 2013 total of 27 adult ewes was an undercount. Our data did not support the alternative hypothesis that this herd experienced high mortality of adult ewes and a low recruitment rate for yearling ewes during this period. The count of 16 male and female yearlings indicates high lamb survival for the 19 lambs counted in 2011.

Sawmill Canyon

We attempted 2 surveys of the Sawmill Canyon herd during this reporting period. Both surveys met with limited success. Bad weather hindered surveyors, and animals were scattered throughout their vast summer range, never congregating in the large groups that have historically allowed for successful counts.

The survey of July 10-13 2012 was the most successful, yielding a minimum count of 22 adult ewes (17 ewes seen and 5 collars not seen – S110, S126, S128, S201, and S206), 2 yearling ewes, 2 yearling rams, 8 lambs, and 5 adult rams (1 ram seen and 4 collars not seen). This is almost certainly a significant undercount of the total population, as 45 adult and yearling ewes were observed in 2011.

In March 2013, 10 uncollared pregnant ewes were taken from this herd for translocation to the Olancha Peak herd unit. Two collared ewes died in the winter of 2012 (S256, killed by coyotes, and S110, killed by a lion). Assuming that data from the 2011-2012 reporting period represents a more accurate minimum count, we can estimate that the Sawmill herd unit contained approximately 45 adult ewes at the end of the 2012 survey season and 33 adult ewes at the end of this reporting period.

Wheeler Ridge

We made 3 coordinated surveys of the Wheeler Ridge herd between December 2012 and April 2013. The most successful survey (April 3-5 2013) counted 25 adult ewes, 10 yearling ewes, 2 yearling rams, and 13 lambs. Four collared adult ewes (S62, S84, S142, and S144) and 2 collared lambs (S245 and S248) were not seen. Results from earlier surveys that winter can be incorporated to add in 2 yearling rams, 25 adult rams seen, and 7 collared adult rams not seen. Including the collars not seen brings the minimum total to 90 animals: 29 adult ewes, 10 yearling ewes, 4 yearling rams, 15 lambs, and 32 adult rams.

Bubbs Creek

We surveyed the Bubbs Creek herd during August 6-10 2012 and counted 5 adult ewes, 1 yearling ewe, 6 adult rams, 1 yearling ram, and 5 lambs. Three collared adult ewes (S168, S169, and S195) were not seen but were heard on the Bubbs Creek winter range west of Charlotte Dome. One collared ram was not seen. Adding these collars to the survey results brings the minimum count to 22 bighorn: 8 adult ewes, 1 yearling ewe, 1 yearling ram, 5 lambs, and 7 adult rams. One collared adult ewe, S195, died in the fall of 2012. Due to the difficult terrain in that area we were unable to investigate the mortality or determine the cause of death.

Convict Creek

The Convict Creek herd, thought to be the result of a natural colonization by ewes from Wheeler Ridge, has persisted in the Esha Canyon area. We surveyed this herd on July 24 2012 and observed 3 adult ewes, 1 yearling ewe, 1 2-year-old ram, and 3 lambs. Based on information gathered during the 2013 survey season, it is likely that the 2012 survey was a significant undercount of the total population of this herd.

Although we have yet to observe any resident mature adult rams in this population, reproduction has occurred annually. This suggests either that the 2-year-old ram is responsible for breeding the Convict Creek ewes, that rams from the nearby Wheeler

Ridge herd unit are traveling to the Convict Creek herd unit to breed these ewes during the rut, or that resident adult rams are using different habitat in the area and have thus far eluded survey crews.

In March 2013 we augmented this population with 3 collared adult ewes from the Mt. Langley herd in the expectation that these collared animals would improve the genetic diversity of this herd and help us to conduct more comprehensive monitoring.

Mt. Gibbs

In July 2012 surveyors counted 7 adult ewes, 1 yearling ewe, 2 yearling rams, 2 lambs, and 9 adult rams (3 adult rams seen and 6 collared adult rams not seen) for a total of 21 bighorn. Two collared rams died during the winter of 2012. In March 2013, 3 collared ewes from the Mt. Langley herd were added to the Mt. Gibbs herd in an effort to boost this population's genetic diversity and reproductive success.

Mt. Warren

On July 5 2012 our survey observed all collared animals in the Mt. Warren population, counting 12 adult ewes, 2 yearling ewes, 11 lambs, and 9 adult rams. Additional surveys on July 11 and July 27 added 1 yearling ewe and 1 yearling ram to the count, resulting in a minimum total of 36 bighorn: 12 adult ewes, 3 yearling ewes, 1 yearling ram, 11 lambs, and 9 adult rams.

