2013-2014 Annual Report
of the Sierra Nevada Bighorn Sheep Recovery Program

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Summary of Progress

This report documents conservation and monitoring activities conducted during May 1 2013-April 30 2014 by the California Department of Fish and Wildlife's (CDFW's) Sierra Nevada Bighorn Sheep Recovery Program (the Recovery Program). Since its inception in 1999, the Recovery Program has worked to restore state- and federally-endangered Sierra Nevada bighorn sheep (Sierra bighorn) through science-oriented adaptive management. We monitor for survival and the presence of disease, track bighorn distribution, abundance, and vital rates, and conduct captures and translocations to deploy radio collars and restore populations to historic ranges.

The *Recovery Plan for the Sierra Nevada Bighorn Sheep* (hereafter the Recovery Plan, USFWS 2007) specifies downlisting and delisting goals that include the occupation of 12 herd units with a minimum total of 305 females. At the end of this reporting period we estimate that the Sierra bighorn population contained at least 258 females in 11 herd units, 10 of which are listed as recovery goals (Figure 1). In March 2014 we carried out the first reoccupation within the Kern Recovery Unit by reintroducing bighorn to the Big Arroyo herd unit in Sequoia National Park. With continued conservation and management, Sierra bighorn may achieve recovery goals in less than a decade.

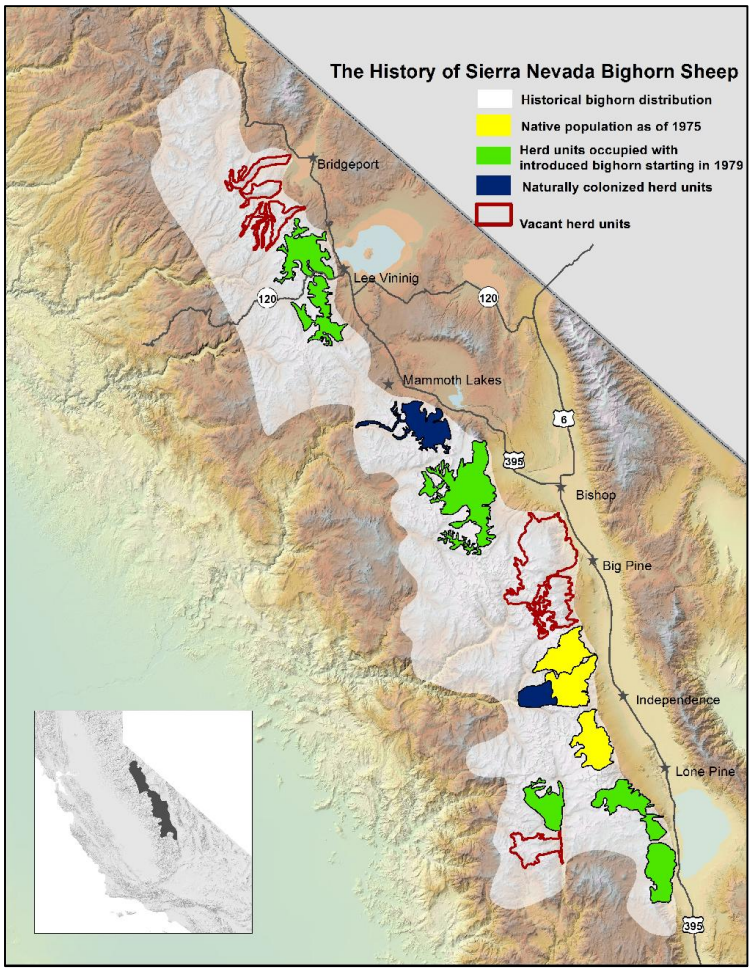

Figure 1. Locations of 16 historic herds of Sierra bighorn. All occupied herd units (filled polygons) are included in recovery goals except Bubbs Creek. One herd unit, Big Arroyo, was occupied with introduced bighorn during this reporting period. Two vacant herd units (Laurel Creek and Taboose Creek)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

Conservation Activities

Translocations

In March 2014 CDFW carried out a reintroduction to the previously vacant Kern Recovery Unit, establishing a population of 10 ewes and 4 rams in historic habitat at Big Arroyo. Nine of the 10 translocated ewes were pregnant; 2 were yearlings. All 10 ewes were removed from the Wheeler Ridge herd unit. One ram was also from Wheeler Ridge; the other 3 rams were from Mt. Baxter. Sierra bighorn were captured via helicopter net-gun, assessed and radio-collared at a central processing area, and transported by helicopter to a release site in the Kern Canyon just north of the Big Arroyo drainage.

In addition, 4 pregnant collared ewes from Sawmill Canyon were translocated to augment the recently-established population at Olancha Peak. We have chosen to follow a regular schedule of augmentations to reach an optimal number of ewes in this population; we may also consider translocating more high-heterozygosity rams to the population to maximize genetic diversity.

Habitat Enhancement

No habitat enhancement projects were attempted during this reporting period.

Disease Management

Wild bighorn are not resistant to some respiratory pathogens carried by domestic sheep and goats; nose-to-nose contact between wild bighorn and these domestic animals can cause devastating pneumonia outbreaks in bighorn populations (Lawrence et al. 2010; Wehausen et al. 2011). Domestic sheep grazing near occupied bighorn habitat greatly increases the risk of a disease outbreak among Sierra bighorn, threatening recovery of the subspecies. CDFW continues to work with local landowners in implementing various strategies to mitigate the risk of disease transmission from domestic sheep and goats to Sierra bighorn.

The U.S. Forest Service is in the process of drafting an Environmental Assessment concerning the possible impacts of pack stock goats on Sierra bighorn. This Environmental Assessment was recently released for public comment; CDFW submitted comments on April 30 2014.

Predator Management

No predator management occurred during this reporting period.

Sierra Bighorn Population Monitoring

Herd Unit Surveys

We conduct annual ground surveys of Sierra bighorn herds in order to assess the health and growth of each herd and overall progress toward recovery goals. We focus our counts on females and associated lambs and yearlings as this sector of the population

drives population growth or decline. Demographic data allow us to track population trends such as reproduction and recruitment. We employ 2 survey methods that together enhance data interpretation. Minimum counts arrive at a population minimum by aggregating all unique individuals observed or known to exist within an area, and can approach total counts under optimal circumstances. Mark-resight estimates extrapolate the total population from the ratio of collared to uncollared animals observed in an unbiased survey.