Geographic Distribution

The Recovery Plan identifies 16 areas of habitat across the Sierra Nevada that bighorn herds likely occupied in the past (Figure 1). These habitat patches, or herd units, stretch from west of the Bridgeport Valley to Olancha Peak. Of these 16 herd units, occupation of 12 is recommended in order for Sierra bighorn to be downlisted to "threatened" status. CDFW has carried out extensive translocation efforts to restore Sierra bighorn to historic habitat and recreate a metapopulation structure that will maintain the genetic diversity of the subspecies. Natural colonizations have populated the Bubbs Creek and Convict Creek herd units. In March 2013 CDFW undertook the first reintroduction in 25 years, repopulating the Olancha Peak herd unit with 10 pregnant ewes and 4 rams from the Sawmill Canyon and Mt. Langley herds. Now, with 10 herd units occupied, only 3 herd units (Big Arroyo, Laurel Creek, and Taboose Creek) remain vacant of the 12 included in recovery goals. Given recent explorations into Taboose Creek by bighorn from the Sawmill Canyon herd (Stephenson et al. 2012), natural colonization of that herd unit is likely. A reintroduction to Big Arroyo is planned for the spring of 2014.

Table 1. Minimum count data and mark-resight estimates (M.R. Est.) from surveys conducted during the 2012-2013 reporting period. Lambs are not identified by sex. Because translocations occurred after surveys were completed, animals translocated to Olancha Peak are shown both in their original herd units and in the Olancha Peak herd unit.

	♀ - Ewes				Lambs	♂ - Rams			Total
Herd	**Adult**	**Yearling**	**Total**	**M.R. Est.**		**Adult**	**Yearling**	**Total**	
Olancha	10	0	10		0	4	0	4	14
Langley	42	5	47	41 (32-53)	27	31	5	36	113*
Bubbs	8	1	9		5	7	1	8	22
Baxter	27	6	33	32 (27-37)	23	33	10	43	99
Sawmill	22	2	24~		8	5	2	7^	39~^
Wheeler	29	10	39	53 (42-67)	15	32	4	36	90
Convict	3	1	4		3	1	0	1	8
Gibbs	7	1	8		2	9	2	11	21
Warren	12	3	15		11	9	1	10	36

*Total includes 3 unclassified animals
~Significant undercount of total ewes
^Significant undercount of total rams

Collaring Efforts

Capturing Sierra bighorn to deploy collars is a necessary action for recovery of the subspecies. VHF and GPS collars yield data used to estimate population size, track survival and mortality, and follow seasonal migrations and occasional extreme movements that have brought bighorn close to domestic sheep allotments, increasing the risk of disease transmission. In addition to deploying collars, we determine genetic diversity, body condition, physical health, disease exposure, and pregnancy status of all captured bighorn.

The Recovery Program's goal is to maintain collars on 30-35% of the Sierra bighorn population (Table 2). The October 2012 capture was a large-scale effort to restore an adequate percentage of collared bighorn after a long period with very few captures. During October 21-30 2012, 66 Sierra bighorn from 8 herds (Mt. Langley, Mt. Williamson, Mt. Baxter, Sawmill Canyon, Bubbs Creek, Wheeler Ridge, Mt. Gibbs and Mt. Warren) were captured by wildlife capture specialists from Leading Edge Aviation using a net-gun fired from a helicopter. All captures occurred on the Inyo National Forest or inside Sequoia and Kings Canyon or Yosemite National Park boundaries. Forty-three ewes, 14 rams, and 9 lambs were captured. One ram received a 12-inch laceration across the chest during capture. The wound was irrigated and stitched closed with 3 subcutaneous stitches and 12 external stitches. To this date, the ram has survived. All other capture-related injuries were minor, and all 66 captured Sierra bighorn were known to be alive at least 2 weeks after capture.

During March 25-27 2013, 24 Sierra bighorn were captured in 2 herds (Mt. Langley and Sawmill Canyon) on the Inyo National Forest for our translocation program. Nineteen ewes and 4 rams were captured. Fourteen Sierra bighorn were relocated to establish the Olancha Peak herd, and the Mt. Gibbs and Convict Creek herds were each augmented with 3 ewes.

One ram died immediately after netting. The field necropsy did not reveal abnormalities. This ram likely died as a result of capture stress. Several recaptured ewes had abrasions on their necks that appeared to be a result of the Lotek collars deployed in October 2012. One yearling ewe with an ill-fitting Lotek collar was recaptured and the collar removed. All other capture-related injuries were minor, and all Sierra bighorn captured and released were known to be alive at least 2 weeks after capture.