Because behavior and habitat use vary between herd units, we survey different herds at different times of year. During the 2013 survey season we surveyed the Olancha Peak, Mt. Langley, Mt. Baxter, and Wheeler Ridge herds in both winter and summer. The Sawmill Canyon, Bubbs Creek, Convict Creek, Mt. Gibbs, and Mt. Warren herds were surveyed only in summer. Mt. Williamson was not surveyed. Survey results are summarized in Table 1.

Olancha Peak

The Olancha Peak herd unit was established by reintroduction in March 2013 with 10 pregnant ewes and 4 rams. All 14 translocated animals were released wearing GPS collars that collect and transmit location data daily. In May 2013, 2 of the rams (S210 and S179) traveled north in the direction of the Mt. Langley herd unit, where both were born. S210 turned around at Mulkey Meadows and returned to Olancha, while S179 rejoined the ram group at Mt. Langley with which he had spent most of his life. At the end of this reporting period, S179 was still at Mt. Langley and 3 rams remained at Olancha. Seven of the 10 ewes were seen with lambs in the summer of 2013; subsequent analysis of lamb fecal pellets revealed that 8 lamb genotypes were present in the population. In March 2014, 4 pregnant ewes from the Sawmill Canyon herd unit were translocated to Olancha to augment this population, which now consists of a minimum of 14 adult ewes, 8 lambs, and 3 adult rams.

Big Arroyo

In March 2014 we established a population of 14 bighorn in this herd unit: 8 adult ewes (7 of which were pregnant), 2 yearling ewes (both pregnant), and 4 adult rams. All animals were released wearing GPS collars. One adult ewe died of unknown causes in mid-April 2014.

Mt. Langley

We conducted 2 surveys of the Mt. Langley herd in September 2013. The first count, September 9-12, was plagued by thunderstorms and snow but resulted in the highest total of adult rams: 30 rams seen and 4 collared rams not seen. The following week, September 16-19, survey teams observed 36 adult ewes, 8 yearling ewes, 9 yearling rams, and 16 lambs. Three nonfunctional collars (S38, S86, and yearling ewe S267) that had not been observed in 6-12 months and were not observed by the end of this reporting period were presumed dead and censored from the count. Two collared ewes not seen but known to be alive (S209 and S265) were added to the count, bringing the

minimum number of adult ewes to 38. One additional yearling ewe seen in the first count was added to bring the total number of yearling ewes to 9. Our surveys resulted in a minimum count of 106 animals in this population: 38 adult ewes, 9 yearling ewes, 9 yearling rams, 16 lambs, and 34 adult rams.

Given that our best counts from the 2012 survey season totaled 42 adult ewes and 5 yearling ewes, and 6 adult ewes were removed from this population for translocations in March 2013, we would expect 41 adult ewes to remain in the Mt. Langley herd assuming 100% survival. The minimum total of 38 adult ewes indicates high survival and is consistent with predictions based on last year's count data.

Mt. Williamson

With limited resources and time, we did not attempt a survey of the Mt. Williamson herd during this reporting period. Frequent telemetry flights indicate that all animals with functioning radio collars are still alive.

Bubbs Creek

We surveyed the Bubbs Creek herd on September 25-26 and counted 24 bighorn: 10 adult ewes, 1 yearling ewe, 1 female of unknown age, 1 yearling ram, 9 lambs, and 2 adult rams. All collared ewes were seen with the exception of S227, a yearling female not observed since capture. Three adult ram collars were not seen but are known to be alive, bringing the total number of adult rams to 5 and the total number of bighorn to 27.

Mt. Baxter

We surveyed the Mt. Baxter herd twice in the summer of 2013. During the June 10-14 survey, most animals were observed in very rugged terrain that made accurate counts difficult. Only 5 yearlings (3 females and 2 males) and no adult rams were observed, but 12 of 16 collared adult ewes were seen. A second survey during August 12-15 produced a significantly higher count: 34 adult ewes, 3 yearling ewes, 6 yearling rams, 31 lambs, and 10 adult rams. Four collared ewes not seen (S123, S138, S139, and S167) were added to the count; 3 of these ewes (S138, S139, and S167) had been observed with lambs during the June survey. Adding in these 4 ewes and 3 lambs resulted in a count of 38 adult ewes and 34 lambs.

Our best survey came during February 10-12 2014, when field teams observed all collared ewes in the Mt. Baxter herd except S263, who was heard with a live signal. Including S263 in the count brought the minimum totals to 40 adult ewes, 6 yearling ewes, 7 yearling rams, and 24 lambs. It is possible that some of the 34 lambs seen on the summer range died before the winter count. The new total of 13 yearlings is a significant improvement from the summer counts, but is still far lower than expected given the 23 lambs observed on winter range the previous year. The lamb survival rate in this herd unit from 2010 to 2011 was 100% and the rate from 2011 to 2012 was 84%. This year's decline to 57% lamb survival may warrant further consideration.

Sawmill Canyon

We scheduled a Sawmill Canyon survey in mid-June, expecting that ewes would have moved out of lambing habitat and into more accessible terrain. Unfortunately most animals remained concentrated in convoluted eastern canyons, and field observations were difficult to obtain. During June 21-28, surveyors observed 22 adult ewes, 6 yearling ewes, 3 yearling rams, 9 lambs, and 2 adult rams. Four collared adult ewes (S126, S128, S129, and S261), 1 collared yearling ewe (S232), and 5 collared adult rams (S130, S204, S207, S230, and S258) were not seen. Adding these animals to the count produced a total of 52 animals: 26 adult ewes, 7 yearling ewes, 3 yearling rams, 9 lambs, and 7 adult rams. Given the most recent near-complete minimum count of 45 adult and yearling ewes in summer 2011, the removal of 10 ewes from this herd for relocation to Olancha Peak in spring 2013, and the deaths of 2 ewes between the 2012 and 2013 survey seasons, we would expect to count approximately 33 adult ewes in this herd unit. The minimum total of 26 adult ewes is likely an undercount.

Wheeler Ridge

In July and August we conducted 2 surveys of the Wheeler Ridge herd. Results from both surveys produced a minimum of 44 adult ewes, 5 yearling ewes, 7 yearling rams, 18 lambs, and 21 adult rams. These counts represent the most successful summer surveys of this herd in many years.

Directly after a heavy winter storm, a survey during March 4-5 2014 recorded 41 adult ewes, the largest number of females counted in any survey this reporting period. Four collared ewes (S62, S142, S144, and S244) were not seen. S144 and S244 were known to be alive and S62 was observed on April 30, 2014, so these 3 collars were added to the count. S142, a 13-year-old female, had not been seen since 2012 and was censored from the count. This brought the total number of adult females to 44. During this March count we recorded 8 yearling ewes, 6 yearling rams, and 17 lambs. Therefore, at the end of the 2013 survey season the Wheeler Ridge population numbered at least 96 animals: 44 adult ewes, 8 yearling ewes, 6 yearling rams, 17 lambs, and 21 adult rams.