Blood, hair samples, and nasal swabs were collected for all animals in both captures. Blood samples were analyzed for antibodies to *Anaplasma marginale*, Bluetongue virus, Bovine Herpesvirus-1, Bovine Respiratory Syncytial virus, *Brucella ovis*, Bovine Viral Diarrhea (BVD) type-1 virus, BVD type-2 virus, Border Disease virus, Chlamydia, Contagious Ecthyma, Epizootic Hemorrhagic Disease virus, and Parainfluenza virus 3, as well as levels of selenium, iron, magnesium, zinc, copper, calcium, phosphorus, sodium, and potassium. Nasal swabs were cultured and stored for *Mycoplasma* analysis to occur once a laboratory contract is approved. Sierra bighorn appeared generally healthy with no clinical symptoms of disease.

Table 2. Distribution of radio collars by herd unit. New captures are previously-uncollared animals captured during the reporting period. Recaptures are collared animals that were recaptured to replace or remove collars containing GPS data; except when non-functional collars are replaced, recaptures do not add to the total collars in a herd. Augmentations and removals indicate animals moved from 1 herd unit to another. The percent of the population collared is based on population size from the most recent complete minimum counts, and includes non-functional collars that serve as marks for the purpose of calculating mark-resight estimates.

	Olancha		**Langley**		**Williamson**		**Baxter**		**Sawmill**		**Bubbs**		**Wheeler**		**Convict**		**Gibbs**		**Warren**	
Sex	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
5/1/2012	**0**	**0**	**16**	**7**	**5**	**2**	**11**	**7**	**9**	**3**	**4**	**2**	**9**	**9**	**0**	**0**	**5**	**6**	**7**	**5**
New Captures	0	0	8	2	2	1	5	1	21	5	3	1	9	4	0	0	0	0	2	1
Recaptures	0	0	9	3	1	0	1	0	0	0	0	0	2	0	0	0	0	1	2	0
Augmentations	10	4	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0
Removals	0	0	-6	-2	0	0	0	0	-10	0	0	0		0	0	0	0	0	0	0
Mortalities	0	0	-1	-1	0	0	0	0	-2	-2	-1	0	0	-1	0	0	0	-2	-5	-2
Censors	0	0	-1	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
4/30/2013	**10**	**4**	**16**	**6**	**7**	**3**	**15**	**8**	**18**	**6**	**6**	**3**	**18**	**12**	**3**	**0**	**8**	**4**	**4**	**4**
% Collared 4/13	**100**	**100**	**40**	**18**	**50**	**30**	**47**	**19**	**55**	**26***	**75**	**38**	**46**	**34**	**43**	**0**	**73**	**44**	**40**	**50**

***The number of rams in this population was estimated from the number of ewes using a ratio of 7 rams per 10 ewes.

Sierra Bighorn Population Dynamics

Population Size

Changes in population size result from the difference between gains from reproduction and immigration, and losses from mortality and emigration. Immigration and emigration events between bighorn herds are rare, and so the population dynamics of Sierra bighorn are primarily driven by successful reproduction, recruitment, and mortality.

Since endangered species listing in 1999, numbers of adult and yearling females in the largest bighorn herds have grown from fewer than 20 to more than 40 (Figure 3). Following the deployment of numerous radio collars in the Sawmill Canyon herd in 2007, we documented significant gains in that population, largely reflecting an increase in the probability of detection. This year's population survey of the Sawmill Canyon herd was likely a significant undercount; the total from the most recent complete count was used.

The number of adult and yearling females has increased in recent years. At the end of the 2012 summer survey season there were at least 217 female bighorn in the Sierra Nevada (Figure 4). This is a 4-fold increase in just over a decade and represents about two-thirds of the recovery goal of 305 females. If population growth continues and reintroductions to vacant herd units take place, Sierra bighorn may reach recovery goals within a decade.