The minimum counts from summer and winter verify that there were over 40 total females in the Wheeler Ridge herd before the March 2014 translocation; according to the minimum criteria set by the translocation plan, this population was eligible to be used as a source for translocation stock.

Convict Creek

The augmentation of this herd with 3 collared ewes in March 2013 helped surveyors to locate animals in this population during the 2013 survey season. However, the translocated ewes associated only occasionally with the native ewes, and survey totals were inconsistent. Our best survey came on September 5-6, when a group of 17 uncollared animals was discovered on Esha Peak: 9 adult ewes, 1 yearling ewe, 2 yearling rams, 4 lambs, and 1 2-year-old ram. The following day the 3 collared ewes were observed with 1 lamb, bringing the total to 21 bighorn: 12 adult ewes, 1 yearling

ewe, 2 yearling rams, 5 lambs, and 1 2-year-old ram. This count dramatically increased the number of bighorn known to inhabit this herd unit. If we assumed high survival of all age classes and complete minimum counts in 2010 and 2011, we would expect a population containing 8-9 adult ewes (5-6 native adult ewes and 3 translocated ewes), 2 adult rams, 0-1 2 year old ram, and 3 yearlings of unknown sex. The appearance of 3-4 additional adult ewes suggests either that previous counts were incomplete or that an immigration event occurred. Further surveys will be necessary to confirm the composition of the population and to gain a better understanding of the habitat these animals use.

Mt. Gibbs

Multiple summer surveys at Mt. Gibbs led to a complete count on August 8. Including the 3 adult ewes translocated here in March 2013, the Mt. Gibbs population now contains 26 animals: 11 adult ewes, 1 yearling ewe, 1 yearling ram, 6 lambs, and 7 adult rams (only 3 uncollared rams were observed during surveys; all 4 collared rams were heard on live signals). Seven lambs were observed early in July, but 1 appears to have died before the August survey. Nonetheless, a total of 6 lambs, 4 of which were born to native ewes, marks a very productive lambing season for this small herd.

Mt. Warren

After a difficult winter with 7 mortalities of collared adult bighorn, we prioritized a complete survey of the Mt. Warren herd so as to obtain an accurate count of the remaining population. After repeated survey attempts in July and August we could account for 21 bighorn in this herd: 7 adult ewes, 4 yearling ewes, 1 yearling ram, 3 lambs, and 6 adult rams. All 3 lambs were genotyped from fecal samples and found to be male. An observation on April 17 2014 consisted of 1 collared adult ram (S239) and 2 2-year-old rams. These animals would have been classified as yearlings until April 15 2014; their presence demonstrates that 1 additional yearling ram was present in the population but was not observed during the 2013 summer counts.

Geographic Distribution

Sixteen areas of historic habitat, designated as herd units in the Recovery Plan, stretch from northern Yosemite to Olancha Peak and west as far as Bubbs Creek and the Great Western Divide (Figure 1). Recovery goals for downlisting the subspecies to "threatened" include the occupation of a specified 12 of these herd units. Since 1979, 6 herd units have been repopulated with translocated bighorn. Natural colonizations populated the Bubbs Creek and Convict Creek herd units; only the latter is included in recovery goals. In March 2013 CDFW conducted the first reintroduction in 25 years, repopulating the Olancha Peak herd unit with 14 Sierra bighorn. In March 2014 CDFW reintroduced Sierra bighorn to the Big Arroyo herd unit in the previously-unoccupied Kern Recovery Unit, an area on the west side of the Sierra Crest where bighorn had not been observed in nearly a century. This leaves only 2 vacant herd units of the 12 included in recovery goals: the Laurel Creek herd unit in the Kern Recovery Unit, and the Taboose Creek herd unit, an area adjacent to the Sawmill Canyon herd unit that often

sees exploration by Sawmill bighorn. A population of Sierra bighorn may already be present in this herd unit and eventual natural colonization of the area is likely (Stephenson et al. 2012). The recent increase in the distribution of Sierra bighorn through reintroductions and natural colonizations represents major progress toward recovery goals.

Table 1. Minimum count data and mark-resight estimates (M.R. Est.) from surveys conducted during the 2013-2014 reporting period. Lambs are not identified by sex. Because translocations occurred after surveys were completed, translocated animals are shown both in their original herd units and in the herd units to which they were translocated.

	♀ - Ewes				Lambs	♂ - Rams			Total
Herd	**Adult**	**Yearling**	**Total**	**M.R. Est.**		**Adult**	**Yearling**	**Total**	
Olancha	14	0	14		8	3	0	3	25
Big Arroyo	9	0	9		0	4	0	4	13
Langley	38	9	47	55 (45-69)	16	34	9	43	106
Bubbs	10	1	12*		9	5	1	6	27*
Baxter	40	6	46		24	16	7	23	93
Sawmill	26	7	33		9	7	3	10	52
Wheeler	44	8	52	^	17	21	6	27	96
Convict	12	1	13		5	1	2	3	21
Gibbs	11	1	12		6	7	1	8	26
Warren	7	4	11		3	6	2	8	22

*Total includes 1 female of unknown age.

^The 2013 mark-resight estimate for Wheeler was not included because of its high coefficient of variation and large confidence interval. We believe the 2013 minimum count at Wheeler was one of the most complete counts obtained in years.

Collaring Efforts

Captures of Sierra bighorn occur for two purposes: deployment of collars to enable monitoring activities that inform adaptive management decisions, and translocations to increase the distribution of this endangered population. During captures we assess body condition, health, and pregnancy status of captured bighorn and obtain samples to test for genetic diversity and the presence of disease. We use data from deployed GPS collars to monitor survival, seasonal migrations, and long-distance movements that may lead to colonization of new habitat or increase the risk of disease transmission through contact with domestic sheep. Furthermore, position data obtained from these collars are incorporated into studies on home range size and resource selection that contribute to planning for future translocations.

Translocations to reintroduce bighorn to Big Arroyo and to augment the new herd at Olancha Peak occurred during March 19-22, 2014. Nineteen Sierra bighorn from 3 herds (Mt. Baxter, Sawmill Canyon, and Wheeler Ridge) 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. Twelve adult ewes, 2 yearling ewes, 4 rams, and 1 male lamb were captured. All 19 captured Sierra bighorn were known to be alive at least 2 weeks after capture.

Blood, hair samples and nasal swabs were collected for all animals. 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 (EHD) virus, and Parainfluenza virus 3 (PI-3), as well as selenium levels. Nasal swabs were cultured and stored for *Mycoplasma* analysis to occur once a laboratory contract is approved.

Overall, Sierra bighorn appeared healthy with no clinical symptoms of disease. Lab results confirm that Sierra bighorn have very few positive titers for any of the tests. All bighorn tested negative for antibodies to *Brucella ovis*, Bluetongue virus, BVD type-1, BVD type-2, Chlamydia, and EHD. Thirteen tested positive for antibodies to PI-3, 10 tested positive for antibodies to Bovine Respiratory Syncytial virus, and 1 tested positive for antibodies to Contagious Ecthyma. All results are indicative of previous exposure. It should be noted that 1 sample could not be evaluated for Contagious Ecthyma due to anti-complementary activity in the sample. One sample had a slightly low selenium concentration. Vitamin E and MuSe were administered to all animals as a prophylactic measure.

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 functional collars and population size from the most recent complete minimum counts, except as noted.

	Olancha		**Big Arroyo**		**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	F	M
5/1/2013	**10**	**4**	**0**	**0**	**16**	**6**	**7**	**3**	**15**	**8**	**18**	**6**	**6**	**3**	**18**	**12**	**3**	**0**	**8**	**4**	**4**	**4**
New Captures	0	0	0	0	0	0	0	0	0	0	3	0	0	0	10	1	0	0	0	0	0	0
Recaptures	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Augmentations	4	0	10	4	0	1^	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Removals	0	-1^	0	0	0	0	0	0	0	-3	-4	0	0	0	-10	-1	0	0	0	0	0	0
Mortalities	0	0	-1	0	-2	0	0	0	0	-1	-2	0	-1	0	-1	-1	0	0	0	0	0	0
Censors	0	0	0	0	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nonfunctional	0	0	0	0	-5	0	-2	0	-4	0	-3	-2	-1	0	-6	-3	0	0	-4	0	-3	0
4/30/2014	**14**	**3**	**9**	**4**	**7**	**7**	**5**	**3**	**11**	**4**	**12**	**4**	**4**	**3**	**11**	**7**	**3**	**0**	**4**	**4**	**1**	**4**
% Collared 4/14	**100**	**100**	**100**	**100**	**18**	**21**	**36***	**30***	**28**	**25**	**46***	**22***	**40***	**60***	**25**	**33**	**25**	**0**	**36**	**57**	**14**	**67**

*The number of animals in these populations is estimated; therefore the percent of the population collared is also an estimate.

^S179, a ram from Langley who was translocated to Olancha in the spring of 2013, returned to his original home in the Langley herd unit in the summer of 2013.

Sierra Bighorn Population Dynamics

Population Size

Population growth or decline results from the difference between gains from reproduction and immigration, and losses from mortality and emigration. In Sierra bighorn, successful reproduction, recruitment, and mortality are the primary factors driving population dynamics. Since endangered species listing in 1999, the number of adult and yearling females in Sierra bighorn herds has increased nearly fourfold. The largest herds now contain more than 40 total females (Figure 2).

After we deployed numerous radio collars in the Sawmill Canyon herd in 2007 we documented significant gains in that population, largely due to an increase in the probability of detection. This year's apparent decline at Wheeler Ridge is likely the result of an overestimate for the year prior generated by mark-resight models. The apparent decline in the Sawmill Canyon herd this year reflects an incomplete count and the removal of 10 animals from that herd for translocation to Olancha Peak in March 2013.

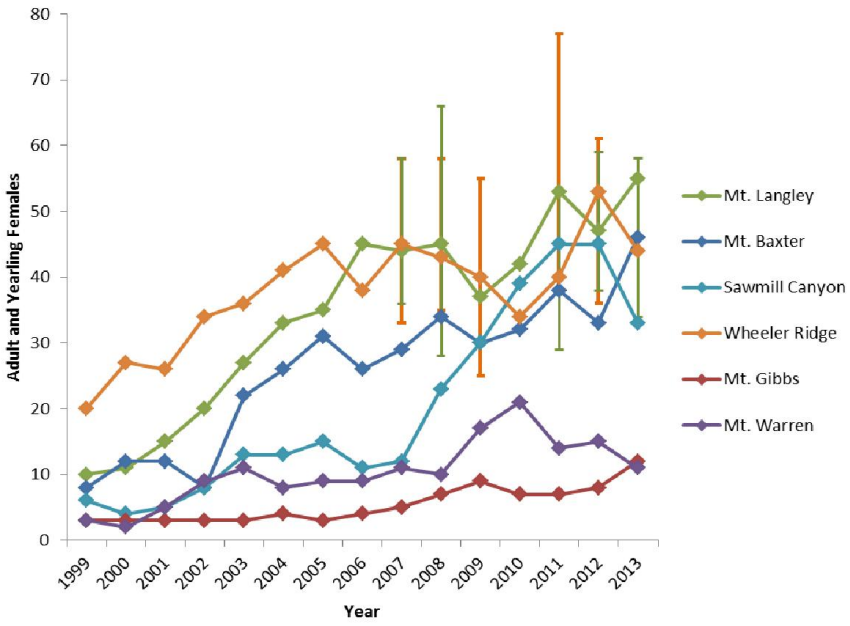

Figure 2. Population trajectories for adult and yearling females from 1999-2013 based on a combination of minimum counts, mark-resight estimates, and reconstructed data for 6 herds in the Sierra Nevada with annual population data. In years when no data were available or when surveys were incomplete, 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.

At the end of the 2013 survey season there were at least 258 female bighorn in the Sierra Nevada. This significant increase from the number counted in 2012 is attributable in part to more accurate counts obtained this year. If population growth continues, Sierra bighorn may reach recovery goals in less than a decade.