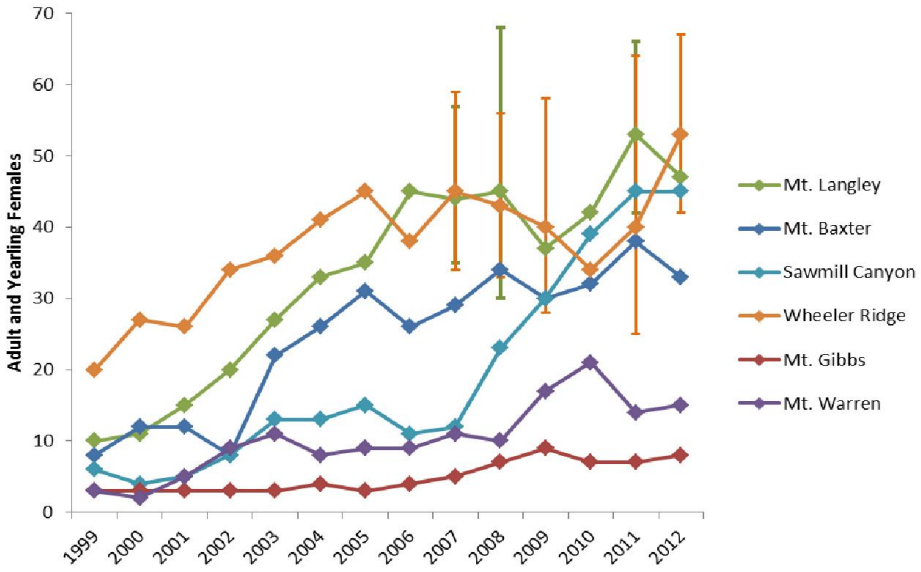

Figure 3. Population trajectories for adult and yearling females from 1999-2012 based on a combination of minimum counts, mark-resight estimates, and reconstructed data for 6 herds in the Sierra Nevada with annual population data. In years when no data were available or when surveys were incomplete, survey totals from the most recent complete count were used. Data from mark-resight estimates are plotted with error bars representing 95% confidence intervals. In all figures, years are defined from May 1 to April 30 of the following year.

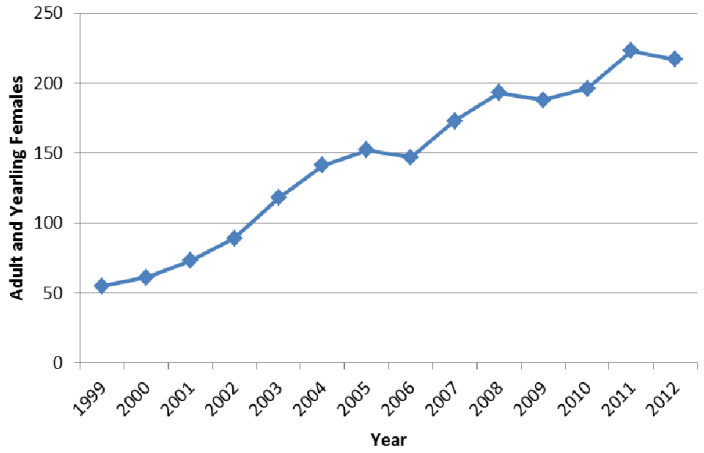

Figure 4. Combined population trajectories for adult and yearling females from all occupied herds (Olancha Peak, Mt. Langley, Mt. Williamson, Bubbs Creek, Mt. Baxter, Sawmill Canyon, Wheeler Ridge, Convict Creek, Mt. Gibbs, and Mt. Warren) from 1999-2012 surveys. Population estimates in earlier years lack data for some herds. Some of the significant increases have been due to better data and cannot be construed as population gains; for example, the increase between 2007 and 2008 is largely due to increased detection at Sawmill Canyon. This year's apparent decrease may be a result of less complete counts.

Survival and Cause-Specific Mortality

A study of Sierra bighorn populations showed that growth rates in some herd units were driven by changes in adult female survival, which was highly variable (Johnson et al. 2010). This differs from typical ungulate populations, in which juvenile survival drives population growth rates. The study was performed at lower population levels and the impact of adult ewe survival may have changed since populations have increased.

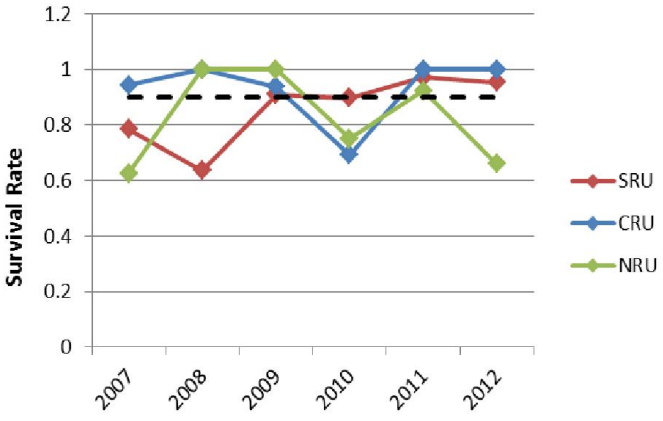

Figure 5. Annual Kaplan-Meier survival rates of radio-collared ewes for 2007-2012 by Recovery Unit. The dashed line represents 90% survival; survival rates above this line are likely to be associated with population increases.

We calculated annual Kaplan-Meier survival rates of radio-collared ewes (Kaplan and Meier 1958) in order to determine whether adult female survival fluctuates greatly in Sierra bighorn populations. Between 2007 and 2012, survival varied from 0.625 to 1 (Figure 5). The lowest survival rates occurred in the Northern Recovery Unit (NRU) in 2007 and in the Southern Recovery Unit (SRU) in 2008. More recently, survival rates declined in the Central Recovery Unit (CRU) and NRU in 2010 when harsh winter conditions killed 11 collared bighorn including 8 ewes. In the winter of 2012, the survival rate in the NRU declined precipitously when 7 collared animals in the Mt. Warren herd unit died of malnutrition, physical injury, predation, and other unknown causes.