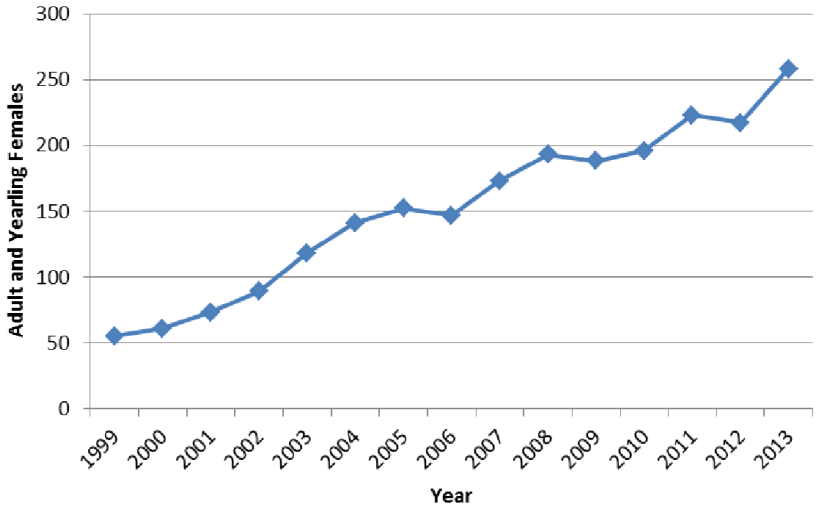

Figure 3. Combined population trajectories for adult and yearling ewes from all occupied herds (Olancha Peak, Big Arroyo, Mt. Langley, Mt. Williamson, Bubbs Creek, Mt. Baxter, Sawmill Canyon, Wheeler Ridge, Convict Creek, Mt. Gibbs, and Mt. Warren) from 1999-2013 surveys. Population estimates in earlier 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 2012 and 2013 is the result of more complete counts in 2013.

Survival and Cause-Specific Mortality

Population growth rates in Sierra bighorn herds may be closely tied to adult female survival (Johnson et al. 2010). In order to track the fluctuations in survival of adult females, we calculate annual Kaplan-Meier survival rates of radio-collared ewes (Kaplan and Meier 1958).

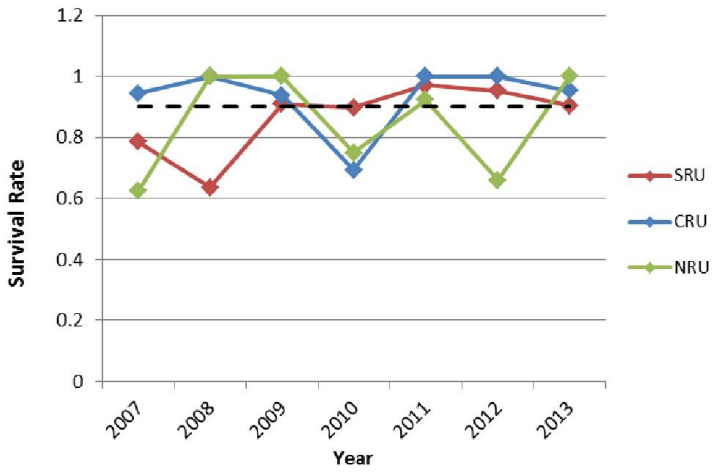

Figure 4. Annual Kaplan-Meier survival rates of radio-collared ewes for 2007-2013 by Recovery Unit. The dashed line represents 90% survival.

Between 2007 and 2013, survival varied from 0.625 to 1.0 (Figure 4). The lowest survival rates occurred in the Northern Recovery Unit (NRU) in 2007, in the Central Recovery Unit (CRU) in 2010, and in the Southern Recovery Unit (SRU) in 2008. More recently, in the winter of 2012, the survival rate in the NRU declined following the deaths of 7 collared animals. In 2013 survival rates for all 3 occupied recovery units were high: 1.0 in the NRU, 0.95 in the CRU, and 0.9 in the SRU. Adult female survival rates above 0.9 are likely to be associated with population increases.

Given the small size of the Sierra bighorn population, even a limited number of mortalities can substantially affect

population growth. One of the primary goals of the Recovery Program is to develop a better understanding of the causes of bighorn mortality and conservation actions that are most likely to promote increased survival. Maintaining radio collars on 30-35% of ewes helps us to detect and locate new mortalities. When possible we investigate these mortalities promptly to determine the probable cause of death, but unfavorable weather conditions or hazardous terrain often delay and occasionally prevent access to mortalities.

During this reporting period we detected 11 mortalities of collared bighorn. One mortality at Mt. Langley was caused by physical injury. Two mortalities at Sawmill Canyon were caused by predation; 1 was determined to be a certain lion kill while the other was determined to be a probable lion kill. We also detected 1 uncollared ram killed by a lion at Mt. Baxter. Eight collared mortalities were of unknown cause; 4 of these animals were well into their teens and nearing the end of the expected lifespan of Sierra bighorn.

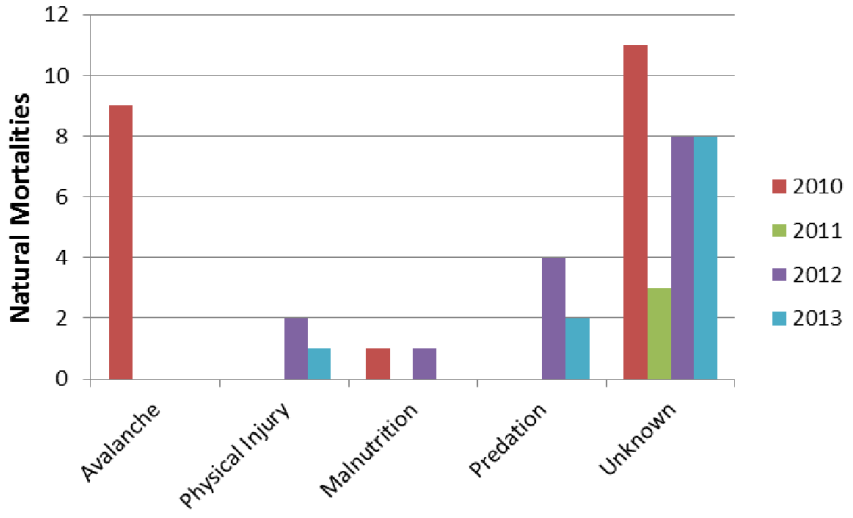

Figure 5. Cause-specific natural mortalities of radio-collared bighorn from May 1 to April 30 of the following year.

Reproduction and Recruitment

Even assuming 100 percent survival of known yearling ewes, the total number of adult ewes counted in 2013 exceeded predictions based on 2012 surveys in some herds. This is likely because of poor surveys in 2012 which produced undercounts of adult and yearling ewes. The number of adult ewes at Mt. Warren was substantially lower than the 2012 prediction in part because 5 collared ewes died following the 2012 survey season (Table 3).

Table 3. Comparison of the number of adult ewes in 2013 to the total number of ewes in 2012 after accounting for recruitment of yearlings and known losses or gains from mortalities or translocations. Populations with poor minimum counts in either year are not included.

Herd	2012				2013
	Adult Ewes	Yearling Ewes	Total Ewes	Known Gains/Losses	Adult Ewes
Langley	42	5	**47**	-6	**38**
Baxter	27	6	**33**		**40**
Wheeler	29	10	**39**		**44**
Gibbs	7	1	**8**	+3	**11**
Warren	12	3	**15**	-5	**7**

The total yearling to ewe ratio, an indication of recruitment, is lower in most herds in 2013 than the lamb to ewe ratio in 2012 (Table 4). A slight decrease in this ratio is typical because not all lambs survive to become yearlings and yearling survival is highly variable; however, a significant decrease in this ratio in the Mt. Baxter herd unit may be cause for further investigation. While these ratios provide a useful estimation of demographic rates, they are sensitive to differences in the percent of the total population counted in consecutive years.

As animals die over the course of a year, estimates of survival and ratios of juvenile age classes to ewes change slightly. 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 2012 to 2013. Populations with poor minimum counts in either year are not included.

Herd	*Lamb:Ewe 2012*	*Total Yearling:Ewe 2013*
Langley	0.675	0.5
Baxter	0.88	0.33
Wheeler	0.6	0.33
Gibbs	0.29	0.18
Warren	0.92	0.86

In populations with nearly complete minimum counts, lamb survival can be estimated by dividing the number of yearlings observed during 2013 surveys by the number of lambs observed during 2012 surveys. Because many lambs die before they are observed, these are likely overestimates of lamb survival. These estimates can also be biased by undercounts in either year. Lamb survival during the 2013-2014 reporting period was high in most herd units but varied from 0.55 at Mt. Warren to 1.0 at Mt. Gibbs (Table 5).

Table 5. Lamb survival estimated by comparing the number of yearlings in 2013 to the number of lambs in 2012. All data are from minimum counts. Populations with poor minimum counts in either year are not included.

Herd	*2012 Lambs*	*2013 Yearlings*	*Lamb Survival*
Langley	27	18	0.67
Baxter	23	13	0.57
Wheeler	15	14	0.93
Gibbs	2	2	1.0
Warren	11	6	0.55

We continued to monitor lambing habitat throughout the spring and summer at Wheeler Ridge, Mt. Gibbs, Mt. Langley, and Olancha Peak. We documented lambing status of collared ewes, total lambs seen, and probable mortalities. At Wheeler Ridge, 23 lambs were born in the spring and summer of 2013; 17 of these lambs survived to be seen during the March 2014 survey.

At Mt. Gibbs, 5 of 8 collared ewes were observed with lambs. Two of the collared ewes with lambs were animals translocated from Mt. Langley in March 2013. An additional 2 lambs were observed with uncollared ewes on July 11, but successive surveys never accounted for more than 6 lambs, indicating 1 lamb mortality. This number is still significant as it represents an extremely productive lambing season for this herd, which has historically experienced low reproductive success.

Surveys at Mt. Langley counted 27 adult ewes and 19 lambs in May and June, shortly after birth. Surveys in September accounted for only 16 lambs, indicating some early mortalities.

Nine of 10 collared ewes at Olancha Peak were observed in June; 7 of those ewes had lambs. Subsequent analysis of lamb fecal pellets revealed that 8 lamb genotypes were present in the population, indicating that 1 lamb was not observed during lambing surveys.

New Findings

Taboose Creek Occupation

Observations made by hikers and Recovery Program staff have revealed that Sierra bighorn occasionally travel within the Taboose Creek herd unit, 1 of the 12 herd units included in recovery goals. In order for a herd unit to be considered occupied, there must be evidence that a population of females persists and reproduces in that area. While Recovery Program staff have observed rams in this herd unit in recent years (Few et al. 2013), no resident adult ewes have been documented in the area. In July 2013, surveyors traveled through the unoccupied Coyote Ridge herd unit and into the northern portion of the Taboose Creek herd unit, covering the area from Bishop Pass through the Palisades to Split Mountain and Red Mountain Creek. The group did not see

any bighorn and saw very little sign, but did encounter 1 very fresh bed site in the vicinity of Mt. Bolton Brown. On April 24 2014, surveyors discovered a group of 12 bighorn below Red Lake on the Red Mountain Creek trail. The group consisted of 2 mature rams, 4 3-year-old rams, 5 2-year-old rams (these animals would have been classified as yearlings until April 15, 2014), and 1 yearling ewe. This marks the first occasion that Recovery Program surveyors have definitively documented the presence of a female in this herd unit. As yearlings and young rams are most commonly associated with adult ewe groups, it is likely that a population of adult ewes inhabits this area. The Recovery Program intends to focus survey efforts in the Taboose Creek herd unit during the 2014-2015 year to further explore what appears to be a natural colonization of this herd unit.

New Habitat Use and Possible Range Expansions

As more GPS collars are deployed, our knowledge of habitat use by Sierra bighorn has increased considerably and we have witnessed some remarkable and unprecedented movements by collared ewes.

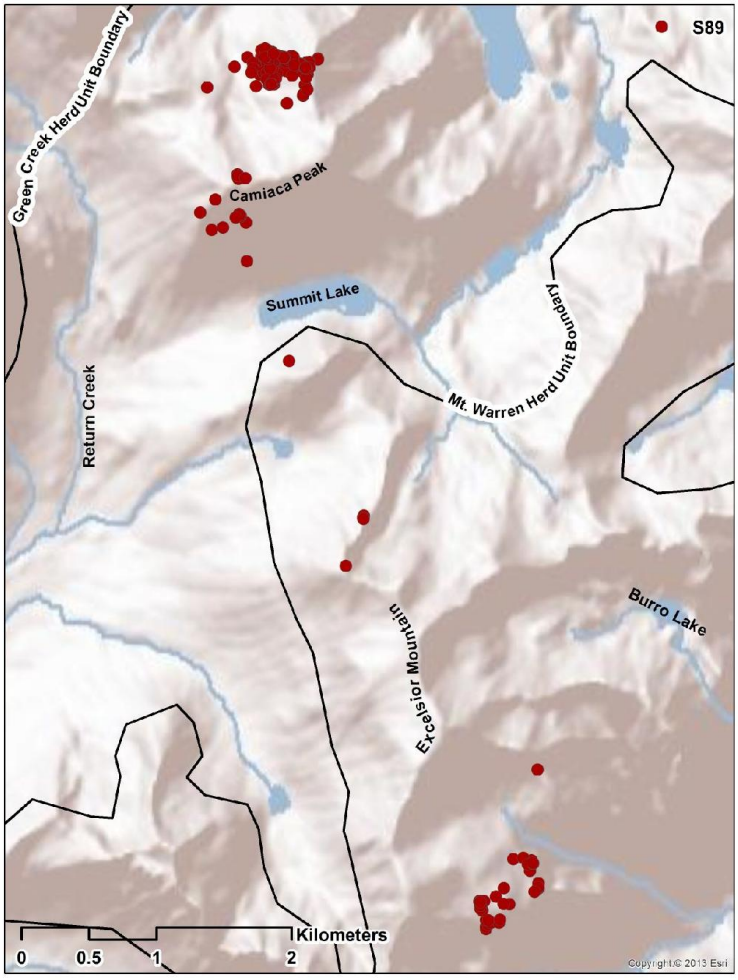

Figure 6. S89's journey north into habitat lying between the Mt. Warren herd unit and the unoccupied Green Creek herd unit.