Understanding the factors that affect adult survival is critical to determining which conservation actions will be most effective in promoting recovery. GPS and VHF collars are equipped with mortality sensors that emit a signal indicating lack of movement; we investigate mortality signals promptly to determine the probable cause of death. From 2000-2011, we were also able to detect mortalities by inspecting GPS clusters from collared mountain lions. These clusters often indicated a kill site and sometimes allowed us to detect mountain lion kills of uncollared bighorn. Since July 2011 we have not captured any additional mountain lions, so we have relied on monitoring of collared bighorn to detect mortalities. A higher percentage of bighorn are collared in each herd now to permit detection of all causes of mortality.

Figure 6 shows the causes of natural mortalities occurring between 2009 and 2012. In 2009 mountain lion predation in the Mt. Baxter and Wheeler Ridge herds was the largest identified cause of mortality. The next year, most mortalities were caused by harsh conditions during the heavy winter of 2010-2011. In 2011 there were only 3 mortalities, all of unknown cause. During the 2012-2013 reporting period, 4 mortalities of collared bighorn resulted from predation (1 documented coyote kill and 3 documented lion kills), 2 from physical injury, and 1 from malnutrition. We also detected 1 mortality of an uncollared bighorn probably killed by a lion. Two of the collared animals killed by lions were from the Mt. Warren herd unit, where lion predation has been absent for many years as this herd unit is not adjacent to a large mule deer winter range. Eight mortalities were the result of unknown causes; 6 of these happened during the winter months and 5 were animals that endured the winter at high elevation. While the remains of these animals did not yield conclusive evidence, we can speculate that exposure to winter conditions in the high alpine contributed to their deaths.

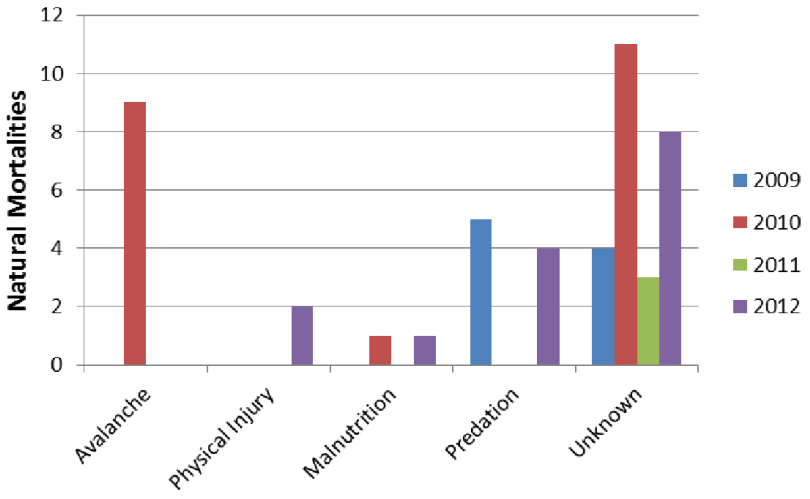

Figure 6. Cause-specific natural mortalities of radio-collared bighorn from May 1 to April 30 of the following year.

Reproduction and Recruitment

Recruitment, or the replacement rate of the reproductive segment of a population, is an important metric for understanding population growth or decline in Sierra bighorn herds. We can measure recruitment by comparing the total number of adult and yearling ewes observed in a herd in one survey season to the number of adult ewes observed in the same herd in the next survey season. If near-complete surveys were obtained in both years, and if we assumed 100% recruitment and no adult mortality, the two numbers would be equal. Table 3 compares the number of adult and yearling ewes observed in 2011 to the number of adult ewes observed in 2012. The number of adult ewes counted in each herd unit in 2012 was equal to or less than the number predicted by complete recruitment of yearling ewes from the year prior. This is to be expected as some adult and yearling mortality is typical in Sierra bighorn herds.

Table 3. Comparison of the number of adult ewes in 2012 to the number of ewes in 2011 after accounting for recruitment of yearlings. Populations with poor minimum counts in either year are not included.