S89, the only adult ewe in the Mt. Warren herd unit with a functional GPS collar, traveled north beyond the Mt. Warren herd unit boundary in November 2013, moving nearly 6 kilometers in a single day (Figure 6). She has remained in an area between the Mt. Warren and Green Creek herd units and has been observed there twice this winter, once in the company of 1 adult ewe, 1 yearling ewe, 1 lamb, and 1 adult ram, and later with 1 adult ewe and 1 lamb. The lamb belongs to S89 and was born in late August 2013, about 6 weeks past the end of normal lambing season.

During the summer of 2013, Wheeler Ridge yearling ewes S240, S241, S242, and S244 and adult ewe S243 spent time in Granite Park and along the ridge from Italy Pass to Black Bear Pass. We have no prior records of bighorn use of this area, which may represent a range expansion for the Wheeler Ridge herd.

Mt. Williamson ewe S166 and a small group of bighorn have continued to inhabit the Mt. Barnard/Wallace Lakes area in the summer and to travel in winter between Hogback and George Creeks. Mt. Baxter ewe S167 returned for the second year to spend the summer south of Kearsarge Pass just outside the boundary of the Mt. Baxter herd unit, but later rejoined other groups on the Mt. Baxter winter range.

Improved monitoring ability has led us to new knowledge about habitat use by Sierra bighorn throughout the range. Population increases may be one explanation for the colonization of new habitat and the movement of animals into available habitat that lies outside established herd unit home ranges.

Habitat Exploration by Naïve Animals

We watched newly-translocated animals closely following the March 2013 capture and observed interesting movements as naïve animals explored new habitat.

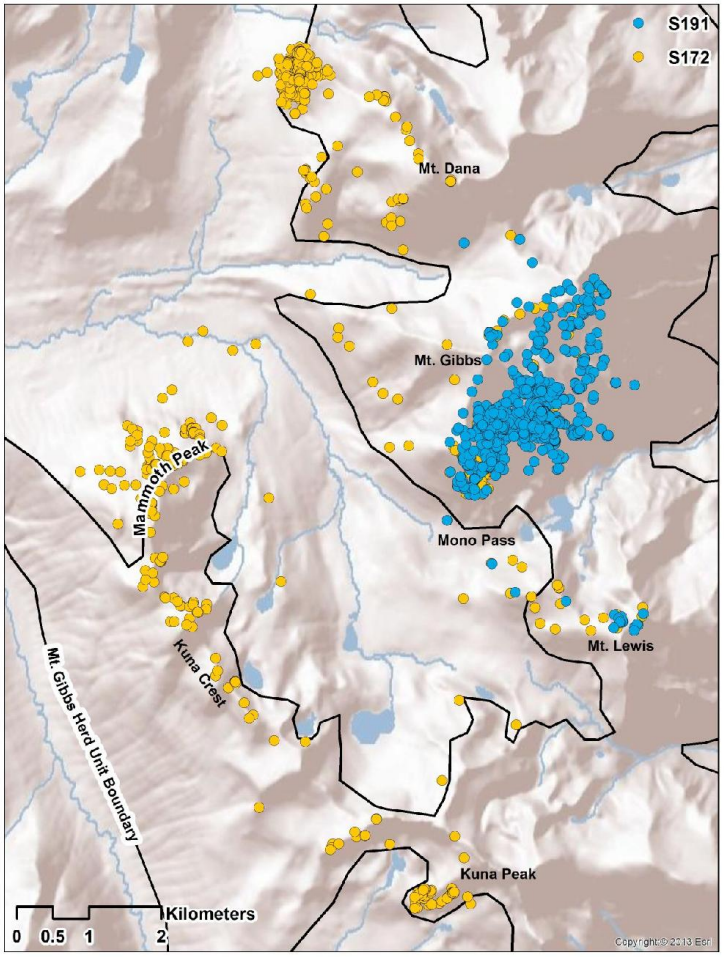

Figure 7. Movements of S172 and S191 after translocation.

S172, a Mt. Langley ewe translocated to Mt. Gibbs, spent several months alone on a feature of Mt. Dana at the northern extreme of the Mt. Gibbs herd unit. During this time her GPS collar locations showed such minimal movement that Recovery Program staff suspected she might be dead. In July 2013, however, she left her post with her newborn lamb and traveled an 8 kilometer circuit in 3 days, at times moving through dense forest, from Mt. Dana south to Mono Pass, southeast to Kuna Peak, and along the Kuna Crest to Mammoth Peak, where she stayed until mid-August. S172 eventually returned to the Mt. Dana/Mt. Gibbs area, where she has remained (Figure 7). In contrast, S191 and S218, the other Mt. Langley ewes translocated to Mt. Gibbs, remained largely in the company of native Mt. Gibbs ewes and did not make similar exploratory movements.

S175 and S148, Mt. Langley ewes translocated to Convict Creek, traveled together to Stanford Peak in August 2013. S148 turned back to the Esha Peak area, but S175 continued south, exploring Hilton Lakes, Mt. Huntington, Half Moon Pass, and finally Mono Pass, approximately 13 kilometers south of her release site, before returning to Esha Peak. Both ewes spent much of the winter on Mt. Morgan North.

S278, a Sawmill Canyon ewe translocated to Olancha Peak, traveled more than 26 kilometers west across the Kern Plateau to the Kern River in May 2013. She spent several days in that area and then returned to Olancha Peak (Figure 8). Other Olancha ewes shifted their use of winter habitat from the Falls Creek drainage, which they occupied during the first winter after translocation, to the Olancha Creek drainage during the winter of 2013.