Herd	**2011**			**2012**
	Adult Ewes	Yearling Ewes	Total Ewes	Adult Ewes
Langley	41	6	**47**	**42**
Baxter	30	8	**38**	**27**
Wheeler	31	4	**35**	**29**
Convict	3	2	**5**	**3**
Gibbs	7	0	**7**	**7**
Warren	12	2	**14**	**12**

Recruitment can also be measured as the yearling to ewe ratio in a population, while the lamb to ewe ratio can be used as an estimate of fecundity. Comparing the lamb to ewe and yearling to ewe ratios gives us a measure of lamb survival. While these ratios are useful tools to help us estimate demographic rates, they can be biased by differences in the percent of the total population counted in either year. In all herd units except Wheeler Ridge, the total yearling to ewe ratio in 2012 was slightly less than the lamb to ewe ratio in 2011 (Table 4). A slight decrease in this ratio is typical because not all lambs survive to become yearlings, and yearling survival is highly variable. The increase in this ratio at Wheeler Ridge in 2012 is due to a decrease in the 2012 count of adult ewes.

Estimates of survival and ratios of juvenile age classes to ewes change slightly over the course of a year as animals die; therefore the data presented in Tables 4 and 5 are not directly comparable in populations surveyed at different times of year.

Table 4. Ratios of juvenile age classes to ewes from 2011 to 2012. Populations with poor minimum counts in either year are not included.

Herd	*Lamb:Ewe 2011*	*Total Yearling:Ewe 2012*
Langley	0.375	0.25
Baxter	0.66	0.62
Wheeler	0.54	0.56
Convict	0.67	0.33
Gibbs	0.57	0.43
Warren	0.36	0.33

Lamb survival, estimated by dividing the number of yearlings observed in 2012 by the number of lambs observed in 2011, is shown in Table 5. It is important to note that these are likely overestimates of lamb survival because many neonatal lambs die before they are observed. These estimates are also sensitive to undercounts in either year. Lamb survival during this reporting period varied across herds, from 0.5 at Convict Creek to 1.0 at Mt. Warren. Lamb survival was high in most herd units.

Table 5. Lamb survival estimated by comparing the number of yearlings in 2012 to the number of lambs in 2011. All data are from minimum counts; populations with poor minimum counts in either year are not included.

Herd	*2011 Lambs*	*2012 Yearlings*	*Lamb Survival*
Langley	15	10	0.67
Baxter	19	16	0.84
Wheeler	15	14	0.93
Convict	2	1	0.5
Gibbs	4	3	0.75
Warren	4	4	1.0

We use another method of estimating lamb survival at Wheeler Ridge. Because lambing habitat there is readily observable and ewes can be monitored almost daily during lambing season, we can determine the number of lambs born and then ascertain the number that survived their first year by conducting winter surveys when these lambs are approaching 1 year of age. At Wheeler Ridge in 2011, 15 of 21 lambs born survived their first year. Of the 20 lambs born in 2012, 15 survived their first year to be counted in winter surveys.

This year we expanded our neonatal lamb survival monitoring to include the Mt. Warren, Mt. Gibbs, and Mt. Langley herds. In May and June we visited lambing habitat within these herd units regularly and documented lambing status of collared ewes, total lambs seen, and probable mortalities.

At Mt. Warren, all 7 collared ewes were observed with lambs in May and June. An additional 1 to 3 lambs were observed with uncollared ewes. Summer surveys counted 11 lambs, indicating high neonatal survival. At Mt. Gibbs we observed 2 collared ewes with lambs. These lambs were still alive in July when we surveyed this population.

At Mt. Langley our lambing surveys counted a total of 20 lambs, 13 of which belonged to collared ewes. Two collared ewes were not seen and lambing status could not be confirmed for 1 collared ewe. Our September survey of this population resulted in a count of 26 lambs, reflecting some late births and a high rate of neonatal survival.

New Findings

Taboose Creek Occupation

Sporadic reports over the years have shown that bighorn occasionally travel to the Taboose Creek herd unit, 1 of the 12 herd units included in recovery goals. The Recovery Program conducts frequent monitoring expeditions to this herd unit to determine whether any bighorn reside permanently in the area. On June 3 2012 a hiker saw a group of 7 bighorn on the north side of Taboose Pass. On June 17 2012 another hiker reported 2 ewes and 1 ram on the Birch Lake trail. On September 25-26 2012, Recovery Program staff observed 2 rams in the cirque of Cardinal Lake, 4 rams (including collared Sawmill Canyon ram S130) in the cirque west of Split Mountain, and considerable sign on the ridge connecting the 2 cirques. While no resident ewe population has yet been discovered, it is evident that bighorn use the Taboose Creek area. A natural colonization of this herd unit may be imminent.

Migration Corridor between Baxter/Sawmill and Bubbs Creek

GPS collar data from 2 rams, S193 (Bubbs Creek) and S249 (Sawmill Canyon) has revealed a migration corridor connecting the eastern slopes of the Sierra with the Bubbs Creek herd unit, which lies significantly west of the Sierra Crest. S193 was captured in the Bubbs Creek herd unit, but regularly travels through Sixty Lakes Basin and Rae Lakes and over Baxter Pass to spend the winter in low-elevation areas east of the Sierra Crest. S249 was captured east of the Sierra Crest in Division Creek, but made his way over Mt. Baxter and crossed the South Fork of Woods Creek into the Bubbs Creek herd unit, where he has remained.