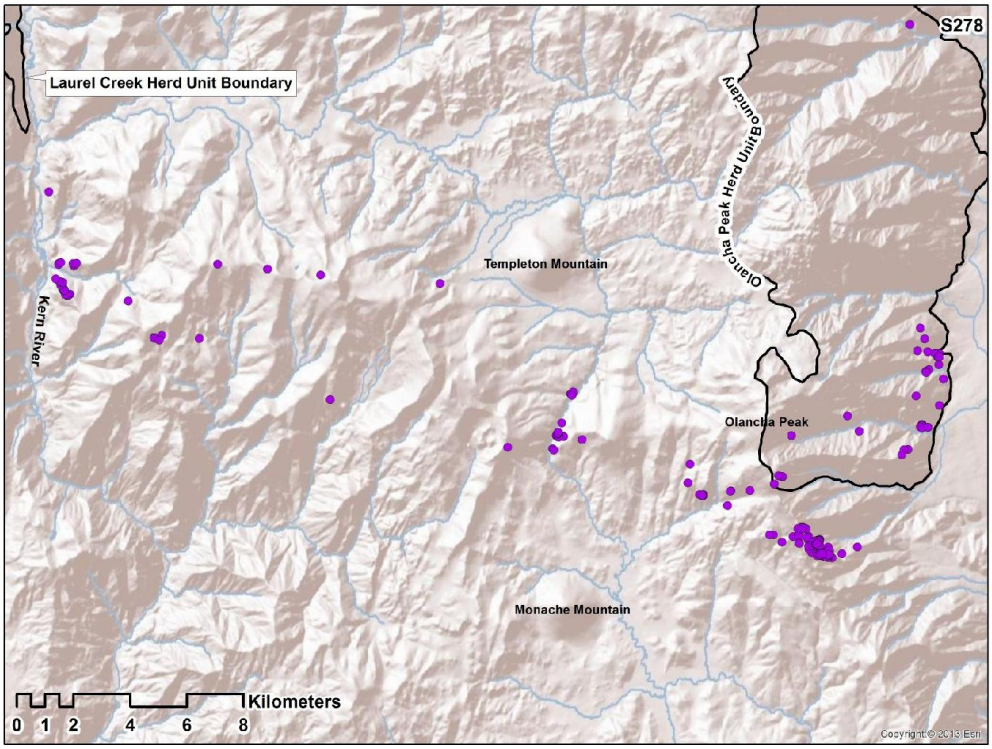

Figure 8. S278's 26-kilometer exploratory trip to the Kern River after translocation.

Two rams (S193 and S200) made dramatic long-distance exploratory movements after their translocation from Mt. Baxter to Big Arroyo in March 2014. S200 traveled over Black Rock Pass, more than 10 kilometers west of his release site. S193 went up Big Arroyo to the Kaweah Ridge, where he summited Second Kaweah at nearly 14,000 feet before returning along the Red Spur to the Kern River area.

In some cases, these exploratory movements by translocated animals result in the occupation of new habitat where bighorn use was previously rare or unknown. Documenting unusual habitat use allows us to refine our models and better prepare for future translocations.

Habitat Scouting

In July 2013, CDFW biologists traveled from Bishop Pass into LeConte Canyon and hiked along the Middle Fork of the Kings River to its confluence with Goddard Creek. South-facing terrain at an elevation of about 6,000 feet was examined for its potential as winter range for Sierra bighorn. Forage quality, connectivity to lambing and alpine habitats along the Black Divide, and visual openness indicate that this would be an excellent site for reintroduction of Sierra bighorn. The connectivity between summer and winter ranges here suggests that bighorn naïve to this area would readily establish necessary migratory routes. No historic remains or observations exist in this area; this is not surprising given that the Black Divide is one of the most remote regions of the Sierra. Indeed, the remote nature of this area would be a significant benefit should Sierra bighorn occupy this habitat. A population here would have an extremely low risk of coming into contact with domestic sheep or goats, and would be somewhat isolated from other herds of Sierra bighorn in the event of a pneumonia outbreak in more connected populations along the Sierra crest.

Public Outreach

Educating the Community

Recovery Program staff have continued to expand public outreach efforts, collaborating with the Sierra Nevada Bighorn Sheep Foundation (SNBSF) to raise community awareness of and involvement in Sierra bighorn conservation. During this reporting period we joined with SNBSF board members and volunteers to staff outreach displays at the Banff Film Festival, Earth Day, and Mule Days in Bishop. These outreach events are important opportunities to inform the public about Sierra bighorn and the work we do to recover the subspecies. We also engage the public in our work by leading bighorn-viewing field trips. During this reporting period, trips in February, March, and April generated enormous interest; each field trip drew more than 30 participants. The April field trip coincided with CDFW participation in local Earth Day celebrations.

Public outreach extended beyond booths at local events and into the classroom. CDFW biologists gave presentations to second graders at Bishop Elementary and to a summer science camp for Owens Valley tribal youth. In addition, Recovery Program leader Tom Stephenson supervised several high school honors biology projects on bighorn sheep and mule deer.

Permanent Outreach Displays

Scientific illustrator Jane Kim's award-winning Migrating Mural project continues along the Highway 395 corridor. Kim's stunning life-size paintings parallel Sierra bighorn habitat along its entire range, and introduce passing

Figure 9. Detail from Jane Kim's newly-completed Migrating Mural at the Lone Pine Airport. (www.inkdwell.com)

residents and tourists to the story of this endangered species. During this reporting period Kim completed a mural in Lone Pine (Figure 9) and began work on the final mural in the series, located at the Forest Service Visitor Center in Lee Vining.

In April 2014, the SNBSF opened a temporary display at the new Mt. Whitney Fish Hatchery Wildlife Interpretive Center north of Independence. The exhibit combined bighorn art and photography with educational displays detailing the history of Sierra bighorn and conservation efforts on their behalf. A display case containing skulls of Sierra and desert bighorn will remain permanently in the Interpretive Center.

Future Recovery Actions

Augmentations and Reintroductions

Pending further study, we will consider scheduled augmentations to the newly-established herds at Olancha Peak and Big Arroyo in order to reach an optimum number of ewes in these populations without removing large numbers of animals from source populations. We will also continue to monitor the Mt. Gibbs herd to assess the results of our augmentation there in terms of that population's genetic diversity.

Only 2 herd units listed in recovery goals remain vacant: Laurel Creek in the Kern Recovery Unit and Taboose Creek in the Southern Recovery Unit. As discussed above, the Taboose Creek herd unit may be in the process of natural colonization.

In the Northern Recovery Unit, where herd unit populations have consistently been too small to support recovery goals, we are considering the addition of a new herd unit. The Recovery Program is working in cooperation with Yosemite National Park to determine whether adequate habitat exists in the vicinity of Washburn Lake, an area that could serve as winter habitat should a herd be reestablished in the Cathedral Range, where historic evidence indicates bighorn occupation in the past. A new herd in this area may greatly accelerate the Sierra bighorn population's progress toward recovery.

Figure 10. A group of Sierra bighorn on the Mt. Baxter winter range.

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