New Habitat Use South of Mt. Williamson Herd Unit

Two ewes captured in the Mt. Baxter herd unit, S166 and S167, have continued their anomalous use of habitat (Few et al. 2012). S166 was recaptured and her GPS collar recovered in October 2012 on Mt. Barnard at the southern border of the Mt. Williamson herd unit. GPS locations retrieved from S166's collar revealed an astonishing journey from Mt. Baxter all the way to the Mt. Langley herd unit and back north to Wallace Lake, an area south of the Mt. Williamson herd unit boundary. She has remained in that area since August 2010. When S166 first traveled to Mt. Williamson in 2010 she was found

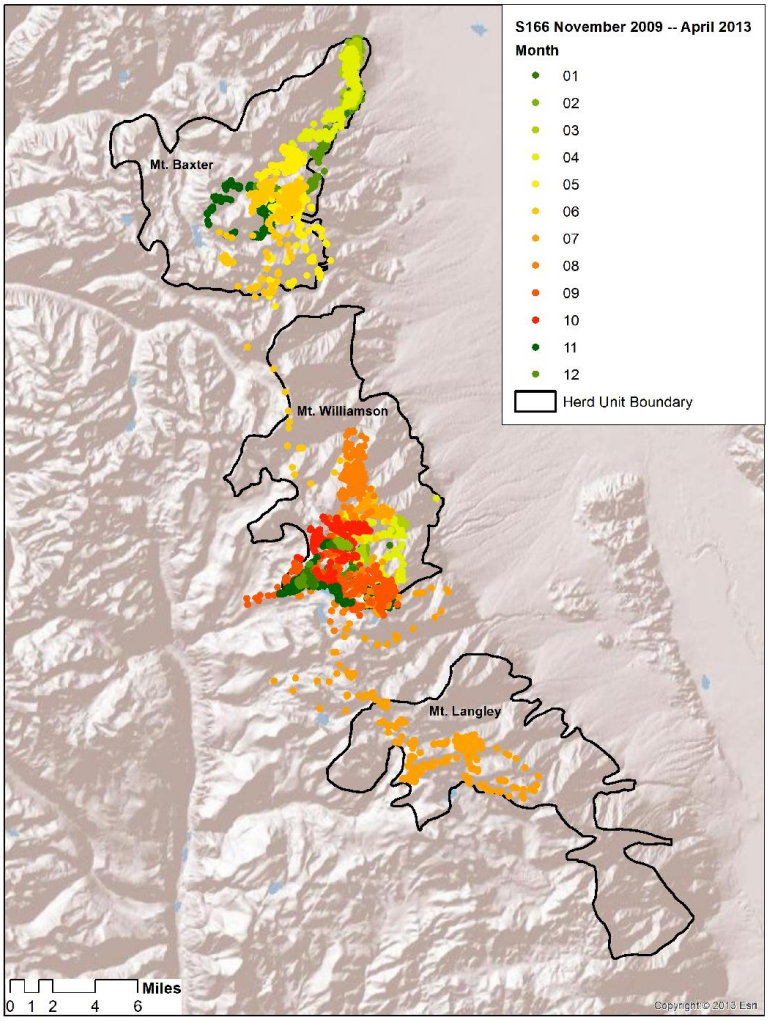

Figure 7. GPS collar locations show S166's long-distance movements from November 2009-April 2013.

with 3 bighorn; genetic analysis revealed that all 4 came from the Mt. Baxter gene pool. When she was recaptured in 2012, S166 was part of a group of 12 bighorn.

S167 rejoined the Mt. Baxter herd on low-elevation range this winter, after spending most of the summer of 2012 in Center Basin and Junction Pass, an area where we have historic evidence of use by bighorn ewes but where only rams have been observed in recent years. Recovery Program staff observed S167 alone with her lamb in this area in September 2012. There was bighorn sign on the Junction Pass plateau and on the north ridge of Mt. Keith, and staff observed a lone ram near the summit of Mt. Keith, but the area did not appear heavily used. In the fall of 2012, S167 moved to the Kearsarge Pinnacles, an area between the Mt. Baxter and Mt. Williamson herd units where bighorn use had never been documented.

Habitat Scouting

Kern Recovery Unit

In the summer of 2012 CDFW biologists made an exploratory trip into Sequoia and Kings Canyon National Parks (SEKI) to examine potential bighorn habitat in the Laurel Creek and Big Arroyo herd units, both of which are included in recovery goals. The team traveled north along the Kern River for 3 days, making side trips up Rattlesnake Creek, Big Arroyo Creek, and Funston Creek. Connectivity between winter and summer ranges was limited, and it was determined that availability of winter range in these herd units will depend on snowfall each year. Habitat models generated from winter GPS locations of collared bighorn will be used to evaluate the quantity and quality of winter range in these herd units.

In the summer of 2012, trained Wildlife Specialists with the U.S. Department of Agriculture traveled extensively in potential Sierra bighorn habitat in the Kern Recovery Unit in search of predator sign that might contraindicate translocation of bighorn to that

area. In the Kern River drainage, an intensive 33-day survey revealed many examples of coyote and bobcat sign but no mountain lion sign with the exception of 1 aged urine mark (Davis et al. 2012). The results of this survey suggest that mountain lion activity in the region is not sufficient to preclude successful reoccupation with Sierra bighorn.

Washburn Lake

During September 24-27 2012, biologists from the Recovery Program and Yosemite National Park traveled from Tuolumne Meadows to Yosemite Valley to explore habitat around the Cathedral Range. Historical records indicate that Sierra bighorn persisted in the Cathedral Range until the early 1900s (Jones 1950). Potential winter range above the Washburn Lake area was examined for terrain features, forage availability, and connectivity to alpine habitat.

The team found evidence that this habitat could support a population of bighorn. The highest peaks of the Cathedral Range offer excellent alpine terrain, although vegetation in these peaks needs further exploration. The south- and southwest-facing slopes above and east of Wasburn Lake may provide mid- to low-elevation winter range and lambing habitat, although snow cover analyses are needed to determine the extent to which these slopes are snow-free. Snow cover analyses would also indicate whether the ridges of the Cathedral Range could provide consistent windswept high-elevation winter habitat. The open slopes of Hutching Creek and the Lyell Fork of the Merced could serve as a migration corridor between the Cathedral Range summer habitat and the Washburn Lake winter range. The Recovery Program recommends reintroduction of Sierra bighorn in this area be considered further. A population in the Cathedral Range would increase the stability of the metapopulation within the Northern Recovery Unit and Yosemite National Park.

Public Outreach

Migrating Mural

Scientific illustrator Jane Kim's award-winning Migrating Mural project continues along the Highway 395 corridor, bringing endangered Sierra bighorn into the public eye through a series of stunning life-size paintings. During this reporting period Kim completed murals in Independence at the Mt. Williamson Motel and in Bishop at the Bishop Gun Club and Sage to Summit running store. Kim plans at least 2 more mural installations in Lone Pine and Lee Vining. The murals have brought a great deal of positive attention to CDFW's recovery efforts, raising awareness of and interest in the fate of Sierra bighorn throughout the communities of the Eastern Sierra.

Educating the Community

Public outreach is an important part of CDFW's mission and a stated goal of the Recovery Plan (USFWS 2007). During this reporting period, the Recovery Program created and staffed outreach displays at a variety of public events from Alabama Hills Day in Lone Pine to the Banff Film Festival, Sierra Discovery Days, Earth Day, and Mule

Days in Bishop. This represents a major expansion of our outreach efforts. Staff members answered questions about Sierra bighorn, explained the difference between Sierra bighorn and desert bighorn, displayed bighorn skulls, and demonstrated the use of telemetry to track radio-collared animals. Staff handed out pamphlets on disease prevention and Recovery Program activities, as well as bighorn coloring books for children.

In the spring of 2012 we worked to increase our presence in local classrooms: program leader Tom Stephenson gave a presentation on Sierra bighorn to the Big Pine Paiute Tribe's afterschool program, and Recovery Program staff held a field trip for students in the Bishop Elementary fourth grade class. Centered around the Migrating Mural at the Bishop Gun Club, the field trip introduced students to many different ways of observing nature through art and science. Students sketched the surrounding landscape, practiced classifying the bighorn in the mural by age and sex, used telemetry to track hidden radio collars, and watched short videos about the cultural significance of bighorn and the recent reintroduction to Olancha Peak.

Finally, the Recovery Program led 3 public field trips in the winter and spring of 2013 during which community members were able to observe Sierra bighorn in the wild. These trips were very favorably received and drew participants from all over the state.

Future Recovery Actions

Reintroductions

Planning efforts are underway for a reintroduction in the spring of 2014. Tentative plans include reintroducing 10 ewes and 5 rams to the Big Arroyo herd unit in the now-vacant Kern Recovery Unit; the occupation of 2 herd units in this recovery unit is recommended in order for the subspecies to be delisted. Additionally, we plan to augment the recently-reestablished Olancha Peak herd unit with 5 ewes to maximize genetic diversity and reduce the risk of extirpation. These translocations will help Sierra bighorn to reach recovery goals as quickly as possible.

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